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THE PHILIPPINE JOURNAL OF SCIENCE

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THE INTESTINAL ANIMAL PARASITES FOUND IN ONE HUNDRED SICK FILIPINO CHILDREN[1]

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and

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ONE TEXT FIGURE

Surveys to determine the incidence of intestinal parasites are not a novelty in the Philippine Islands. Several excellent surveys have been made, the results of which are familiar to workers in tropical medicine. So far as we have knowledge, however, nothing approaching a survey by recent methods has been made among young Filipino children. This study can hardly be said to rank as a survey, for the number of cases considered is too small, but they have been studied with such care and thoroughness as to warrant us in the belief that we have missed few if any of the latent positives. One hundred twelve cases were studied, but twelve of these were dropped because of the death or discharge of the patient before investigation of the case was complete. The study of these cases has involved the examination of more than four thousand five hundred microscopic preparations and more than five hundred stool concentrations.

In undertaking this study we believed it possible that we might secure some suggestive data that might lead to an investigation, on a more extensive scale, into the possible influence on infant mortality in the Philippine Islands of infestation by

[1] Contribution from the Bureau of Science and the department of pediatrics, College of Medicine and Surgery, University of the Philippines.

intestinal animal parasites. On reviewing our results and conclusions, we believe that we have at least been partly successful and that we have developed some suggestive matter.

At this time we desire to express our gratitude to Prof. José Albert, chief of the department of pediatrics of the Philippine General Hospital, and a leader in the movement to reduce infant mortality among the Filipinos, who has freely placed the patients on his service at our disposal, and who has in other ways aided and encouraged the work.

Of the one hundred children who remained under our control sufficiently long to admit of a thorough examination of their fæces, 92 per cent were found to be parasitized. This is 3 per cent under the number reported in 1909 by Garrison and Llamas(23) in their examination of the stools of one hundred fifty-eight Manila children, but sufficiently high to warrant endorsement of the statement by Garrison in 1908 [2] that—

> The population of the Philippines presents a higher percentage of infection with intestinal worms than has ever been definitely reported from any other people and the condition is essentially a chronic one, the results of which manifest themselves indirectly in the general physical impoverishment of the people and the high rate of morbidity and mortality accredited to other diseases.

If there is any one point that has been made clear by this brief study, it is the need for careful investigation of the effects produced by each parasite we have found. We have studied cases in which we have found as many as six species of parasites—multiple parasitism has been exceedingly frequent. In the presence of such an array of infesting organisms, showing such a variety of conduct as to mode of life and nutrition, it is exceedingly difficult to analyze cases with respect to the effects produced by the individual parasites.

Another striking point is the absence of infections with obligatory tissue parasites, such as *Entamœba histolytica* and *Balantidium coli*,[3] no case of infection with either having been encountered in our series. Furthermore, Professor Albert informs us that in his practice he has rarely encountered entamœbiasis

[2] Philip. Journ. Sci. § B 3 (1908) 73.

[3] We apply the term "obligatory tissue parasite" to *Balantidium coli* with a mental reservation. We are of the opinion that *Balantidium* is rather closely adapted to tissue parasitism, but the fact that the *motile forms* are frequently found in cases exhibiting no symptoms of colitis implies that it may be capable of living in the lumen of the intestine and deriving its nourishment from the contents thereof over comparatively long periods of time.

among children under 15 years of age. He has been able to recall only a very few cases in an experience extending over nearly thirty years. The senior author, in several years' observation, has seen only one case of infection with *Balantidium* in a young child. The child was under treatment for bacillary dysentery at the time the ciliates were discovered in its fæces; and, although the case has since been observed from time to time, no further dysenteric symptoms have been noted.

Obligatory tissue parasites, such as *Entamœba histolytica* and *Balantidium*, when they give rise to trouble, usually produce symptoms of a fairly positive character; not so with the parasites we have found in this series. We feel we cannot go beyond the statement that the association of *Ascaris* and *Trichuris* seems to evoke a more or less constant symptom-complex which, however, is subject to confirmation by the microscopist. The physician is forced to lean heavily on the microscopist for diagnosis of these cases, simple as they seem, for we have a record of more than one patient in this series to whom santonin had been given for ascarids that were not present in the intestinal tract. In only two instances have we failed to detect the ova of *Ascaris* in the fæces of cases that later were shown to be infected through vomiting or defecation of worms. The possible reasons for our failure to detect these infections will be discussed later.

Leaving aside, for the time being, a discussion as to the pathogenicity of the parasites we have encountered, it is perfectly clear that they are, to say the least, undesirable guests. The utter misery and wretchedness, if not actual suffering, they produce, apart from any other harm they may inflict upon their unhappy little hosts, are sufficient in themselves to bring about a vigorous repudiation and condemnation of the statements made in so many textbooks of medicine that these parasites are, for the most part, neither important nor particularly dangerous.

In dealing with the general problem of intestinal parasitism, we believe that the parasites may injure their hosts in many ways. Among the possible effects that may be produced by them are:

1. The production of antigrowth vitamines or growth-inhibiting substances.
2. The production of substances directly toxic, cytolytic, or hæmolytic.
3. Unfavorable effects upon the host through the liberation of the products of metabolism of the parasite.
4. Mechanical irritation of the mucous surfaces by the parasites when present in large numbers.

5. The conveyance of pathogenic organisms from one part of the body to another.
6. Interference with absorption in the intestine through the adherence of large numbers of parasites to the surface of the epithelium, as in the case of *Giardia*.
7. Actual invasion and destruction of the tissues with all its concomitants and sequelæ.

The children included in this series ranged in age from 7 months to 13 years. The girls numbered fifty-three, and 86.6 per cent of these were parasitized. There were forty-seven boys, 97.8 per cent of whom were parasitized, the incidence of infection in the boys being higher by 11.2 per cent than in the girls.

Considered in groups, 66.6 per cent of the children under 1 year of age were found to be infested. This was a very small group, consisting of only nine cases, and we are not inclined to generalize on that incidence. It does show, however, that even breast-fed children are not free from parasitism under the conditions obtaining here. The second group, formed of children between the ages of 1 and 2 years, was shown to be infected to the extent of 73.6 per cent. This gives the total incidence of infection in our series of children between the ages of 7 months and 2 years as 71.4 per cent. We may add that we had no opportunity to examine any child under the age of 7 months.

The third group, comprising children more than 2 years and not more than 13 years of age, showed 100 per cent infection. This group was formed of seventy-two children, all of whom, without exception, were infested with one or more parasites. Notwithstanding the group was small, the results are rather startling. We can only say that there was absolutely no selection of cases, and this fact was discovered only when we began to tabulate and study our results at the conclusion of the examinations.

The earliest infection was found in a child 7 months old, which was found to harbor *Spirochæta eurygyrata* and *Ascaris lumbricoides*. Allowing for the period of development of the worm before ovulation, this infection took place certainly not later than between the fifth and sixth months following birth. Unfortunately we were unable to secure data as to the feeding and other habits of the child. The infection apparently was light, for it was detected only on the second concentration of the stool, and the ova were few and far between.

Another child showed an infection with *Trichuris trichiura* at the tenth month which, allowing for the development of the worm, must have been contracted not later than the ninth month. This, also, was a light infection, although it was detected on the first concentration of the stool. Further reference will be made to this case later on.

The protozoal and helminthal findings are recorded in Table 1. In this table are considered only protozoa in the strict sense. "Blastocystis" and *Spirochæta eurygyrata* are excluded; but, in view of the recent work of Kofoid, Kornhauser, and Swezy(35) and of Brug(5) we include Wenyon's "I Cysts" under the protozoa without at this time expressing an opinion as to whether they are the cysts of *Entamœba nana* (*Endolimax nana*) or "Entamœba williamsi."

So far as "Blastocystis" is concerned, we record it as a parasite without regard to its pathogenic or nonpathogenic possibilities. It was found alone, to the exclusion of all other parasites, in only one of our cases. In each case where we have recorded "Blastocystis," we have done so only after satisfying ourselves, beyond a reasonable doubt, that we were not dealing with aberrant cysts of some definitely known protozoön. We have classified all intestinal spirochætes as *Spirochæta eurygyrata* for we were unable to determine, without a tedious and time-consuming series of measurements, whether or not we were encountering any of the other spirochætes that have been reported from the human intestine.

TABLE 1.—*Protozoal and helminthal findings.*

	Cases.	Total infections.
With protozoa	33	41
With protozoa alone	2	
With helminths	80	138
With helminths alone	49	
Mixed protozoal and helminthal infections	31	
Spirochæta eurygyrata alone	8	
"Blastocystis" alone	1	

The parasites recorded by us in this study lie in thirteen genera and as many species. We have adopted Brug's designation(5) of *Entamœba nana* as *Endolimax nana,* and in the case of hookworm infections we have made no attempt to distribute them between the genera *Ancylostoma* and *Necator,* but have simply recorded them as "hookworm."

The incidence of the various parasites is set forth in Table 2.

Table 2 shows *Trichuris trichiura* to be the most prevalent

TABLE 2.—*Incidence of protozoa and helminths.*

Parasite.	Males.	Females.	Cases.
Spirochæta eurygyrata	33	28	61
"Blastocystis"	14	20	34
Entamœba coli	2	5	7
Endolimax nana	3	4	7
Dientamœba fragilis	3	0	3
Trichomonas intestinalis	6	4	10
Giardia intestinalis	7	1	8
Eutrichomastix sp. (?)	0	1	1
Chilomastix mesnili	0	3	3
"I Cysts"	1	1	2
Trichuris trichiura	33	36	69
Ascaris lumbricoides	24	32	56
Hookworm	4	8	12
Oxyuris vermicularis	1	0	1

parasite in the series. *Spirochæta eurygyrata* comes next, and *Ascaris lumbricoides*, third. Table 1 has shown the comparatively low incidence of protozoal as compared with helminthal infections, a condition we shall discuss farther on. It is to be noted that no evidence of either cestode or trematode infection was discovered in any case.

By far the greater number of patients studied resided in Manila, only twenty-three having come from the provinces. Obviously we have dealt with too few cases to enable us to draw any conclusion regarding either geographical distribution or the incidence of any particular parasite in the several localities. Incidentally, we might remark, however, that previous work has shown that the geographical distribution of animal parasites in the Philippine Islands is somewhat irregular, the trematodes, with the exception of *Echinostoma ilocanum*, for instance, being found in the southernmost provinces only. A thorough bionomic study would undoubtedly reveal the reason for this seemingly anomalous condition.

Be that as it may, however, 92.2 per cent of the children residing in Manila were found to be infested with parasites. Only one child in the provinces was uninfested, thus giving us a provincial incidence of 95.2 per cent. This child was 1 year old and had always been breast-fed. The locality from which it came is not renowned for its sanitation, but the immediate surroundings of the child were, nevertheless, "clean."

We have made careful inquiry into the immediate home surroundings and habits of these patients and the water drunk by them—as to whether it came from wells, the city water supply, or some other source. We are led to the conclusion that the immediate surroundings and the water drunk have less bearing on the incidence of parasitism than is generally believed. We have recorded children living under the best hygienic conditions as regards cleanliness of surroundings but who, notwithstanding, were more or less heavily parasitized; and, in contrast, we have found instances where the children lived in surroundings that were filthy and overcrowded, but who survived the ordeal and failed to exhibit the slightest evidence that they were parasitized with either helminths or protozoa. It is perhaps easier to explain the first than the second condition.

The geographical distribution of our cases is set forth in Tables 3 and 4.

TABLE 3.—*Incidence of parasitism in Manila.*

District.	Cases.	Parasitized.	Not parasitized.
Binondo	2	1	1
Ermita	5	5	
Intramuros	1	1	
Malate	7	7	
Paco	10	10	
Pandacan	1	1	
Quiapo	1	1	
Sampaloc	9	8	1
San Lazaro	2	1	1
San Miguel	1	1	
Santa Ana	4	4	
Santa Clara	1	1	
Santa Cruz	12	9	3
Santa Mesa	3	3	
Singalong	6	6	
Tondo	5	5	
Trozo	2	2	
Undetermined	5	5	
Total	77	71	6

TABLE 4.—*Incidence of parasitism in the provinces.*

Province.	Cases.	Parasitized.	Not parasitized.
Bataan	1		1
Batangas	1	1	
Bulacan	1	1	
Cavite	5	5	
Mindoro	1	1	
Nueva Ecija	1	1	
Pampanga	2	2	
Pangasinan	2	2	
Rizal	9	9	
Total	23	22	1

MATERIAL AND METHODS

The cases were all drawn from the pediatrics ward in the Philippine General Hospital. There was no selection, the patients simply being taken as they were admitted. The larger proportion included children admitted for the treatment of disorders of the digestive and respiratory tracts, which preponderate over other diseases treated in the children's wards; but there were cases of malaria, beriberi, chorea, and other maladies. One or two developed cholera (a disease notoriously difficult to diagnose in children) during their stay in the hospital. Relatively few came in for treatment directed specifically against parasites.

The general plan comprehended at least five separate stool examinations, extending over seven to ten days, as circumstances permitted. At each examination three cover-glass preparations of the fresh material were carefully studied, five slides were fixed and stained for subsequent study, and at least 1 gram of the stool (samples being taken from different parts of the stool) was concentrated by the method of Cropper and Row.(10)

In the examination of the fresh specimen the fæces were diluted, when necessary, with physiological salt solution faintly tinted with neutral red. Cysts were studied with double strength Gram's iodine solution containing a small amount of glycerin, and with Aragao's modification of Hayem's solution. The former was found to give the best results. A careful study in each case was made of the cellular exudate, and in nearly every case the microscopic diagnosis of bacillary dysentery was confirmed by the clinical course of the disease. The fæces were not examined bacteriologically.

The stained preparations were all fixed in Bouin's picro-aceto-formol solution. Two of the five were stained in Mayer's hæmalum, which is admirable for cysts, and the other three by Dobell's iron-hæmatein, which gives beautiful results with trophozoites. Occasionally smears were treated by the Benians Congo-red method for the demonstration of spirochætes. The latter were very frequently detected in the fresh material and always appeared in the stained preparations. Smears from cases infected with flagellates were occasionally stained by Giemsa's method after methyl-alcohol fixation (following brief exposure to the vapor of osmic acid), because this gives an excellent demonstration of the flagella which can then be readily counted.

We used the ether-concentration method of Cropper and Row in preference to any of the excellent flotation methods, because our experience bears out that of Cropper and Row that solutions of high concentration have a tendency to distort protozoan cysts, thereby rendering their identification more difficult. The flotation method is unquestionably an excellent and convenient one when the search is restricted to ova of helminths.

In no case did we detect cysts of protozoa on concentration that we failed to find in the course of examining the slides of fresh or stained material.

Our method did not differ essentially from that of Cropper and Row, except that we emulsified the fæces in a test tube. The lumps of fæces were transferred to the tube with a small amount of saline solution and then thoroughly broken down and emulsified by stirring with a glass rod. Saline solution was gradually added and the stirring continued until there was complete emulsification of the mass. The maximum amount of solution was then added and the tube thoroughly shaken for several minutes. The entire sediment left in the centrifuge tube was examined microscopically.

This method, of course, necessitated careful attention to the cleansing of all utensils. This was not entrusted to the laboratory attendant, but was performed by one of us. All the apparatus was thoroughly washed off in a strong stream of running water, carried into a jar of strong lysol solution, and repeatedly scrubbed out with a stiff test-tube brush, the lysol being changed several times, after which the apparatus was again subjected to running water and carefully dried with absorbent cotton rolled around a small stick of wood.

Notwithstanding our figures are not widely different from those recorded by careful workers in the Philippines in the past, we would, had we not employed concentration methods, have missed 32.6 per cent of the helminthal infections. Table 5 shows the infections picked up on concentration that were missed on direct examination.

TABLE 5.—*Infections detected only on concentration.*

Trichuris	31
Hookworm	8
Ascaris	5
Oxyuris	1
Total	45

Furthermore, two cases (Nos. 20 and 34) were missed in the laboratory, but later proved to be infested with *Ascaris* through the vomiting or passage of worms by the patients during their stay in the ward.

Several factors, some of them rather remote to be sure, may intervene to defeat a laboratory diagnosis in certain cases of nematode infection. The parasites may be present in exceedingly small numbers; but in such cases, unless one or more of the other conditions to be mentioned is present, the infection is almost certain to be detected sooner or later, especially if concentration methods are employed. The worms may be too immature to produce eggs. In such an event a wait of three or four weeks at the most, in a suspicious case, will probably settle the matter. Such cases would hardly be likely to develop symptoms, however. All the worms present may be males—a remote possibility, but one that has been shown by Hall(25) to exist in lower animals. Added to these is the difficulty experienced in handling dysenteric stools, especially those containing considerable mucus; but we believe it is possible, in the greater number of such instances, to pick up helminthal infections during the course of a series of examinations such as we have conducted. We failed to detect the ova of helminths in six individuals among the twenty-two cases of ileocolitis that occurred in our series. Of these six negative cases, four were found in the group of children between the ages of 1 and 2 years, eight cases of ileocolitis having occurred in that group. This group has been shown to have yielded 26 per cent less infections than the other higher groups and about 7 per cent more than the 7 to 12 months group. However, it must be admitted that stools of that character are troublesome and uncertain to deal with, but as we were taking the general run of cases, we had to deal with conditions as we found them. Incidentally, we might remark that we were unable to determine any marked tendency to expel worms during the course of a febrile disorder. It did occur in some instances, but it was not an invariable event.

For some reason or other the ova of *Ascaris* and *Trichuris* occasionally failed to come down on centrifugation. This occurred ten times in the case of *Ascaris* and five times in the case of *Trichuris*. The infections, however, were either detected on the slides or were thrown down in subsequent—or, in some cases, earlier—concentrations. One very odd situation was afforded by a case that was persistently negative for *Trichuris* on concentration and on examination of fresh cover-glass preparations. It was marked negative until a solitary egg of *Trichuris* was found on one of the stained preparations.

It would probably take careful study to determine the exact reasons for these occurrences. It seems likely that they were due to some error in technic such as insufficient dilution on shaking of the emulsion, or slowing down or speeding up of the centrifuge, which at times ran irregularly. In the case of *Ascaris* it has occurred to us that possibly the gelatinous coat of the egg may at times absorb ether and prevent the ova from settling in the separatory funnel.

Out of the twelve hookworm infections found, four were diagnosed on direct microscopical examination of the fresh fæces, the remaining eight being found only on concentration.

Many of the protozoal findings were not made until the stained preparations were studied; because, for the most part, they were light infections with the exception of those with *Trichomonas intestinalis*, which usually were fairly heavy. It was necessary, however, to study the stained preparations for the identification of *Endolimax nana* and *Dientamœba fragilis*, and to count the flagella of the trichomonads. The hæmalum preparations served as a check on encysted forms of the amœboid group, but Dobell's method gave the best pictures of the cysts of *Giardia* and *Chilomastix*.

Before passing on to a detailed consideration of the various groups of children, it seems worth while briefly to mention those cases that were not parasitized. As has been said, all of these occurred in children under the age of 2 years. Of these (eight) cases, one (case 32) is known to have been parasitized in the past, for it gave a history of having vomited an ascarid before admission. Like the others, this case was persistently negative on repeated examination, so there exists the possibility that the worm vomited was the only one with which the child was infested. The data on these cases are presented in Table 6.

It is interesting to note that, notwithstanding five of these children were seriously ill, there was only one death in the nonparasitized group. This was the case of a girl (No. 52) with a severe ileocolitis that ran a protracted course of more than a month. The child developed a secondary stomatitis and finally died of exhaustion. She had been ill for three weeks before coming to the hospital.

There were nine deaths in the series, only one of which occurred in a nonparasitized child. This was the case (No. 52)

TABLE 6.—*Cases not parasitized.*

[R, recovered; I, improved; D, died.]

Case.	Age.	Sex.	Diagnosis.	Termination.
	Mos.			
3	24	♀	Ileocolitis with secondary bronchitis; severe	R
5	14	♀	Ileocolitis; moderately severe	I
32	22	♀	Bronchial asthma; rachitis; indigestion. (Vomited an ascarid before admission.)	I
52	14	♀	Ileocolitis; secondary stomatitis	D
57	10	♀	Indigestion	R
64	12	♀	do	R
83	18	♂	Bronchopneumonia; moderately severe	I
100	12	♀	Malaria with secondary splenomegaly	I

that has just been mentioned. Strangely enough, not one of these was infected with protozoa sensu stricto. The data on these cases are presented in Table 7.

The age distribution and incidence of the several parasites together with the number of cases in each group are presented in Table 8.

Inspection of Table 8 will show that infection with *Spirochæta eurygyrata*, "Blastocystis," *Trichuris*, and *Ascaris* takes place exceedingly early in the life of the child, and these parasites are found in children of every age up to our limit of 13 years. Hookworm infections in Manila and the vicinity apparently do not get a fair start much before the sixth year, only an isolated case having been picked up between the third and fourth years. Protozoal infections begin to take place after the first year and are more or less uniformly distributed through the series thereafter.

Tables 9 to 21 summarize the laboratory and clinical data throughout the entire series. It has been found interesting to break the series up into thirteen groups representing each year of the child's life, for it was felt that such an arrangement might form a useful basis for comparison in later work. The parasites recorded represent only those found in our laboratory examinations, without reference to the passage or vomiting of worms before the child entered the hospital, or to the cases where children vomited or passed ascarids in the ward when laboratory examination had failed to discover the ova. There were only two such instances.

The clinical diagnosis is that made in the ward and does not necessarily include the laboratory diagnosis. It is mainly a record of the salient features of the diagnosis as made when

TABLE 7.—*Deaths from all causes.*

Case.	Age.		Sex.	Cause.	Parasites found.		
					Miscellaneous.	Protozoa.	Helminths.
	Yrs.	*mos.*					
11	3	0	♀	Ileocolitis; gingivitis	"Blastocystis"		*Trichuris; Ascaris.*
13	3	0	♀	Ileocolitis; stomatitis; septicæmia	do		*Trichuris.*
22	7	0	♀	Tuberculosis; pleurisy and effusion			*Trichuris; Ascaris;* hookworm.
38	3	0	♂	Tuberculous peritonitis	*Spirochæta*		*Trichuris.*
46	1	0	♂	Bronchopneumonia	"Blastocystis;" *Spirochæta*		*Trichuris; Ascaris.*
52	1	2	♀	Ileocolitis; exhaustion			
54	10	0	♂	Typhoid; intestinal hæmorrhage			*Trichuris; Ascaris.*
91	1	8	♂	Ileocolitis; gangrenous gingivitis	*Spirochæta*		*Ascaris.*
98	8	0	♀	Ileocolitis; bronchopneumonia	do		*Trichuris; Ascaris.*

TABLE 8.—*Age distribution and incidence of parasites.*

Age.	Cases in group.	*Spirochæta eurygyrata.*	"Blastocystis."	*Entamœba coli.*	*Endolimax nana.*	*Dientamœba fragilis.*	*Trichomonas intestinalis.*	*Giardia intestinalis.*	*Eutrichomastix* sp. (?)	*Chilomastix mesnili.*	"I Cysts."	*Trichuris trichiura.*	*Ascaris lumbricoides.*	Hookworm.	*Oxyuris vermicularis.*
7 months to 1 year	9	5	1	----	----	----	----	----	----	----	----	2	2	----	----
1 to 2 years	19	10	1	----	1	----	1	----	----	----	----	5	7	----	----
2 to 3 years	11	3	4	1	----	----	1	----	----	1	----	9	9	----	----
3 to 4 years	11	9	3	----	----	----	1	2	----	----	----	9	6	1	----
4 to 5 years	11	7	3	3	----	----	----	----	----	1	----	10	5	----	----
5 to 6 years	6	6	3	----	3	----	----	1	----	1	----	5	5	----	----
6 to 7 years	8	5	4	1	----	----	2	1	----	----	----	6	6	3	----
7 to 8 years	7	3	5	----	1	2	2	3	----	----	1	7	4	1	----
8 to 9 years	3	3	1	1	----	----	1	----	----	----	1	3	1	3	----
9 to 10 years	5	3	2	----	----	----	1	1	1	----	----	4	4	2	----
10 to 11 years	3	2	2	1	1	1	----	----	----	----	----	3	2	----	1
11 to 12 years	4	3	4	----	1	----	----	----	----	----	----	4	4	1	----
12 to 13 years	3	2	1	----	----	----	1	----	----	----	----	2	1	1	----
Total	100	61	34	7	7	3	10	8	1	3	2	69	56	12	1

the patient was received in the hospital. The termination records the status of the patient at the time the entire series of observations was concluded. It was necessary to record them thus, because several patients remained in the hospital after the work was completed and others were transferred to other institutions and thus passed out of our control.

By physical development should be understood the condition presented to the physician on admission—that is to say, the general physique and nutrition of the patient as brought out in the usual physical examination.

Circumstances made it impossible for us to make an exact determination of the mental development of these children, such as the application of the Binet-Simon test. The mental fitness of each child was simply appraised after watching its conduct with its toys and with the other children in the ward, the readiness with which it answered questions, and its general ability to talk, walk, and otherwise behave in harmony with its age. In later work it would probably be found desirable to enlist the coöperation of a specialist in child psychology, or, failing that, it might be found convenient to use the Standard Score Card for Babies as outlined by the American Medical Association. This has already been employed in an interesting series of observations on Filipino children by Albert and Arvisu.(2)

Unless otherwise noted, the column devoted to abdominal symptoms records the symptoms observed by the patient or those with whom he lived prior to the onset of the disease that led to his being brought to the hospital. So many of the children included in this series were suffering from diseases of the alimentary tract, that in themselves give rise to more or less positive abdominal symptoms, that it was realized that this distinction must be drawn.

Symptoms referred to the nervous system presented some difficulty; but we followed the same general rule, eliminating, so far as we could, all phenomena clearly referable to some condition other than parasitism. We realize that we may not have been entirely successful in our treatment of this factor, but we have done the best we could under the circumstances.

When it came to collecting information as to the vomiting or passage of worms before the patient was admitted to the hospital, we had to rely largely on the statements of parents or others with whom the child lived; but we have felt perfect security in so doing, for it would probably not be easy to find a Filipino mother who did not know a round worm when she saw it. In all cases where reference is made in the table to the passage or vomiting of worms, it should be understood that the worm to which reference is made is *Ascaris lumbricoides*.

The youngest group of children is recorded in Table 9. With the exception of cases 46 and 56 none showed abdominal symptoms of any importance. Case 46 was infested with four parasites; while case 56, which showed the most marked symptoms, was rather lightly infected with *Trichuris*. Case 87, which was infected with *Ascaris*, had never, so far as we could ascertain, shown symptoms referable to the abdomen or the nervous system. The infection was light and, as has been said, was detected on the second concentration of the stool.

Case 46 had been breast-fed from birth to the time of admission, but after the eighth month the mother reënforced its diet with bread and rice. Case 56 had been bottled-fed since birth. We were unable to obtain reliable data on case 87. With the exception of case 63, which had been given other food from time to time, all the children had been breast-fed from birth to date of admission.

One of the most interesting cases in Table 10 is No. 83, a 2 year old girl who was admitted for treatment of an acute bronchitis. This child was infected with "Blastocystis," *Endolimax nana*, *Trichuris*, and *Ascaris*. The physical development of the child was only fair. She was abnormally quiet and, not-

TABLE 9.—*Findings in children between 7 months and 1 year.*

[R, recovered; I, improved; D, died.]

Case.	Age.	Sex.	*Spirochæta.*	"Blastocystis."	*Trichuris.*	*Ascaris.*	Clinical diagnosis.	Termination.	Physical development.	Mental development.	Abdominal symptoms.	Nervous symptoms.	Vomited worms.	Passed worms.
	Mos.													
46	12	♂	+	+	+	+	Tuberculosis; ileocolitis	D	Bad	Backward	Tympanitis and distention.	None	—	—
51	12	♂	+				Acute bronchitis; pneumonia.	I	Fairly good	Normal	None	do	—	—
56	11	♀			+		Acute bronchitis	I	Emaciated	do	Distention, tympanism and vomiting.	Insomnia: irritability.	—	—
57	10	♀					Indigestion	R	Fair	do	Occasional flatulence	Irritable	—	—
63	11	♀	+				Malaria	I	Fairly well developed; poorly nourished.	do	Splenomegaly	None	—	—
64	12	♀					Indigestion	R	Fairly good	do	None	Occasional convulsive attacks.	—	—
71	8	♀	+				Bronchopneumonia	R	Good	do	Slight tympanism	None	—	—
87	7	♂	+			+	Acute bronchitis	R	do	do	None	do	—	—
100	12	♀					Malaria	I	Fairly good	do	Splenomegaly	do	—	—

withstanding her age, could not talk. There was a history of abdominal distention and occasional pain, but no symptoms referable directly to the nervous system. The infections were fairly heavy, but an inquiry into the gastronomic history of this patient robs this condition of some of its significance. We learned that the child had been breast-fed up to the age of 10 months; between that time and the age of 18 months she had subsisted on *linugao* (a native dish consisting of rice cooked to form a sort of porridge) and gruel, after which she had received the same rations as the adult members of the family. It is cases such as this that increase the difficulty of determining the symptoms referable directly to infestation with animal parasites. Case 99, infested with *Ascaris*, complained only of indigestion and slight distention. It had been breast-fed the first year and since then had received a variable diet including rice and bananas. Although it was 2 years old, the child was unable to talk.

The other cases in this group were fed as follows:

Case 2. Breast-fed for the first fourteen months; artificially fed thereafter.
Case 3. Breast-fed for the first five months; artificially fed thereafter.
Case 5. Breast-fed the first month; received pasteurized milk thereafter.

With the exception of case 2, which was infested with *Spirochæta eurygyrata*, these three children were free from parasites.

Case 16. Artificially fed "for a long time."
Case 32. Breast-fed for the first nineteen months; artificially fed thereafter.
Case 35. Breast-fed since birth.
Case 43. Breast-fed since birth, but lately it has been given an occasional artificial feeding.
Case 44. No data.
Case 52. Breast-fed the first ten months; artificially fed thereafter.
Case 59. Breast-fed the first thirteen months; artificially fed thereafter.
Case 62. Breast-fed until recently, when it was placed on artificial feeding.
Case 67. Breast-fed the first two months; since then the child has received condensed milk.
Case 72. From the viewpoint of the parasitologist this was one of the most interesting cases in the series, but unfortunately we could obtain no reliable data as to the child's diet.
Case 74. Breast-fed for the first year; artificially fed since then.
Case 76. Breast-fed since birth.
Case 88. No data.
Case 91. Breast-fed for the first eighteen months; artificially fed thereafter.

TABLE 10.—*Findings in children more than 1 and not over 2 years.*

[R, recovered; I, improved; U, unimproved; D, died; O, vomited; or passed *Ascaris* before admission; H, vomited or passed *Ascaris* in hospital.]

Case.	Age.	Sex.	*Spirochæta.*	"Blastocystis."	*Endolimax nana.*	*Trichomonas.*	*Trichuris.*	*Ascaris.*	Clinical diagnosis.	Termination.	Physical development.	Mental development.	Abdominal symptoms.	Nervous symptoms.	Vomited worms.	Passed worms.
	Mos.															
2	24	♂	+						Chronic indigestion	I	Emaciated but fairly developed.	Normal	Distention	Irritable	—	—
3	24	♀							Ileocolitis; bronchopneumonia.	R	Poor	do	None	do	—	—
5	14	♀							Ileocolitis	I	Good	do	do	do	—	—
16	24	♂					+	+	Tuberculosis; ileocolitis.	U	Poor	Backward; does not talk; fontanelle is still open.	Pain and distention	do	—	—
32	24	♀							Asthma; rachitis; indigestion.	I	do	Normal	Pain and distention relieved on vomiting worms.	Profuse sweating; irritability.	O	—
35	16	♀	+						Ileocolitis; stomatitis	R	Fair	do	Referable to present illness.	Occasionally irritable.	—	—
43	21	♂						+	Bronchopneumonia	R	Good	do	Occasional flatulence	None	—	—
44	24	♂	+						Intoxication secondary to constipation.	R	Fair	do	Slight distention	Convulsions	—	—
52	14	♀							Ileocolitis	D	do	do	Referable to present illness.	Irritable	—	—
59	15	♂	+				+		Bronchitis	R	do	do	None	None	—	—
62	18	♂	+						Bronchopneumonia	R	Good	do	Occasional diarrhœa, distention and tympanism.	do	—	—

67	24	♂	+	----	----	----	+	----	Bronchopneumonia; adenitis.	R	Poor	Backward; does not talk or sit up; apathetic to surroundings.	Occasional pain. diarrhœa, and distention.	do	—	—
72	24	♀	+	----	----	+	+	+	Bronchitis; ascariasis	I	Good	Normal	Frequent pain	do	O	OH
74	13	♂	+	----	----	----	----	+	Tuberculosis; ileocolitis.	U	Poor	Backward	do	Dull to irritable	H	—
76	13	♂	+	----	----	----	----	----	Bronchopneumonia; malaria.	R I	Good	Normal	Splenomegaly	None	—	—
83	24	♀	----	+	+	----	+	+	Acute bronchitis	R	Fair	Abnormally quiet; does not talk.	Distention and occasional pain.	do	—	—
88	18	♂	----	----	----	----	----	----	Bronchopneumonia	I	Poor	Backward; cannot sit up straight or talk.	Occasional pain in the past.	Irritable	—	—
91	20	♂	+	----	----	----	----	+	Ileocolitis; gangrenous gingivitis.	D	Good	Too quiet	None	None	—	—
99	24	♀	----	----	----	----	----	+	Indigestion	I	Fair	Cannot talk	Slight distention	do	—	—

TABLE 11.—*Findings in children more than 2 and not over 3 years.*

[R, recovered; I, improved; U, unimproved; D, died; O, vomited or passed *Ascaris* before admission; H, vomited or passed *Ascaris* in hospital.]

Case.	Sex.	*Spirochæta.*	"Blastocystis."	*Entamæba coli.*	*Trichomonas.*	*Chilomastix.*	*Trichuris.*	*Ascaris.*	Clinical diagnosis.	Termination.	Physical development.	Mental development.	Abdominal symptoms.	Nervous symptoms.	Vomited worms.	Passed worms.
11	♀	----	+	----	----	----	+	+	Ileocolitis; gangrenous gingivitis.	D	Fair	Normal	Pain	None	O	—
13	♀	----	+	----	----	----	+	----	Ileocolitis; gangrenous stomatitis; septicæmia.	D	do	do	None	do	—	—
20	♀	----	+	----	----	+	+	----	Bronchitis; ascariasis	I	do	do	Frequent pain since the 18th month.	do	—	H
38	♂	+	----	----	----	----	----	+	Pulmonary tuberculosis; bronchopneumonia; pleurisy.	D	Poor	do	Pain, distention, and tympanism.	do	—	—
42	♀	----	----	----	----	----	+	+	Bronchopneumonia; alveolar abscess.	I	Fair	do	Occasional pain	Irritable	—	—
49	♀	----	+	+	----	----	+	+	Lobar pneumonia	I	Good	do	None	None	—	—
60	♀	----	----	----	----	----	+	+	Chorea; ascariasis	I	Fair; since 3d month, strabismus; falls in walking.	do	Frequent pain	Restless; cries without cause; sleepless at times.	—	O
75	♀	----	----	----	----	----	+	+	Bronchitis; chronic rhinitis.	R	Good	do	None	None	—	—
78	♂	+	----	----	----	----	+	+	Erysipelas; acute bronchitis.	U	do	do	do	Irritable	—	—
89	♀	----	----	----	+	----	----	+	Pulmonary tuberculosis; enteritis.	U	Poor	Does not talk	Marked distention	None	—	—
96	♂	+	----	----	----	----	+	+	Phimosis; conjunctivitis catarrhalis.	R	Good	Normal	Slight distention	do	—	—

TABLE 12.—*Findings in children more than 3 and not over 4 years.*

[R, recovered; I, improved; O, vomited or passed *Ascaris* before admission; H, vomited or passed *Ascaris* in hospital.]

Cases.	Sex.	*Spirochæta.*	"Blastocystis."	*Trichomonas.*	*Giardia.*	*Trichuris.*	*Ascaris.*	Hookworm.	Clinical diagnosis.	Termination.	Physical development.	Mental development.	Abdominal symptoms.	Nervous symptoms.	Vomited worms.	Passed worms.
23	♀	+	----	----	----	+	----	+	Lobar pneumonia	I	Fair	Normal	None	None	—	—
31	♀	+	----	----	----	+	----	----	Acute bronchitis	R	Good	do	Occasional pain and distention.	do	—	—
37	♀	+	----	----	----	----	+	----	Malaria	I	Fair	do	Occasional pain; splenomegaly.	do	—	—
39	♀	----	----	----	----	+	+	----	Bronchitis; ascariasis.	I	do	do	Pain and distention	Drowsy	—	O
41	♂	+	----	----	----	+	----	----	Tonsillitis	R	Good	do	Occasional pain	None	—	—
48	♂	+	+	+	----	+	+	----	Tuberculosis; bronchopneumonia; ascariasis.	I	Poor	Will not answer questions.	Frequent pain and twitching of body.	Dull to restless at times.	H	OH
61	♀	----	+	----	----	----	----	----	Paresis of upper and lower extremities.	I	Fair	Normal	Occasional pain	None	—	—
66	♂	+	----	----	+	+	----	----	Alveolar abscess	I	Good	do	Distention; occasional pain causing loss of sleep.	Wakes up and screams at night.	—	—
69	♀	+	----	----	----	+	+	----	Ascariasis	I	Fair	Normal, but does not play.	Distention and pain	Irritable. Trembles when frightened.	—	H
70	♂	+	+	----	+	+	+	----	Chorea	I	Fair development but nutrition poor.	Normal	Frequent pain and distention.	Fits of drowsiness; restless at times; insomia.	—	H
90	♂	+	----	----	----	+	+	----	Lobar pneumonia	R	Good	do	Frequent pain, relieved on passage of worms.	None	—	O

TABLE 13.—*Findings in children more than 4 and not over 5 years.*

[R, recovered; I, improved; U, unimproved; O, vomited or passed *Ascaris* before admission; H, vomited or passed *Ascaris* in hospital.]

Case.	Sex.	*Spirochæta.*	"Blastocystis."	*Entamœba coli.*	*Chilomastix.*	*Trichuris.*	*Ascaris.*	Clinical diagnosis.	Termination.	Physical development.	Mental development.	Abdominal symptoms.	Nervous symptoms.	Vomited worms.	Passed worms.
1	♀	+	+	+	----	+	----	Ileocolitis; œdema.	I	Fair	Does not talk. Too quiet in bed. Will not answer questions.	Ascites	Dull	—	—
10	♂	----	----	----	----	+	----	Ileocolitis	I	do	Normal	Occasional pain	do	—	—
19	♂	+	+	----	----	+	----	do	R	Good	do	None	None	—	—
21	♀	+	+	----	----	----	----	do	R	do	do	do	do	—	O
27	♀	+	----	+	+	+	+	{Ileocolitis Mitral insufficiency	R I }	Fair	do	Pain and distention	do	—	—
30	♀	+	----	+	----	+	----	Ileocolitis; secondary nephritis; œdema.	U	do	Too quiet	Has twice passed *Ascaris* since 2 years old.	do	—	O
50	♀	----	----	----	----	+	+	Ileocolitis	R	Good	Normal	None	do	—	—
58	♀	+	----	----	----	+	+	Lobar pneumonia	R	Fair	do	Ocasional pain	do	—	—
73	♀	+	----	----	----	+	+	Bronchitis; ascariasis	I	Good	do	Frequent pain relieved by passage of worms.	do	O	OH
81	♂	----	----	----	----	+	+	Ascariasis	R	Good, but thin and pale.	do	Patient was writhing with pain on admission.	do	—	H
97	♂	----	----	----	----	+	----	Ileocolitis	I	Good	do	Occasional pain, relieved by passage of worms.	Once fainted 6 months ago; sweats; loss of activity and appetite.	—	O

TABLE 14.—*Findings in children more than 5 and not over 6 years.*

[R, recovered; I, improved; O, vomited or passed *Ascaris* before admission; H, vomited or passed *Ascaris* in hospital.]

Case.	Sex.	*Spirochæta.*	"Blastocystis."	*Endolimax nana.*	*Giardia.*	*Chilomastix.*	*Trichuris.*	*Ascaris.*	Clinical diagnosis.	Termination.	Physical development.	Mental development.	Abdominal symptoms.	Nervous symptoms.	Vomited worms.	Passed worms.
8	♀	+	+	+	----	+	+	+	Malaria	I	Fair	Normal	Occasional pain relieved by vomiting worms.	Excitable	O	—
29	♂	+	----	----	----	----	+	----	Indigestion; ascariasis.	I	Rather poor	do	Distention and occasional pain with fever, relieved by passage of worms.	None	—	OH
33	♂	+	+	+		----	+	+	Malaria	I	Fair, but anæmic	do	Occasional pain	do	—	—
55	♂	+	----	----	+	----	----	+	Empyema	R	Fair	do	Occasional pain, relieved by passage of worms.	do	—	O
85	♀	+	+	+	----	----	+	+	Lobar pneumonia	R	Good	do	Distention and severe pain, relieved by passage of worms.	Very irritable	—	O
93	♂	+	----	----	----	----	+	+	do	R	do	do	Attacks of severe pain with vomiting and passage of worms.	None	O	O

TABLE 15.—*Findings in children more than 6 and not over 7 years.*

[R, recovered; I, improved; U, unimproved; D, died; O, vomited or passed *Ascaris* before admission.]

Case.	Sex.	*Spirochæta.*	"Blastocystis."	*Entamœba coli.*	*Trichomonas.*	*Giardia.*	*Trichuris.*	*Ascaris.*	Hookworm.	Clinical diagnosis.	Termination.	Physical development.	Mental development.	Abdominal symptoms.	Nervous symptoms.	Vomited worms.	Passed worms.
12	♂				+					Tuberculosis Severe ileocolitis	U I	Poor	Answers questions slowly; dull and indifferent to surroundings.	Pain referable to ileocolitis.	None	—	—
14	♂		+	+		+	+			Ileocolitis	I	Well developed; poorly nourished.	Slow in answering questions; dull.	Occasional pain, distention, and tympanitis, with vomiting and passage of worms.	do	O	O
22	♀						+	+	+	Tuberculosis; pleurisy with effusion.	D	Poor; cannot stand	Normal, but dull at times.	Diarrhœal stools with passage of worms.	do	—	O
47	♀	+					+	+		Ileocolitis	R	Good	Normal	Occasional pain	do	—	—
79	♀	+	+				+	+	+	Influenza	R	do	do	Occasional pain relieved by passage of worms.	do	—	O
80	♀	+					+	+		Tuberculosis; bronchopneumonia.	U	Bad	do	Occasional pain	do	—	—
86	♂	+	+		+			+		Typhoid fever	I	Fair	do	Referable to the typhoid.	do	—	—
92	♂	+	+				+	+	+	Lobar pneumonia	R	Good	do	Frequent pain relieved by passage of worms.	do	—	O

TABLE 16.—*Findings in children more than 7 and not over 8 years.*

[R, recovered; I, improved; U, unimproved; D, died; O, vomited or passed *Ascaris* before admission; H, vomited or passed *Ascaris* in hospital.]

Case.	Sex.	*Spirochæta.*	"Blastocystis."	*Endolimax nana.*	*Dientamæba.*	*Trichomonas.*	*Giardia.*	"I Cysts."	*Trichuris.*	*Ascaris.*	Hookworm.	Clinical diagnosis.	Termination.	Physical development.	Mental development.	Abdominal symptoms.	Nervous symptoms.	Vomited worms.	Passed worms.
7	♀		+	+			+		+	+		Lobar pneumonia	U	Poor	Normal	None	None	—	—
18	♂		+		+				+			Post-infective psychosis; ascariasis.	R	Fair	Talks incoherently; shouts at times; does not recognize mother; formerly was normal.	Pain 4 days before admission, relieved by vomiting *Ascaris.*	See mental symptoms.	O.	—
34	♂					+			+		+	Typhoid fever	R	do	Normal	Frequent pain with vomiting of *Ascaris.*	None	H	—
36	♂	+	+			+	+		+			Tuberculosis	I	do	do	Occasional pain with passage of *Ascaris.*	Very irritable	—	O
40	♀	+	+					+	+	+		Typhoid fever; parotitis.	R	do	Dull and indifferent.	Distention, tympanitis and occasional pain.	None	—	—
82	♂		+		+		+		+	+		Cerebral abscess; suppurative meningitis.	D	do	Normal	Occasional pain	do	—	—
98	♀	+							+	+		Ileocolitis	I	do	do	do	Irritable	H	—

TABLE 17.—*Findings in children more than 8 and not over 9 years.*

[R, recovered; I, improved.]

Case.	Sex.	*Spirochæta.*	"Blastocystis."	*Entamœba coli.*	*Trichomonas.*	"I Cysts."	*Trichuris.*	*Ascaris.*	Hookworm.	Clinical diagnosis.	Termination.	Physical development.	Mental development.	Abdominal symptoms.	Nervous symptoms.	Vomited worms.	Passed worms.
25	♂	+	----	----	----	----	+	----	+	Malaria	I	Fair	Normal	Chronic constipation	None	—	—
53	♂	+	+	+	+	+	+	----	+	do	I	do	do	Constant feeling of heaviness; no actual pain.	do	—	—
77	♀	+	----	----	----	----	+	+	+	Lobar pneumonia	R	Good	do	Occasional pain	do	—	—

TABLE 18.—*Findings in children more than 9 and not over 10 years.*

[R, recovered; I, improved; U, unimproved; D, died; O, vomited or passed *Ascaris* before admission; H, vomited or passed *Ascaris* in hospital.]

Case.	Sex.	*Spirochæta.*	"Blastocystis."	*Trichomonas.*	*Giardia.*	*Eutrichomastix* (?)	*Trichuris.*	*Ascaris.*	Hookworm.	Clinical diagnosis.	Termination.	Physical development.	Mental development.	Abdominal symptoms.	Nervous symptoms.	Vomited worms.	Passed worms.
9	♀	----	+	----	----	+	+	+	+	Ileocolitis; eczema; ascariasis.	R	Fair, but pale and anæmic.	Normal	Occasional pain with passage of worms.	None	—	O
15	♀	+	----	+	----	----	+	+	----	Ascariasis	I	Fairly developed, but emaciated and anæmic; has had fainting fits.	do	Severe pain accompanied by distention and vomiting of worms.	do	H	—
54	♂	----	----	----	----	----	+	+	----	Typhoid fever; parotitis; conjunctivitis.	D	Fair	do	None	do	—	—
65	♀	+	+	----	----	----	+	+	+	Epilepsy; occasional convulsions.	U	Good; teeth irregularly developed; posterior part of head flat.	Feeble-minded; melancholic; does not answer questions intelligently; grimaces.	do	do	—	—
84	♂	+	----	----	+	----	----	----	----	Infected wound of foot; tetanus.	R	Good	Good	Occasional pain and diarrhœa.	do	—	—

TABLE 19.—*Findings in children more than 10 and not over 11 years.*

[R, recovered; U, unimproved.]

Case.	Sex.	*Spirochæta.*	"Blastocystis"	*Entamœba coli.*	*Endolimax nana.*	*Dientamœba.*	*Trichuris.*	*Ascaris.*	*Oxyuris.*	Clinical diagnosis.	Termination.	Physical development.	Mental development.	Abdominal symptoms.	Nervous symptoms.	Vomited worms.	Passed worms.
28	♀	----	+	+	----	----	+	----	----	{Pleurisy with effusion. / Mitral insufficiency.}	R / U	Fair	Normal	None	None	—	—
45	♂	+	----	----	+	+	+	+	+	Typhoid fever	R	Good	do	do	do	—	—
68	♀	+	+	----	----	----	+	+	----	Influenza	R	do	do	Occasional pain and fullness in epigastrium.	do	—	—

TABLE 20.—*Findings in children more than 11 and not over 12 years.*

[R, recovered; I, improved; O, vomited or passed *Ascaris* before admission; H, vomited or passed *Ascaris* in hospital.]

Case.	Sex.	*Spirochæta.*	"Blastocystis."	*Endolimax nana.*	*Trichuris.*	*Ascaris.*	Hookworm.	Clinical diagnosis.	Termination.	Physical development.	Mental development.	Abdominal symptoms.	Nervous symptoms.	Vomited worms.	Passed worms.
6	♂	----	+	----	+	+	----	Ascariasis	I	Fair	Normal	Frequent, acute pain with vomiting and passage of worms; this occurs about twice a month, worms being vomited each time.	Easily excited; timid.	OH	OH
17	♀	+	+	----	+	+	----	Influenza	R	do	do	None	do	—	—
94	♂	+	+	+	+	+	----	Tuberculosis	I	Fair but anæmic	do	Occasional pain; severe at times	do	—	—
95	♀	+	+	----	+	+	+	Influenza	R	Good	do	None	do	—	—

TABLE 21.—*Findings in children more than 12 and not over 13 years.*

[R, recovered; I, improved; O, passed *Ascaris* before admission.]

Case.	Sex.	*Spirochæta.*	"Blastocystis."	*Trichomonas.*	*Trichuris.*	*Ascaris.*	Hookworm.	Clinical diagnosis.	Termination.	Physical development.	Mental development.	Abdominal symptoms.	Nervous symptoms.	Vomited worms.	Passed worms.
4	♂	+	----	----	+	----	----	Beriberi	R	Good	Normal	Occasional epigastric pain with no relation to meals.	Occasional dizziness.	—	—
24	♂	----	----	----	+	+	----	Tuberculosis	I	Poor	do	No pain, but patient occasionally passes worms.	None	—	O
26	♀	+	+	+	----	----	+	Hysteria; ancylostomiasis; ascariasis.	I	Small and undeveloped, no signs of puberty; pale and jaundiced.	do	Persistent pain in upper abdomen, of 5 years duration.	Sentimental to melancholic.	—	—

From the foregoing data it will be seen that breast and artificial feeding do not necessarily confer freedom from parasitism. It appears to us that they somewhat reduce the chances of infection. Two children (Nos. 35 and 76) aged 16 and 13 months, respectively, had been breast-fed since birth and, so far as the laboratory findings and history showed, had escaped infection with protozoa or helminths although both were infected with spirochætes. One gains the impression that trouble starts with the beginning of artificial or bottle feeding. We shall discuss the factors involved later on.

The group shown in Table 10 comprised nineteen cases, of which eleven were boys and eight were girls. Ten of the boys and four of the girls were found to be infested with one or more parasites.

The foregoing tables are more or less informative from a certain viewpoint, and the reader gains the general impression that infestation with intestinal parasites is accompanied, in a large proportion of cases, by certain phenomena. General impressions of this nature, however, are not particularly satisfactory as a basis for diagnosis or treatment. The reader cannot fail to notice the rather striking similarity in the picture presented by individual and collective infestations with the helminths, but he will seek in vain for any manifestation that will point unerringly to infection with any particular species. This is trite but none the less true. Variations in the severity of symptoms in practically similar combinations of parasites can, in many instances, be accounted for by differences in the intensity of infection; but this does not furnish an explanation in every case.

For the most part, effects upon the mental development and the nervous system seem not to be especially marked, but allowance must be made for the methods of estimating these that circumstances forced us to adopt. It is not unlikely that more exact methods would yield different results. The abdominal symptoms are, however, more suggestive and, in many instances, are rather striking. In as much as these findings are capable of interpretation from several different viewpoints, our inclination is to let the reader study the records and make his own interpretations, bearing in mind that only Filipino children are involved. Nevertheless, several points of general interest occur to us that it seems worth while to discuss.

INFECTIONS WITH PROTOZOA AND PARASITES OTHER THAN HELMINTHS

Spirochæta eurygyrata.—This parasite was first reported from the Philippine Islands by Crowell and Haughwout,(12) who found it in 73 per cent of a series of adult Filipino patients studied in the Philippine General Hospital. In the present series, it was detected in 61 per cent of the cases, the earliest infection having been found in a boy 7 months old. Spirochætes occurred to the exclusion of all other parasites in eight cases, none of them more than 2 years of age. Study of these cases as presented to us failed to yield any evidence on which to base an opinion regarding their harmfulness. We have noticed, however, that the spirochætes seem to flourish exceedingly in the fæces of patients suffering from bacillary dysentery or cholera. In such stools they are frequently present in enormous numbers, often appearing in tangled masses or agglomerations. We have in mind one particularly striking case of a male child, 5 years old, admitted with bronchopneumonia and showing meningitic symptoms and marked abdominal distention. Fresh preparations of the fæces were literally alive with spirochætes from 10 μ to 15 μ in length. Preparations kept in the moist chamber still showed actively motile spirochætes at the end of twenty-four hours. On the night following admission, the child had several convulsions and died in one of them. The case was looked upon with suspicion at the time, and autopsy and bacteriological examination showed the child to have died of Asiatic cholera. This case is not included in our series, however, for the reason that only one examination of its fæces was made. Several severe cases of ileocolitis showed the same luxuriant growth of spirochætes.

This parasite is of wide geographical distribution and frequent occurrence, and the tendency has been to regard it as nonpathogenic. Some writers, however, regard it with suspicion. Nevertheless, we believe that in some instances it may behave in a manner similar to that attributed to certain of the flagellated protozoa. Fantham(17) has described the penetration of shed epithelial cells from the intestinal wall by this spirochæte, adding that in this position the spirochætes sometimes produce their resting coccoid bodies. If this really occurs, there is ground for the belief that under certain conditions the spirochætes may penetrate the epithelial cells in situ and incidentally do damage to the mucous membrane.

Crowell and Haughwout have suggested that *Spirochæta* *eurygyrata* may be a factor in a certain type of rebellious entamœbic dysentery which, while especially resistant to ipecacuanha and its derivatives, frequently yields to treatment with salvarsan.

"Blastocystis."—We include this organism in our report with some hesitation because of the lack of definite knowledge concerning its nature and significance. In as much, however, as neither has been determined, we thought it wise to make a record of our findings as a basis of comparison in future work. We encountered "Blastocystis" in thirty-four cases, but it occurred as an exclusive parasite in only one case. Stained preparations of these bodies were studied in every case to differentiate them from the "Iodine Cysts" of Wenyon and others, now regarded by Kofoid, Kornhauser, and Swezy(35) as the cysts of a large race of *Endamœba nana* (*Endolimax nana*), and the aberrant forms sometimes assumed by some of the other intestinal amœbæ of man. In view of the findings of Kofoid, Kornhauser, and Swezy in their excellent study of the "Iodine Cysts," we perhaps should have carried over our two cases of "I Cyst" infection to the *Endolimax nana* column. However, we satisfied ourselves beyond a reasonable doubt that none of the bodies we have classified under "Blastocystis" represent encysted stages or aberrant forms of any of the intestinal amœbæ, and there we leave them.

Entamœba histolytica.—No case of infection with this parasite was discovered in our series, and this we are inclined to regard as possibly of great significance. Another interesting thing was our failure to observe Charcot-Leyden crystals in more than one case. We observed them once only, in the fæces of a 12 year old girl whose stool was positive for "Blastocystis," *Spirochæta eurygyrata, Trichuris,* and hookworm. In view of the recent work of Acton(1) on Charcot-Leyden crystals in the fæces, we made a particularly thorough study of this case without, however, discovering either the cysts or trophozoites of *Entamœba histolytica.* Acton has shown that there is a very high degree of association between these crystals and *Entamœba histolytica,* and he lays considerable stress on them in connection with the laboratory diagnosis of entamœbiasis; for they are, according to his figures, rarely found in other infections. Castellani has reported them as occurring in ancylostomiasis, and it should be noted that our case was infected with hookworm. The crystals found in this case were of the shorter type that Acton designates as characteristic of chronic and carrier cases, and it may be that this case was a carrier. Acton states that the crystals may persist in the stools for some time following treatment when the encysted amœbæ have disappeared. Inquiry into the history of this case, however, failed to develop any evidence of dysentery, which, nevertheless, does not necessarily establish a clean bill of health for the child.

Matthews and Smith,(40) in their recent paper, have shown a rather low incidence of *Entamœba histolytica* infection in five hundred forty-eight Liverpool children, only 1.8 per cent of whom were infected with the organism. They found 11.1 per cent infected with *Entamœba coli* as against 7 per cent in our series, and 2.7 per cent *Endolimax nana* infections as contrasted with our 7 per cent. Yorke(56) in a study of autochthonous entamœbic infections in England and Wales, examined the stools of two hundred forty-six children under 12 years of age. Cysts of *Entamœba histolytica* were found in only 0.8 per cent, and cysts of *E. coli* in 10 per cent of the subjects. Out of fifty cases of colitis of various types found by Mendoza-Guazon(43) in her post-mortem studies of one thousand Filipino children under 5 years of age, only one was of the amœbic type.

Recently the incidence of bacillary dysentery in Manila has considerably overshadowed entamœbiasis as judged by the cases that have come under our observation; nevertheless, entamœbiasis is of frequent occurrence among adults of all races, and there is no reasonable doubt that the opportunities for infection with this organism are as good in the case of children as they are with adults. There would seem to be ground for the belief that the obligatory tissue parasites among the protozoa, such as *Entamœba histolytica* and *Balantidium coli*, for some reason or other, find the conditions in the juvenile intestinal tract unsuitable and rarely succeed in establishing themselves there. This is a matter that we believe should be given the most careful study—first of all to determine if such is actually the case and, if so, why. We hesitate to believe that the intestinal mucosa of the child affords a more effective mechanical barrier than that of the adult. It certainly does not seem to in the case of the helminths. We venture to suggest that the key may be found in the physiology of the child—possibly in the secretion of some endocrinal gland that functions with greater activity in childhood than it does after adolescence and which may, in some way, exert an inhibitory influence on the growth and development of certain tissue-dwelling organisms.

It is suggested that the solution of this question may lead to a new line of therapeutic attack in the treatment of entamœbiasis in adults.

Entamœba coli.—As has been said, this parasite was found in 7 per cent of our cases, appearing for the first time between the ages of 2 and 3 years. The infections for the most part were rather light and do not seem to merit discussion here.

Endolimax nana.—This parasite likewise yielded 7 per cent infections in the series. It appeared in one case between the first and second year, but other cases were not encountered until the sixth year.

This parasite was first observed by the senior author in the fæces of a colleague in 1914. At that time he referred it provisionally to the genus *Vahlkampfia* and regarded it as a free-living species that had strayed from its accustomed path. The infection persisted, and the organism was given further study and compared with several other amœbæ parasitic in lower animals, having nuclei of the "limax" type. Before the study was completed Wenyon and O'Connor published their description of *Entamœba nana,* and pressure of other work necessitated the abandonment of the study. Since then he has observed this organism frequently in the stools of Americans and Europeans, but it is only recently that he has begun to find cases among the Filipinos. The apparent preference of *Endolimax nana* for white-skinned hosts was very puzzling until it developed that there was no descrimination on the part of the organism.

Dientamœba fragilis.—This organism, encountered in 3 per cent of our cases, did not put in an appearance until the eighth year. Once it was associated with *Endolimax nana.* This parasite was first seen by one of us (F. G. H.) in the fæces of an American woman residing in Manila, shortly after Jepps and Dobell(33) published their paper on *Dientamœba fragilis.* So far it has been found in Manila in five cases, one American and four Filipinos, two of them being adults.

Kofoid, Kornhauser, and Place(34) have recently reported this amœba in two cases. One case was that of a soldier on overseas service, and the other a soldier on home service in the United States. This extends the distribution of the parasite from England to the United States and through to the Philippine Islands. Jepps and Dobell's paper suggests that the distribution may be even wider than this. Probably *Dientamœba fragilis* has been mistaken for *Endolimax nana* in many instances.

Four species of flagellated protozoa, representing four genera of the Polymastigida, were encountered in our series.

Trichomonas intestinalis.—This was the most frequently encountered flagellate. It was first seen in a child between 1 and 2 years of age. Thereafter it was distributed fairly uniformly through the series. It occurred ten times.

All of the trichomonads we encountered are referable to this species, careful study having failed to discover either *Tetratrichomonas* or *Pentatrichomonas*. A case of infection with *Pentatrichomonas* in a Filipino child has recently been described by Haughwout and de Leon (28) in which large numbers of the organisms were seen to contain erythrocytes apparently in various stages of digestion. The stool examined in that case contained immense numbers of intact erythrocytes (the child was suffering from ileocolitis) that were greedily taken up by the flagellates. The authors were inclined to regard the ingestion of the red blood corpuscles as indicating a certain degree of adaptation to tissue parasitism. In view of this we examined our *Trichomonas* cases with especial care, but notwithstanding they occurred, in some cases, in stools containing free erythrocytes, in no instance did we find flagellates that had ingested corpuscles.

Yorke and Macfie (57) have recently published a note in which they describe the phagocytosis of erythrocytes by an amœba of the *Vahlkampfia* or "Limax" type which they obtained from human fæces. In so doing they cast a doubt on the validity of the conclusions of Wenyon and O'Connor that the presence of phagocytized erythrocytes is diagnostic of *Entamœba histolytica*. It must be admitted that the experiments of Wenyon and O'Connor on *Entamœba histolytica* and *Entamœba coli* were scarcely extensive enough to justify sweeping generalizations, but we incline to the opinion that while the ingestion of erythrocytes by different organisms is interesting and suggestive, still, it is important to discover whether or not the corpuscles are *digested*.

Marty [4] has described a case from the Congo the fæces of which contained spirochætes, *Giardia*, and amœbæ, some of which contained red corpuscles and some of which did not. The case was treated with subcutaneous injections of emetine, and according to Marty the amœbæ that did not contain red corpuscles, the spirochætes, and *Giardia* were unaffected, whereas the amœbæ that contained erythrocytes disappeared. This

[4] Bull. Soc. path. exot. 10 (1917) 539.

brings recollection of the statement of Escomel[5] who concluded that *Entamœba histolytica* will not engorge the red corpuscles of a person taking emetine, but will readily engorge those of a normal person. He gathered from this that emetine renders the erythrocytes unpalatable to *Entamœba histolytica.* This is scarcely more convincing than the other observations cited. Nevertheless, we believe that further work is needed to establish or disprove the diagnostic value of ingested corpuscles in the entamœbæ. For the present we shall continue to lay due stress on the presence of ingested corpuscles in the cytoplasm of intestinal amœbæ. In connection with the trichomonads observed in this series we may say that we frequently encountered individuals that had engorged bacteria, a thing that was not observed by Haughwout and de Leon in their pentatrichomonads.

The trichomonad infections seen in this series gave us no evidence of the pathogenicity of the organism, either microscopically or clinically. The flagellate occurred to the exclusion of other parasites only once. This was the case of a boy between 6 and 7 years of age (No. 12), who was suffering from ileocolitis and tuberculosis. While the symptoms may have been wholly referable to the ileocolitis, it was noted that the abdominal pain, which was fairly constant, even when the stools were not being passed, was of extraordinary severity. The first stool that was examined was watery, feculent, and gave off a very foul odor. It was full of necrotic cellular débris and erythrocytes, and the flagellates were present literally in swarms. Notwithstanding the conditions for the ingestion of erythrocytes seemed ideal, no trichomonad was seen that contained a blood corpuscle. Many were seen that contained bacteria. This is in striking contrast to the observations of Haughwout and de Leon in the case of *Pentatrichomonas.*

The ileocolitis in this case ran a very stormy and protracted course but eventually terminated in recovery. Were it not for the complicating tuberculosis and the poor general condition of the patient as a whole, we should be inclined to lay considerable stress on the superimposed flagellate infection on the dysentery, especially in view of the protracted course of the disease.

Giardia intestinalis.—This organism first appeared in the stool of a child between the third and fourth years. Only one of the eight cases found produced the flagellated trophozoites

[5] Bull. Soc. path. exot. 8 (1915) 573.

in the stools. Diagnosis of the other cases was made by means of the cysts. Considerable variation was noted in the size of the cysts in some of the cases, which suggests that there may be two or three local strains or races—possibly with varying degrees of virulence. Our figures of incidence are lower than those of Liverpool children as recorded by Matthews and Smith,(40) who found 16.4 per cent in children between 1 and 5 years of age, and 14.3 per cent in children 5 to 12 years old.

The case in which the *Giardia* trophozoites appeared in the stools was of some interest. It was presented by a boy 7 years old who had been suffering from a severe and protracted attack of ileocolitis. Previous to its onset he had vomited ascarids. The stool was examined for the first time on August 21. It was soft and yellow, and beyond the presence of the ova of *Trichuris* nothing especially noteworthy was seen. Concentration of this stool showed a heavy infestation with *Trichuris* and nothing more. The same observations were made when the stool was again examined on August 23.

On August 26, however, the stool was diarrhœal, and large numbers of *Giardia* trophozoites and cysts were present. Something apparently had happened to the flagellated forms for they were practically nonmotile, and those that showed any signs of life were sluggish and moved about as if they were waterlogged. "Blastocysts" were found in considerable numbers; also *Entamœba coli,* some of which had engulfed small "blastocysts." The following day both the trophozoites and cysts of *Giardia* were absent from the stool and they did not appear again during the time the child was under observation. This child was heavily parasitized with both protozoa and helminths; and it is, of course, impossible to fasten the blame for persistent abdominal pain, before the onset of the dysentery, on any particular one of them. We are inclined to believe that the pain, which was complicated at times by distention and tympanism, was stirred up by the *Trichuris* infection.

Case 84, a boy 10 years of age, gave a history that might be referred to *Giardia.* The child came into the hospital suffering from tetanus and an infected wound of the right foot. He received antitetanus serum and recovered. The stools were markedly diarrhœal and contained *Spirochæta eurygyrata* and cysts of *Giardia.* The patient gave a history of occasional abdominal pain but had never passed or vomited worms. No helminth ova were found. The general physical and mental make-up of the child was good. The other cases in which *Giardia* were found were so parasitized with other organisms as to render it futile to speculate upon them.

We are inclined to regard this organism as potentially harmful, particularly in children. Much has been written concerning it; but we lay considerable stress on the views of Fantham and Porter,(18) who have studied it experimentally in animals as well as clinically in man. They conclude that the organism is pathogenic to man and is capable of producing diarrhœa that may be persistent or recurrent. They also state their belief that the virulence of the parasite varies.

Mantovani(38) takes a rather extreme view of the case, however, in reporting symptoms which even included ulceration of the rectum. His patients exhibited tenesmus and passed as many as thirty or forty stools a day. We have seen nothing of the kind in our experience, and we are inclined to attribute the tenesmus and ulceration about the rectum to something else, especially in view of the fact that *Giardia* is normally an inhabitant of the small intestine. The unencysted forms are seldom encountered so far down in the intestine as the rectum. We have seldom found unencysted forms in the fæces.

Eutrichomastrix sp. (?)—A single individual was found in the examination of fresh preparations in one of our cases. We failed to find others on repeated examination of the stool or the stained preparations.

This parasite was not discovered until the second stool was received in the laboratory. At first it was thought that the organism belonged to the trichomonad group, and it was carefully followed for upwards of half an hour to discover if it would ingest any of the erythrocytes that were present in large numbers in the stool. It did not. Gradually it became apparent that what at first had been regarded as an undulating membrane with its marginal flagellum was, in reality, a free flagellum of prodigious length directed downward and backward in heteromastigote style. Careful scrutiny showed that the organism possessed three anteriorly directed flagella and a posterior projection that we interpreted as an axostyle. We were unable to determine with certainty whether or not there was a cytostome.

We regard it as possible that this organism was identical with the flagellate described by Chatterjee(7) under the name *Trichomastix hominis*. However, there is room for some doubt here, and we wish to be understood as only provisionally placing this organism in the genus *Eutrichomastix*. This genus has been defined by Chalmers and Pekkola (6) as follows:

Eutrichomastix Kofoid and Swezy 1915.

Parasitic Tetramitidae with an axostyle and a cytostome, without thickened lips and with three anterior and one free trailing flagellum, but without an undulating membrane or contractile vacuole. *Type species: Eutrichomastix lacertae* (Blochmann 1884), found in the intestine of *Lacerta agilis.*

Chatterjee, in describing the organism seen by him, says that in some individuals "a small dark line is seen originating from the nucleus and ending in the posterior end." However, he states that neither cytostome nor any axostyle-like organ could be made out, and speaks of the rather close resemblance between his organism and Aragao's *Copromastix prowazeki.* (4)

Chatterjee's parasite was found in the stool of a dysenteric patient. No amœbæ were found in the stool. Our patient, a girl aged 10 years, was suffering from a mild ileocolitis from which she recovered. Her stools were fluid, feculent, and contained necrotic cell débris, cast-off epithelium, and erythrocytes. Other parasites present were "Blastocystis," *Trichuris, Ascaris,* and hookworm. Abdominal symptoms exhibited before the onset of the ileocolitis are probably attributable to the other parasites present.

In discussing the genus *Trichomastix,* in which Chatterjee, following Parisi, placed his organism in 1917, Chalmers and Pekkola, writing in 1918, point out that the name was preempted in 1878 by Vollenhoven for the hymenopteron *Trichomastix polita,* which, of course, supersedes Blochmann's designation for the protozoön in 1884. Raillet altered the spelling to "Trichomastyx" in 1893; but Chalmers and Pekkola consider the alteration insufficient, so they adopt the generic name *Eutrichomastix* proposed by Kofoid and Swezy in 1915, (36) though expressing a preference for their own name *Axomastix* as establishing a greater distinction between the hymenopteron and the protozoön.

Chilomastix mesnili.—Under the generic names *Tetramitus* and *Macrostoma,* this parasite has been reported several times in the Philippines. Apparently it does not occur with great frequence. Three cases were found in our series. In one the diagnosis was made from the free-swimming trophozoites, and in the other two the diagnosis was made by discovering the encysted forms on the stained preparations. It never occurred as an exclusive parasite. Its earliest appearance was between the second and third years.

No sporozoan or ciliated forms were encountered in the series.

HELMINTHAL INFECTIONS

The infestations here were exclusively confined to the Nematoda, not a single case of infection with either the Cestoda or the Trematoda having been discovered. This is probably attributable, in a large degree, to the small number of cases that form this series, for nearly all the workers in the past who have conducted inquiries into the incidence of intestinal parasites in the Philippines and who have dealt with larger numbers than we, have discovered representatives, in small numbers, of both groups. *Tænia solium* and *Tænia saginata,* as well as *Hymenolepis nana,* have been reported by various observers; and Mendoza-Guazon(42) has reported on the finding at autopsy of an infestation of a child with *Dipylidium caninum.* Garrison(22) and Hilario and Wharton(31) have reported cases of infestation with the trematode *Echinostoma ilocanum* in Filipinos from the northern provinces. Other trematode infections have been reported from the southern provinces. The occurrence of trematodes in Filipinos residing in the neighborhood of Manila would seem to be exceedingly rare. The senior author has encountered several cases of infection with *Schistosoma* and *Clonorchis* in Manila, but in each case the patient was either a Chinese or a Japanese who, without much doubt, had contracted the infection before coming to the Philippine Islands. He has never seen such a case in a Filipino.

Trichuris trichiura.—If our series is a criterion, and we believe that it is, this is the most prevalent animal parasite occurring in children in and about Manila. It was found in 69 per cent of our cases. Of these thirty-three were male and thirty-six female. This shows a slight preponderance of infections in girls over those occurring in boys, which is in accord with the previous findings of Garrison and Llamas,(23) Garrison,(21) Musgrave and Clegg,(45) and other investigators.

High as our figures are they are considerably under those reported by Garrison and Llamas in their examination, made in 1909, of one hundred fifty-eight children living in Manila in whom they found an incidence of *Trichuris* infection amounting to 92 per cent. These authors do not state the age incidence in their cases, so we are left in doubt in our efforts to make a comparison; but knowing as we do that some of the earlier workers laid little stress on the examination of breast-fed and very young children, assuming that they were unlikely to be infected, we think it possible that their study did not include children under 2 years of age as ours did. However, it will be seen, from a study of the data in connection with Tables 9 and 10, that breast-fed and bottle-fed children are not necessarily free from intestinal parasites. Furthermore, our series of one hundred children included twenty-eight who were not more than 2 years old, and on excluding them from our series we find an incidence among the remainder of 86.1 per cent, which is not far under the figure of Garrison and Llamas.

It is interesting, in this connection, to recall that Musgrave and Clegg encountered several *Trichuris* infections in breast-fed children, and they report on the case of a child 3 months old that was infected with this parasite.

While considering these figures it is also interesting to note that those of Garrison and Llamas for *Ascaris* are identical with ours (56 per cent), while they show 11 per cent hookworm incidence as compared with 12 per cent in our series.

In contrast to the above are the figures quoted by Willets(55) for *Trichuris* infections occurring among children residing on the tobacco plantations of the Cagayan Valley. Willets has tabulated the age incidence of these infections from children under 1 year old up to those between the ages of 10 and 14 years. No infections with *Trichuris* were discovered until the second year, when these parasites were encountered in 3.26 per cent of the children examined. The incidence reached its maximum between the seventh and ninth years with 8.8 per cent infections. Between the tenth and fourteenth years this had fallen to 7.68 per cent. Most of the infections he encountered were light. He attributes this low incidence to lack of introduction of *Trichuris* in great numbers to the haciendas and cites evidence in suport of this view.

Garcia,(20) in reporting on the intestinal parasites of ninety-eight children in the Southern Islands Hospital at Cebu, found *Trichuris* in 44.08 per cent of the cases. He qualifies his report, however, with the explanation that his figures probably represent the minimum for they are based on the examination of only "two or more cover-glass preparations."

Crowell and Hammack,(11) in a study of the intestinal parasites encountered in five hundred autopsies in Manila, found *Trichuris* in only 34 per cent of their subjects. They included adults and excluded children under 3 years of age, and their study did not include the microscopic examination of fæces.

In our series *Trichuris* occurred as the only helminth present in thirteen cases. Five of these gave no history of abdominal discomfort or pain; seven gave histories of abdominal pain, distention, or diarrhœa, or combinations of the three; and one gave a history of distention, tympanism, and vomiting. One of them gave a history of attacks of vertigo. Three of the thirteen cases were infested with *Trichuris* to the exclusion of all other parasites. The salient features of these cases were as follows:

Case 10. Under treatment for ileocolitis. Gave a history of occasional abdominal pain before the onset of the ileocolitis.

Case 56. Under treatment for acute bronchitis. The child was emaciated. It gave a past history of abdominal distention, tympanitis, and vomiting. It had suffered from nervous irritability and insomnia.

Case 97. Under treatment for ileocolitis. Had suffered in the past with occasional abdominal pain and had spontaneously passed *Ascaris* in the stool before admission to the hospital. The child had once fainted without apparent cause and for a long time had been subject to attacks of sweating. It had shown a progressive loss of appetite and a slowing down of its activities before the attack of ileocolitis. In the hospital the stool failed to show the ova of *Ascaris* or any parasite except *Trichuris*.

When this study was undertaken we planned to make total and differential blood counts and hæmoglobin estimations of all the cases, but pressure of other duties and other circumstances prevented us from carrying this out. We were able to make only a few differential counts—and those of one hundred cells only. Unfortunately the three cases noted above received no blood examination. This is greatly to be regretted, for they afforded the only material available to us for recording the eosinophilia in pure infections with *Trichuris*.

Five of the cases in which *Trichuris* was the sole helminth present were examined and yielded the following percentages of eosinophile leucocytes: No. 4, 9 per cent; No. 14, 4 per cent; No. 20, 2 per cent; No. 29, 3 per cent; No. 30, 2 per cent.

Thirteen cases of mixed *Trichuris* and *Ascaris* infections gave eosinophile counts ranging from 0 to 5 per cent.

One case of mixed *Trichuris* and hookworm infection gave 6 per cent eosinophiles.

Three cases of mixed *Trichuris, Ascaris*, and hookworm gave the following eosinophile percentages: No. 9, 4 per cent; No. 22, 3 per cent; No. 79, 0.

One case of uncomplicated hookworm infection gave an eosinophile count of 12 per cent, and one of *Ascaris*, a count of 2 per cent.

We do not wish to be understood as generalizing on the above data; but we would suggest, as have other investigators, that the whole subject of eosinophilia in its relation to parasitic infestations needs thorough reinvestigation at the hands of competent parasitologists and hæmatologists. We believe that entirely too much has been taken for granted regarding the eosinophile count.

Notwithstanding these particular observations, as included in our series, give us really very little *definite* basis for conclusions, we regard *Trichuris* as a parasite that is potentially harmful. In itself we regard it as dangerous, while we think our data show that its partnership with *Ascaris* constitutes a combination that is decidedly inimical to the comfort and welfare of children at least. While we are not entirely prepared to concur unqualifiedly in the views of Strong(51) who says that "the symptoms and sign of trichocephaliasis are practically identical with those of ankylostomiasis, the only difference being that of severity," still we believe his statement furnishes food for serious consideration. At the same time we must bear in mind that Strong was dealing with American children, while all our patients were Filipinos. This is a distinction that may be found to form the basis of the difference of opinion between Strong and ourselves. Strong cites five cases in which he contends that *Trichuris* "can give rise to very annoying and even severe symptoms such as severe anæmia, dirt eating, etc." He adds that eosinophilia is of constant occurrence and lymphadenopathy is fairly frequent just as in ankylostomiasis and ascariasis." [6]

[6] Apropos of Strong's statements is a case in which the senior author was consulted just as this paper was being written. It was presented by an American boy, 2 years old, anæmic and more or less emaciated. The child was nervously irritable and generally run down, and was about to be sent into the hills for recuperation. When the stool was first examined, it was impossible to apply the cover glass closely to the preparation on the slide because of an accumulation of grit and dirt contained in the fæces. The mother was questioned, and she said that it was practically impossible to prevent the child from eating dirt. She said that unless he was watched carefully he would take dirt from the flower pots on the porch and swallow quantities of it. Hookworm was, of course, suspected, but repeated concentration of the stool failed to yield the ova. There was, however, a massive infection with *Trichuris*, an infection with *Trichomonas*, and a few unfertilized *Ascaris* eggs were found in one of the centrifuged specimens. In the absence of any effective treatment for *Trichuris*, and in view of the poor physical condition of the patient, we bespeak a rather trying period in the life of this young man.

Da Matta(13) has reported two rather interesting cases of *Trichuris* infection in young children that were associated with fatal results. They were encountered in a study of helminthal infections in a large series of children at Manaos, during which he found an incidence of *Trichuris* infection amounting to 82.3 per cent.

The first case was in a child 4 years old, very pale and œdematous. The total erythrocyte count was 580,000; eosinophiles, 14.3 per cent. The hæmoglobin was 15 per cent. The stools showed numerous ova and abundant mucus. There was hyperalgesia of the skin—marked over the cæcum and colon. At autopsy two hundred ninety-five *Trichuris* were found in the colon.

The other case was that of a child 8 years old. At autopsy eleven *Trichuris* were found in the lumen of the appendix attached to the wall, while one hundred nine were collected from the cæcum.

Musgrave and Clegg,(45) in their paper on trichocephaliasis, report four cases, including two fatal cases, in which *Trichuris* seemed to play a rather important part. The blood pictures were particularly interesting, showing low erythrocyte counts and hæmoglobin percentages of 20 to 36. Eosinophilia was incompletely reported. In one case that went to autopsy, numerous *Trichuris* were found in the small intestine—mainly the ileum—and two hundred were found in the large intestine. In another case death was caused by an embolism of the left coronary artery caused by a *Trichuris*, the posterior third of which remained free in the aorta.

Musgrave and Clegg express doubts as to the commensal nature of *Trichuris* and suspect it to be pathogenic. Crowell and Hammack,(11) however, in their autopsy studies, report their failure to find tangible evidence of the pathological effects of *Trichuris*.

Ascaris lumbricoides.—As has been stated this parasite occurred in 56 per cent of our cases. Of these, twenty-four cases were found in boys, and thirty-two in girls. Garcia, in his Cebu series, found 42.85 per cent of the ninety-eight children he examined infected with *Ascaris*. Willets found that in Cagayan Valley the *Ascaris* infections in children ranged from 15 per cent in children under 1 year, up to 69.9 per cent between the ages of 10 and 14 years. Garrison's series of Bilibid Prison adults yielded only 26 per cent infections, but the group was composed of persons coming from many widely separated parts of the Archipelago and possibly gives a fair idea of the adult distribution of *Ascaris* in the Philippine Islands. It has been the general impression among microscopists in Manila that *Ascaris* occurs almost twice as frequently in children under 15 years of age as it does in adults in middle life.

In this series, at least, it is rather hard to consider *Ascaris* and *Trichuris* infections apart from one another. The two parasites occur together with great frequency, and their association seems to be accompanied by a fairly recognizable train of symptoms referable to the abdomen, such as pain, distention, tympanism, and frequently the vomiting and passage of *Ascaris* or both vomiting and passage of the worms.

This combination of parasites is one that may be expected to keep the greater portion of the entire intestinal tract in a state of chronic to acute irritation—mechanical as well as chemical. *Ascaris* lives in the small intestine, but it is a confirmed nomad—something of an explorer—and its wanderings frequently take it from end to end of the small intestine and occasionally into the stomach, the liver, and other places where it properly has no business. Not infrequently it rubs elbows with the hookworm. Such a condition may well be held to account for considerable trouble in the small intestine; when there is added to this the irritation produced in the large intestines by the presence of numerous *Trichuris* which may even invade the appendix, and in rare instances the ileum, it will be seen that the involvement of the digestive tract is fairly complete from end to end. It is in cases such as these that we frequently encounter more or less severe abdominal pain, distention, and either the vomiting or the passage, or both, of worms when no treatment whatever has been instituted to bring about the expulsion of the parasites. In connection with this it is interesting to review some of our *Ascaris* cases.

These two cases were infected with *Ascaris* to the exclusion of all other parasites: Case 43, male, 21 months old. The patient was under treatment for bronchopneumonia. He gave a history of occasional flatulence. Case 99, female, 2 years old. The patient was under treatment for indigestion. The child gave a history of having suffered from abdominal distention. Mentally, the girl was backward and did not talk. In both these cases it will be noted that the abdominal symptoms were decidedly mild.

The following cases, also, are rather interesting:

Twelve cases of *Ascaris* infection in which the patients gave no history of abdominal disturbances:

Unaccompanied by other helminths, 2.
Accompanied by *Trichuris*, 8.
Accompanied by *Trichuris* and hookworm, 2.

These five cases of *Ascaris* infection gave a history of tympanitis and distention:

Unaccompanied by other helminths, 3.
Accompanied by *Trichuris*, 2.

Abdominal pain was a prominent feature of the following twenty-five cases of *Ascaris* infection:

Unaccompanied by other helminths, 3.
Accompanied by *Trichuris*, 21.
Accompanied by *Trichuris* and hookworm, 1.

Abdominal discomfort or pain accompanied by the vomiting of *Ascaris* occurred in these eight cases:

Accompanied by *Trichuris*, 7.
Accompanied by *Trichuris* and hookworm, 1.

Abdominal discomfort or pain accompanied by the passage of *Ascaris* occurred in these thirteen cases:

Unaccompanied by other helminths, 1.
Accompanied by *Trichuris*, 8.
Accompanied by *Trichuris* and hookworm, 4.

In only one case in the last two groups did *Ascaris* occur to the exclusion of other helminths. Contrast these with cases 43 and 99. In other words, with an increase in the severity of the abdominal symptoms there seems to be a tendency toward a falling off of solitary infections with *Ascaris*. With this appears a corresponding rise of the association with *Trichuris* to the extent that one strongly suspects that the combination of pronounced abdominal symptoms and the spontaneous expulsion of *Ascaris* is frequently the expression of a coexisting infection with *Trichuris* and possibly attributable to it.

A clinical diagnosis of ascariasis was made by the admitting physician in several of our patients before the stools were examined. It is interesting to note that *every one of these cases,* twelve in number, *was positive for Trichuris as well as Ascaris.* These cases were numbered 6, 9, 15, 18, 20, 29, 39, 48, 60, 69, 72, and 81. Case 29 passed *Ascaris* in the stool before admission to the hospital, and its fæces were negative for the ova when examined by us.

Such data are, of course, only suggestive, but the cases are those that seemed to show symptoms sufficiently characteristic to justify the admitting physician in making a diagnosis of ascariasis without waiting for the laboratory report. In some cases there was a history of the passage or vomiting of worms before admisison, but not in all. Bearing on this are a few cases that came to our attention, where outside physicians had ordered heavy doses of santonin that had been administered without bringing about the expulsion of any worms, the explanation being very simple—there were no worms there to expel. These cases were all negative for the ova on examination by us. In proper hands, santonin is a safe drug, but we believe its administration for the purpose of making a therapeutic diagnosis of ascariasis should be discouraged. Except for those rare, almost theoretical, cases where male worms only might be present, it is exceedingly likely that a laboratory diagnosis could certainly be made in every case. Furthermore, we are growing to place less and less reliance on santonin in the treatment of ascariasis and recently one of us (F. S. H.) has undertaken a study of the action of oil of chenopodium in these infections with results that are, so far, quite satisfactory.

We observed twenty-five cases that gave a history of having vomited or passed, or passed and vomited, ascarids before admission to the hospital. None of these cases had received anthelminthic treatment, so the occurrence cannot be attributed to the action of santonin. All of these cases underwent our series of examinations, and eight of them were found to be negative for the ova of *Ascaris*. In other words it would appear that eight of the patients had purged themselves of their roundworm infections. We think it extremely likely, however, that they have contracted new infections of *Ascaris* since then.

Four of these cases vomited the worms. Of these, two were negative and two positive on microscopical examination.

Sixteen patients passed the worms, and of these, five were negative and four positive on microscopical examination.

Five patients both vomited and passed worms. On microscopical examination one was negative and four were positive.

In the hospital eight patients either vomited or passed worms. Of the four that vomited them, one was negative for the ova on microscopical examination, and one was found negative out of the four that passed ascarids. These are the two cases that were missed microscopically and diagnosed in the ward. Unfortunately, the worms were not saved by the nurse, hence we are unable to state that they were males in extenuation of our failure to diagnose the infections in the laboratory. We might add in connection with these eight cases that some of the patients had received santonin and calomel, so that the expulsion of worms cannot be said to have been spontaneous in all cases, as was the case with the others.

Ascaris, in recent years, has been steadily losing its reputation for harmlessness. Unfortunately, much of the evidence against it has been accumulated on the operating table and at autopsy. We now know it as a not infrequent cause of intestinal obstruction. Perforation of the intestine has been traced to it in some cases, and invasion of the bile ducts, the liver, and the appendix are not uncommon. More than one foreign physician we have known has received a shock during his early days in the Philippines by witnessing "vermiform movements" of an appendix he has been called upon to remove. Degorce(14) has recently reported the formation of calculi in the bile ducts about the eggs of *Ascaris.*

A new phase of the mischievous activities of *Ascaris* has recently been suggested as a result of the brilliant work of Stewart and others on the life history of this nematode. It would be out of place here to go into details regarding the complex, devious, and seemingly anomalous developmental cycle of this organism described by Stewart and apparently sustained by other workers. As we have said, *Ascaris* is a nomad and there seems at present no reason to doubt that in its larval stages *Ascaris* penetrates the intestinal wall, travels through the blood stream to the lung, remains there for a while, and ultimately regains the intestine via the trachea, mouth, and œsophagus.

The thing that interests us most at this time is the possibility that in its peregrinations the worm, small as it is in this stage of its development, may cause serious trouble en route. This is a problem that is worth the most careful investigation, but it is a problem that it seems to us will be extremely difficult to handle on anatomical grounds alone.

Several investigators have observed lung symptoms in experimental animals following the ingestion of developed *Ascaris* eggs and they are exceedingly suggestive. These observations, however, have not been confined to lower animals. Mosler(44) and Lutz(37) have reported the observation of symptoms referable to the lungs in human beings a few days after the ingestion of the eggs of *Ascaris.* Lutz's experiment is of particular interest. He administered ripe eggs of *Ascaris lumbricoides* to a woman aged 32 years following which the woman suffered an unusually severe bronchitis accompanied by a slight remittent fever.

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Pantin [7] reports an incidence of 100 per cent *Ascaris* infections in Kien Province, China. She describes a "wormy" cough that is not uncommon in the more heavily infected. She has noted, further, that bronchitis in children is cured by doses of santonin and aperients without the use of expectorants. If such a connection could be established it would appear to indicate that this was not due to the migration of the larvæ through the lungs, for it is scarcely to be expected that this treatment would be effective in the lung stages.

Ransom and Foster, (48) in an exceedingly readable paper written shortly before the untimely death of Foster, have summarized the present knowledge of the life history of *Ascaris*. In the course of this paper (p. 98), they say:

> * * * In addition to the likelihood that Ascaris infection will be found to be responsible for certain lung troubles in human beings, particularly in children, it is quite likely that Ascaris has something to do with many of the cases of lung disease in pigs. Large numbers of young pigs suffer and die from lung affections the causes of which have never been satisfactorily explained. The symptoms shown by the experimentally infected pigs at the time of the invasion of the lungs by the larvae are frequently exactly similar to those exhibited by pigs suffering from so-called "thumps," a popular name for a serious condition of very common occurrence among pigs, and it is accordingly not improbable that Ascaris is an important factor in the production of "thumps," especially when it is considered how very commonly Ascaris occurs as a parasite of pigs. Though we can not yet form a true estimate of the actual importance of Ascaris as a cause of lung disease it is evident that this parasite has capacities for harm not formerly suspected. Stewart's very interesting discovery of the migration of the larvae through the lungs has therefore not only added materially to our knowledge of the life history of Ascaris, but also by opening up a new line of investigation in pathology is likely to lead to a better understanding of the cause, prevention and treatment of certain diseases of the lungs.

Out of the one hundred children studied by us in this series, thirty-three were admitted to the hospital for treatment of diseases of the respiratory tract other than tuberculosis, influenza, or pleurisy. The distribution of these cases is shown in Table 22.

TABLE 22.—*Respiratory diseases in the series.*

	Cases.
Bronchitis	11
Bronchopneumonia	12
Lobar pneumonia	9
Asthma	1
Total	33

[7] Pantin, Mabel, Brit. Med. Journ. Sept. 14 (1918) 287.

This is rather a large proportion of diseases of a certain type to occur among the admissions to a general medical service, but it is a fair index of the prevalence of respiratory diseases among Filipino children. All are exceedingly prevalent, and tuberculosis is a veritable scourge in the country.

We encountered twelve cases of tuberculosis in our series. Six of these were diagnosed as tuberculosis of the peribronchial glands, and six as pulmonary tuberculosis. We do not wish, at this time, to be understood as attempting to explain tuberculosis in Filipino children as developing from early *Ascaris* infections; the time is not ripe for that. Mendoza-Guazon,(43) in her study of the autopsy findings in Filipino children under 5 years of age, reports bronchopneumonia in 18 per cent of her cases, and lobar pneumonia in 3.6 per cent. Her tuberculosis findings were 8 per cent. She calls attention to the fact, which Musgrave and Sison have indicated, that among the Filipinos "infection among children probably is much below that in adults, because many die before the first year of life and no doubt before tuberculosis has been contracted or has developed to a degree sufficient for recognition."

Mendoza-Guazon also draws attention to the views of Rothe(49) and Dunn,(16) who believe that the respiratory tract is the usual entrance of tubercular infection in children.

On the whole, however, it seems better not to carry pulmonary involvement in ascariasis beyond the pneumonias and bronchitis until we have more definite knowledge than we now have. Furthermore, discussion on the basis of the incidence of pulmonary diseases in children in the United States can scarcely be said to promise much along these lines until we have more reliable data regarding the incidence and distribution of ascariasis among the children of that country.

With all deference to the fallacy of concomitant variations, it would seem worth while seriously to inquire into the possible relationship between diseases of the respiratory tract and early infestation with *Ascaris* among Filipino children.

At the same time the situation presents interesting problems from the viewpoints of the parasitologist and the pathologist. Naturally, it occurs to the pathologist and clinician to inquire how many larvæ would be required to produce a definite, harmful reaction in the lungs. Apparently the lung stages of *Ascaris* do not exceed 2.5 millimeters in length. In other words they are exceedingly minute; but that, in itself, does not necessarily prove anything. The capacity of these larval forms to work injury in the lung would seem to us to depend upon one, or a combination, of three factors: 1, The number of infesting worms; 2, their physiology—that is to say, the character of the substances, if any, eliminated by them in the lung and the general nature of their life there; 3, foreign matter, such as bacteria from the intestinal tract possibly brought in by them. In the human host it will likely be somewhat difficult to ascertain these facts.

In the feeding experiments carried out on lower animals in which lung symptoms such as pneumonia were seen to accompany the migration of the larval forms through the lungs, large numbers of eggs were administered in nearly every case and the resulting infections were, of course, correspondingly heavy. Furthermore, while fatal pneumonia is a frequent concomitant of early *Ascaris* infection in pigs, it must be remembered that the feeding habits of pigs are of a nature such as necessarily to bring about exceedingly heavy infections with any organism whose portal of entry is the alimentary tract.

Do human beings acquire the massive single infections with *Ascaris* that attend the above circumstances? We are inclined to believe that they do not. It must be admitted that hundreds of ascarids have been found in the intestinal tracts of human beings in individual cases, but in these instances it seems to us that the total number represents the accumulation of many successive infections and not a single massive infection. Therefore, it is to be supposed that the number of larval forms passing through the human lung at any given time is probably insufficient to give rise to serious trouble there as a result of purely mechanical irritation or injury to the tissues. If the observations of those who have reported pulmonary symptoms in man in the course of an early *Ascaris* infection are to be relied upon, we probably must seek the cause of the trouble in some other factor, and therein would seem to lie the basis of some interesting work for the future.

This introduces, of course, the question of immunity in *Ascaris* infections. It is held by some writers that a degree of immunity develops following an initial infection. The experiments of Yoshida(58) in connection with this are inconclusive, but cast doubt on the proposition. Yoshida quotes Stewart who claims to have immunized a rat by one infection with *Ascaris* larvæ. In a series of observations now being carried on by one of us

(F. G. H.) evidence is accumulating to show that immunity in man is, at least, not invariable.

The physiology of *Ascaris* has been looked into by several investigators, and much has been brought out that may be interesting in connection with the foregoing. Schwartz,(50) who has recently made an investigation into the nature of certain hæmotoxic substances in *Ascaris*, has reviewed the work of some of the other investigators. Hall(26) quotes Garin as stating that the nematodes of the digestive tract live in all cases at the expense of the wall of the intestine and not on the food to be found in the lumen of the gut. *Oxyuris* and *Ascaris*, he says, live on epithelial cells, and *Ancylostoma* and *Trichuris* on blood. The nature of the attack on the tissues by hookworms, he states, is mechanical; that of *Trichuris* is chemical. Crowell and Hammack cite the case of Albert and Mendoza(3) where a toxic action was attributed to *Ascaris*. They also cite Flury(19) who experimented on *Ascaris* recovered from the intestine of the horse and the pig.[8]

Flury succeeded in demonstrating volatile aldehydes of fatty acids; free valerianic, butyric, and other acids; alcohols and esters in the body substances and excretions of his ascarids. He was led to the belief that irritation of the intestinal mucosa and the nervous and other clinical symptoms of ascariasis could be attributed to these substances.

Haughwout(27) cites Gibson who believes that *Ascaris* may produce an antivitamine or growth-inhibiting substance. He quotes Gibson as follows:

> The existence of an anti-vitamine or at least of growth inhibiting substances formed by ascarids is suggested by an observation which I made in connection with some milk feeding experiments with puppies. In a series of five young puppies fed on cows' milk growth stopped in four of the animals when 44 days old. Following the administration of an efficient vermifuge, there resulted the passage of many ascarids from the four dogs in which growth had ceased. Growth was immediately reëstablished.

By kind permission of Professor Gibson and his collaborator, Dr. Isabelo Concepcion, we reproduce the growth chart of the above-mentioned dogs (fig. 1).

[8] *Ascaris suum* or *A. suilla*, of the pig, is morphologically indistinguishable from *A. lumbricoides* of man, and these species are looked upon as identical by many helminthologists.

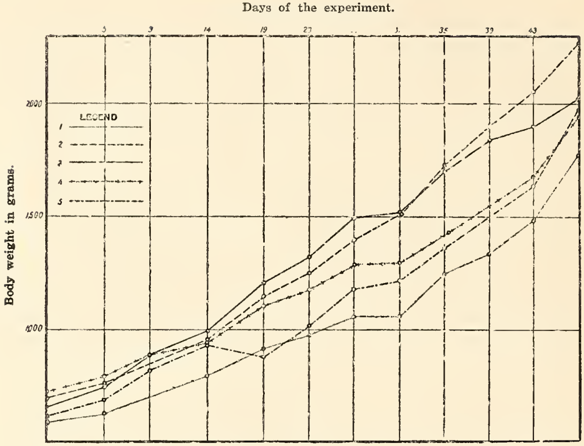

FIG. 1. Growth curves for dogs fed on fresh and autoclaved milk. Note the falling off of growth between the twenty-seventh and the thirty-first day. Note also that dog 2, which was not infected with *Ascaris*, continued to grow at about the normal rate.

The paper of Schwartz represents the most recent contribution to this subject that is accessible to us. Among the other conclusions he has drawn from his experiments are the following:

The failure to demonstrate hemolytic principles in the excretions of the worms when kept *in vitro* appears to favor the view that hemotoxic substances of ascaris partake of the nature of endotoxins. There is also to be considered the possibility that the death of a worm in the intestine may be followed by a rapid disintegration of its tissues and the liberation of toxic substances before it passes out of the body of the host. Tallquist, in fact, has shown that in the case of another parasite (*Dibothriocephalus latus*) that the toxic substances are liberated only when the worm disintegrates, which affords a possible explanation why Dibothriocephalus sometimes produces no ill effects on its host, whereas in other instances a severe anemia is present. The fact that in some cases human beings and other animals infested with ascarids remain in apparent good health while in other cases they show evidences of suffering from such infestation may perhaps be explained in much the same way as the differences observed in cases of infestation with Dibothriocephalus.

Further on Schwartz adds:

The above observations [evidence as to the mechanical attack of *Ascaris* upon the mucosa and the ingestion of blood], coupled with the presence of oxyhemoglobin in the worms, a substance which apparently is constantly being excreted by the parasites (to judge from their behavior *in vitro*) and which consequently must be as constantly renewed, appear to favor the view that Ascaris probably supplements its food intake by sucking blood from time to time * * *. In this connection it is interesting to observe that coincident with the disappearance of oxyhemoglobin from the worms *in vitro* they become sluggish, and that their existence after the complete elimination of this substance is very brief.

Schwartz's paper should be consulted by those who are interested in the details of the work that has led him to these conclusions.

We feel compelled to end our discussion of *Ascaris* at this point with the comment that another feature presented by the possibility of lung involvement in ascariasis will be the difficulty of diagnosis. Naturally, stool examinations in these early cases will prove nothing one way or another. This presents another problem to the laboratory man. From the foregoing data regarding the physico-chemical phenomena attending *Ascaris* infection it seems to be suggested that the reactions of the blood may prove to be a promising line of attack. It may develop that the differential blood count may show something characteristic during the lung stages of *Ascaris* development. Something may even be done with sero-diagnosis. Already something has been done along the latter line in helminthal infections, notably in precipitin reactions and complement deviation in echinococcus infection and the complement deviation in paragonomiasis. The work of J. G. Thomson(52) on the complement fixation in malaria is another instance of the promise of such work in connection with the animal parasites.

Hookworm.—Only twelve infections with hookworm occurred in this series. The parasite occurred alone in but one case. In four cases it appeared accompanied by *Trichuris*, while *Trichuris* and *Ascaris* were its companions in seven cases. Only one of these infections appeared in a child below 7 years of age. That was case 23, a girl 3 years old. Seven cases occurred in children residing in Manila, or 9 per cent of those living in the city who were in the series; and five cases, or 21.7 per cent, occurred in children from the provinces. That is to say, the incidence of hookworm infection was more than twice as high in provincial as it was in urban children. The probable reasons for this are so obvious as to make it unnecessary to discuss them here.

Both *Necator* and *Ancylostoma* are found in the Philippine Islands. Their incidence and the phenomena accompanying hookworm infection in general have been studied and reported upon by competent observers. There has been found to be not a little difference in the degree of incidence in various localities. These differences seem to be quite explainable on the basis of local conditions. For instance, in Cagayan Valley, Willets found an incidence of hookworm infection in children under 1 year of 5 per cent, with a steady increase with age until an incidence of 62.22 per cent is recorded by him for children between the ages of 10 and 14 years. This, Willets believes, is due to conditions in the tobacco fields that are peculiarly favorable to the development of the larvæ. We are inclined to suspect that a large proportion of the infections in children under 1 year and in children residing in the city of Manila are orally contracted. "Ground itch" is frequently reported in our out-door dispensary service, but we are reluctant at this time to attribute more than a small proportion of the cases to hookworm invasion. Garcia reports an incidence of 14.28 per cent in his series of Cebu children; Garrison and Llamas report 11 per cent in children. These figures group rather closely around our figure of 12 per cent.

The general impression in the Philippines among physicians and laboratory workers is that the hookworm is not nearly so dangerous a parasite to the Filipinos as it is to other people. We are not yet convinced of the entire truth of that impression; but, at the same time, we do not consider this series justifies us in arguing the point at present. Apparently the incidence of hookworm is greater in adults than it is in children. As an instance of this, one of us,(29) in a recent study of nine cases of dysentery in adult Filipinos, found the ova of *Ancylostoma duodenale* in six of them, which is in harmony with his routine observations.

Many of these infections are exceedingly light and are diagnosed only on centrifugation, while others are so heavy as to yield a diagnosis on direct examination of the fæces. We are quite willing to admit that in a large proportion of cases in children and adults the symptoms are exceedingly mild, but we have seen cases in Filipinos that in every way presented the picture characteristic of severe hookworm infection.

This modification of the symptoms in Filipinos has been explained in two ways. Gomez,(24) who made a clinical study of hookworm infection in the Philippines, doubts that it can be explained on the basis of racial immunity. He inclines to the belief that a prevailing lightness of infection is the determining factor. Other observers adopt the suggestion made by Stiles and others that racial immunity may exist. In this connection it is interesting to note the behavior of filarial infections in Filipinos. The parasite is very frequently found in some parts of the Southern Islands, but symptoms such as chyluria and elephantiasis are so rare as to attract considerable attention when they occur. Furthermore, in Filipinos as in many other Malayan peoples the larval forms show no diurnal periodicity, but usually may be detected in the blood throughout the twenty-four hours.

Perhaps the answer to these questions could be found were we able to turn back the pages of the Book of Time and discover when the Filipinos or their ultimate ancestors first became infected with nematodes. We are rather inclined to regard these strange phenomena as indicative of a high degree of adaptation between certain nematodes and that congeries of people spoken of as the Filipino people. In that event we should expect that the association of the hookworm, *Filaria*, and their Philippine hosts had dated back to very remote times. If it were possible approximately to fix the date of entrance into the Philippine Islands of the New World hookworm, we might derive some interesting data from a comparative study of the clinical manifestations accompanying infections with *Necator* and *Ancylostoma*.

It seems worth while to mention only one of our cases of hookworm infection, and we leave it to our readers to extract such information from our tables as may interest them.

This was the case of a girl (No. 26), 13 years old, from Batangas Province. Her stool was positive for "Blastocystis," *Spirochæta eurygyrata*, *Trichomonas*, and hookworm. When her fæces were first examined on August 27, hookworm ova were found in considerable numbers on the first fresh preparation that was made.

The clinical diagnosis was hysteria, ancylostomiasis, and ascariasis. We never discovered any evidence of *Ascaris* infection. The child was stunted as to growth and showed no signs of puberty. Mentally she seemed bright enough, but she was morbid and melancholic at times and when some little attention was shown her she, to use the expression of one of the physicians on the ward, became "very sentimental." After admission it was noted that the child, who complained of pain in the upper abdomen that had persisted for five years, was pale and jaundiced. The total erythrocyte count was 3,280,000, and the hæmoglobin 60 per cent. There were 12 per cent eosinophilic leucocytes. Polymorphonuclear neutrophiles numbered 59 per cent, lymphocytes 28 per cent, and large mononuclears 1 per cent. Roentgen-ray examination gave no evidence of gall-bladder trouble or peptic ulcer, and the fæces were negative for occult blood.

The patient suffered acute pain in the epigastrium of such severity that it was found necessary to administer morphine. Chenopodium treatment was started, but on September 19 the patient was still suffering severe pain notwithstanding that chenopodium had been given twice.

However, repeated concentration of the stools which by this time were dark and very hard in consistence, failed to reveal any more hookworm ova. The hysterical symptoms abated somewhat, but the pain in the abdomen continued to recur periodically, and the patient was eventually taken from the hospital by her relatives against our advice.

We cite this case as illustrating the possibilities of hookworm infection in Filipino children. We feel that it is unwise to be misled into a false sense of security by the stress that has been laid in the past on the apparent modification of hookworm symptoms in the Filipino. Aside from cases of this kind it seems worth while to repeat the statements of two of the earlier workers in the Philippines. Garrison (21) says:

> Whether or not the explanation of this apparent rarity of clinical symptoms in hookworm infection among the Filipinos is a racial immunity on the part of the people to the toxins secreted by the worms, * * * the fact that severe clinical manifestations of uncinariasis are rare in the Philippines materially alters the problem which is presented. Instead of producing an acute condition * * * it would appear that in the Philippines hookworm infections play a part more nearly resembling that of the other common intestinal worms to which no definite pathology or severe symptomatology is usually attributed.

Cole, (8) who studied the problem in native scout soldiers, regards the hookworm as a real menace in much the same sense as we regard it. He says:

> Everyone suffering from uncinariasis, although it may be mild, is more susceptible to other diseases and having contracted a complicating disease, is more severely attacked because of his weakened condition and also his period of illness is necessarily longer.

In closing our discussion of hookworm infection, and because it has a direct bearing on parasitism in young children, we wish to allude briefly to the statement of Howard, (32) who has reported the finding of hookworm ova in the fæces of a child 14 days old. The mother was infected and showed the usual symptoms of hookworm disease. She gave a history of ground-itch during pregnancy. Howard points out that if infected at the time of birth the infant could not show ova in the stool sooner than the end of the fourth week after its birth. Consequently, he reasons, ova found in the fæces before the end of the fourth week must result from prenatal infection. He reports cases he saw in Ceylon in 1916 in which "the apparent clinical manifestations were out of proportion to the degree of infection and the length of time these children could have had the disease had they acquired it in the usual way and post-natally."

In this connection it may be mentioned that a case of prenatal infection with bilharzia was recorded in Egypt in 1905.[9] This suggests an interesting line of inquiry in favorable localities such as Cagayan Valley, where the incidence of hookworm infection is high.

Oxyuris vermicularis.—This parasite was encountered once only in our series, through the discovery of one of the ova in a centrifuged specimen of the stool. Garrison and Llamas report it in 1.33 per cent of the children they examined, and Garcia in 0.17 per cent of his series of Cebu children. Other investigators have reported its occurrence in small numbers from various parts of the Philippines. We are of the opinion that it is slightly more common among the American children in Manila and the vicinity. Our case came from Cavite Province.

These figures apparently indicate that *Oxyuris* occurs infrequently in Filipino children. However, the methods of examination used in this series do not favor the detection of *Oxyuris* infections, and other means must be employed if the incidence of this parasite is to be determined. Dr. Luis Guerrero, of Manila, who has had a wide experience in treating parasitism in children assures us that *Oxyuris* is very frequently encountered not only in Filipino children, but in adults as well.

At the beginning of this study there were two points upon which we were especially anxious to secure information. They were included in the cases of dysentery and those suffering from disorders of the nervous system. At the conclusion of our work we find ourselves just as well informed as we were at the beginning and no better.

There is little to be found on study of our cases of ileocolitis that is suggestive of any immediate influence exerted by animal parasites on the course of ileocolitis in children. The only crumb of comfort is afforded by the fact that but one of the six cases that was free from helminthal infection died of the disease. It is left to the surmise of the reader just what influence, as regards the lowering of the vitality of the child before the onset of the disease, was exerted by protozoal and helminthal infections. We prefer not to touch upon it at this time.

The other point was suggested by the paper of Plantier (47) on spasmophilia and intoxication as factors in epilepsy. Plantier has stated that in eliminating the causes for spasmophilia in epilepsy it is wise not to be too hasty in ascribing it to heredity or diagnosing it as essential epilepsy. He states his belief that

[9] Trop. Dis. Bull. 12 (1918) 184.

a continuous abnormal excitation may be transmitted to the motor neurons from foreign bodies, sequestræ, calculi, *helminths,* and so forth. He believes this maintains a kind of tetanization of the hyperactive motor nerve cell of which the partial or complete epileptic seizure is the result. He adds that a superposed toxic action has a tendency to hasten or intensify this.

This looked promising, but unfortunately only one case of epilepsy occurred in the series. That was case 65, female, 10 years old, showing a marked flattening of the skull over the occipital region. Dr. Elias Domingo, of the department of psychiatry of San Lazaro Hospital, to whom the case was referred, gave it as his opinion that in addition to symptoms of marked mental deficiency the child was suffering from essential epilepsy. The child was infected with "Blastocystis," *Spirochæta eurygyrata, Trichuris, Ascaris,* and hookworm. It was necessary to transfer her to the psychiatric ward at San Lazaro, so we were unable to observe the effects of anthelminthic treatment on her.

Case 60 was admitted for chorea. She was infected with *Ascaris* and *Trichuris.* She seemed less restless after the administration of an effective dose of santonin, but she was discharged before we could observe any marked change in her condition.

DISCUSSION

The great factor with which to reckon here and the one that sets all schemes of sanitation agog is the total lack of appreciation by children, the world over, of the most elementary principles of sanitation and personal hygiene. In this respect the Filipino child is no better and no worse than the child of any other race. With him as with the others if there is an obscure and unlikely means of contracting infection with any given organism, he is exceedingly likely to find it. The fact that 100 per cent of a small group of children have been found to harbor parasites of one kind or another does not in the least constitute an indictment of the modern principles of hygiene and sanitation. It, however, calls for redoubled efforts to clean things up and keep them clean. More than that, it calls for the strengthening of the one weak link in the chain—a closer attention to household hygiene—a task of such formidable proportions in the Tropics and the Far East in general as to seem practically an impossibility.

One can picture the extent of the "clean-up" process that would be required to purge a community of *Trichuris* alone, a job that would make the hookworm campaign seem like child's play in some respects; for, to begin with, we have no treatment of proved efficacy against *Trichuris*, and the eggs of the organism will remain viable for *five* years. Nematode infections are probably more or less self-limited, and it is likely that in the lapse of time the original race would die out, a given host would be purged of his infection and everything would be serene for the patient. The eggs, however, may have five years to live. Furthermore, our observations over a period of years confirm us in the belief that the supply of worms in the intestine is kept pretty constant, and that reinfection with new and vigorous strains occurs with regrettable frequency. With the helminths we have met in this series, with the exception of *Oxyuris*, auto-infection fortunately does not have to be considered.

With the protozoa the proposition is a little different. The life cycles of the species inhabiting the intestinal tract are not perfectly known except that the question of intermediate hosts and exogenous development seem not to be regulating factors. Forms such as *Coccidium*, *Eimeria*, and *Isospora*, which, of course, did not occur in this series, require at least a number of hours for sporozoite development before they become infective, but their cysts are extraordinarily resistant to unfavorable environmental conditions—much more so than the cysts of the flagellates and intestinal amœbæ. Cysts of the latter are probably infective as soon as they leave the intestine, and it seems probable that in a large proportion of cases they represent rejuvenated strains of the organism, imbued with all the vitality and potentiality for harm which characterized the strains that originally infested the host.

In groups of people confirmed in the habit of feeding themselves with their fingers and whose habits at stool are not above reproach, one is left to speculate as to how many cases are truly chronic and how many represent the working out of a vicious circle that includes the mouth and anus of a single individual.

Dobell and Stevenson(15) have cited cases of *Entamœba histolytica* infection running courses of from sixteen to thirty-four years. But there we have a tissue parasite that in the normal course of events passes very little of its time in the lumen of the intestine and of whose conduct in the tissue we have only imperfect knowledge. Matthews(39) cites a case of *Entamœba coli* infection that seems to have been limited to about one year, but he also cites James' case (in a negro) that ran six years; but there the factor of auto-infection obtrudes itself.

It seems not unlikely that, barring auto- or reinfection, the general run of lumen-dwelling parasites will seek new hosts and leave the original host in the course of a few years at the most. As for the tissue-dwelling parasites, we shall know better when we have means of ascertaining how they maintain their vitality over these long periods of time—just as we are seeking the solution of the same problem with regard to the trypanosomes and the parasite of malaria. With *Entamœba histolytica,* autogamy may occur periodically and solve the problem. In *Balantidium coli* we have a much more highly organized protozoön and one in which there is evidence of conjugation which, when it is fully worked out, may not be dissimilar to the process that has been so fully described in *Paramœcium* by Calkins and Cull. The conditions for conjugation would not seem to be especially favorable in the tissues, but in view of the extreme chronicity of *Balantidium* infections and the high type of the organism, and the fact that evidence of conjugation has never been observed in the tissues, it has long been the opinion of the senior author that endomixis may occur and be the means by which the virulence of the organism is maintained. It is considered good form to regard protozoal infections as being especially virulent in children and young animals. In a general sense this is probably true, but the impressions we have gained, not only in connection with this series, but also from past observations, regarding *Entamœba histolytica* and *Balantidium coli* in connection with children, incline us to the belief that certain things have been overlooked in the past.

These are some of the biological factors involved, but the main factor of practical application would seem to lie in the personal equation—a purely social element. The public schools, visiting nurses, and physicians in Government and private practice will have to shoulder the responsibility in dealing with this very real menace—subtle no less than real. Work along the lines of general sanitation should be pushed with renewed vigor, but the keynote lies in the application of the principles of personal and household sanitation and hygiene that are apt to elude the sanitary inspectors. That means an educational campaign, vigorous and long-sustained. Work of this kind has been undertaken more or less successfully against hookworm and malaria, but it should be stretched to include everything else. It might be remarked that almost every parasite carries its own little individual problem in relation to transmission.

Epigrammatically expressed, we might regard the presence of protozoan parasites as an expression of an *immediate* filth, where helminth infection possibly presents an index of a more remote and diffuse filth which is all the harder to deal with from the sanitary viewpoint.

Transmission.—Protozoan diseases of the intestine for the most part are cyst-borne. We express ourselves with this reservation for the reason that the problem attending encystation and the transmission of parasites of the trichomonad group is still unsettled in so far as the forms infesting man are concerned. Cysts may be carried by various means—food, water, flies, and, if the whole truth were known, probably by a fairly wide range of arthropod vectors. As a vehicle for the conveyance of protozoal diseases, with the possible exception of the species included in the group of "coccidia," dust is probably a negligible factor, for the cysts of the entamœbæ and probably the general run of intestinal flagellates are poorly adapted to resist desiccation, a fact that has been well established in the case of *Entamœba histolytica.* It is to this that we attribute, in a large degree, the preponderance of helminthal over protozoal infections in this series. The cysts of *E. histolytica* are quickly killed by drying, which may explain in part the low incidence of entamœbiasis in children. But, again, there seems little reason to believe that the cysts of other intestinal protozoa, with the exception of those mentioned, would behave very much differently.

We have regarded *Giardia* as rather a rare parasite in Manila and were somewhat surprised at its incidence in this series. However, we have no basis for forming an opinion as to whether or not there is a tendency to a rise in the incidence. A large proportion of the cases of *Giardia* infection seen by the senior author during the past few years he has been able to trace to Chinese gardeners and, in some cases, to China. Whether rodents are responsible for any of the incidence in the Philippines we cannot say. The senior author has found very few *Giardia* infections in Manila rats.

We have already spoken of the rarity of infections with *Balantidium coli* among children. The problem seems to be somewhat similar to that presented by *Entamœba histolytica,* but certain conditions applicable to *Balantidium* would appear to lend support to our belief that some physiologic factor inherent in children operates to limit infections in them with the obligatory protozoan tissue parasites.

Walker(53) seems to have established pretty definitely the identity of the balantidia of the pig and of man, and among other important points he has made is that which establishes the domestic pig as the chief source of human infections with *Balantidium* in the Philippine Islands. Furthermore, he has shown that a large proportion of the pigs in and about Manila (and there are many of them) are parasitized with *Balantidium* and are constantly passing the encysted forms of the parasite in their fæces. Encysted forms rarely occur in human fæces. The senior author confesses never to have seen encysted *Balantidium* in human fæces; but Walker was fortunate enough to find them in one or two of his cases, which would appear to be added proof that *Balantidium* is not yet completely adapted to man and that the pig is, perforce, the main source of the infection.

We cannot be absolutely certain that none of our children were infected with *Balantidium;* but, from the thoroughness with which our examinations were made, we think it unlikely that we missed any cases. Latency, however, is a prominent feature of *Balantidium* infections, and the parasites may be absent from the stools over long periods of time during which there will be a total absence of symptoms. Walker says this latency in man is due chiefly to the fact that the patient, although parasitized, is not infected with the parasite, but in part to the chronicity of the ulcerative process in infected cases.

In a measure, the problem of infections with *Balantidium* is tied up with that of *Ascaris;* for, granting that *Ascaris suum* is identical with *Ascaris lumbricoides,* we may assume that the pig may serve as a source of infection with both organisms. That being the case, why do children whose daily life brings them into frequent contact with the ground that has been traversed by pigs, and often in more or less intimate contact with the pigs themselves, contract *Ascaris* infections and escape infections with *Balantidium?*

Of the helminths occurring in our series only one, *Oxyuris* (and that occurred in a solitary instance), is capable of direct transmission or auto-infection. Hookworms have in the past been thought to have a comparatively limited existence in their passage between hosts, but recent observations raise a doubt on this point. *Ascaris* and *Trichuris* ova are known to be long-lived and resistant to unfavorable conditions, and it seems likely that many cases are picked up by the children when they play about the dusty streets and roads. Carriage by flies has been proved, but we doubt if this is an important factor with the children—there are too many other better and more "convenient" opportunities.

Commes(9) has reported some interesting observations from Africa which might apply in the rural districts of the Philippines. He has written of the frequency of helminthal infections of natives and Europeans at Bamako, Upper Senegal. The source of these infections, he believes, may be traced to the drinking water taken from the Niger. He has made periodical examinations of the deposit resulting from the addition of alum to 10 liters of river water and has found microscopically, after centrifugation, the ova of *Trichuris*, *Ascaris*, and *Ancylostoma*. He has found that the *Trichuris* eggs occur in greatest abundance in the dry season and those of *Ascaris* during the winter months. The ova of *Ancylostoma* show no seasonal variation.

Dogs abound in and about Manila to the extent that they constitute a real nuisance at times, but notwithstanding this they do not appear to figure as important factors in the spread of helminthal diseases. Mendoza-Guazon, in her paper describing the only case of human infection with *Dipylidium caninum* recorded in the Philippines, explains this on the ground that Filipino children of the lower classes are not fond of playing with dogs and cats as are the children of other races, and are usually kept out of the reach of these animals in their infancy. As regards people of the tribes that eat dog meat, she adds that the hair of the dog is singed before the skin is removed.

In his study of the intestinal worms of dogs in the Philippine Islands, Wharton(54) reported these findings in dogs obtained from the public pound in Manila:

	Number.	Per cent infected.
Dogs examined	118	....
Dogs infected	115	97.45
Hookworms (Ancylostoma caninum)	114	96.61
Toxascaris limbata	8	6.77
Gnathostoma spinigerum	8	6.77
Spiroptera sanguinolenta	7	5.92
Dipylidium caninum	55	46.56
Dibothriocephalus sp	7	5.92
Total infections	199	168.55

At least two of the above are under suspicion as being capable of infesting man. *Dipylidium* has already been reported by Mendoza-Guazon, and Hall(25) has reported a case of human infestation with *Toxascaris limbata* in Michigan, U. S. A.

Both Wharton and Mendoza-Guazon comment on the well-known rarity of cestode infection in the Orient, and Wharton adds that he has never discovered infestation with any tapeworms of the family Tæniidæ in either a dog or a cat in the Philippines.

Wharton, however, speaks of several cases of larval infections of man with *Echinococcus granulosus*, but has no authentic report of the finding of an adult in the Philippine Islands. He accounts for the absence of tænia forms that are found in dogs by the lack of suitable intermediate hosts—rabbits and sheep.

The question of infant feeding has engaged the attention of medical men since the early days of American occupation, and it is still a difficult problem. In Manila, much good has been accomplished by the free milk depot of the Gota de Leche, but it can provide for only a small proportion of the infant population of the city. The prevalence of rinderpest is responsible in a large degree for the difficulty experienced in getting fresh milk for infant feeding. Musgrave and Richmond(46) quote Carter as pointing out that even when fresh milk is obtained, it is frequently improperly diluted or contaminated by the use of water from an impure source, giving rise to intestinal disorders and malnutrition which are rapidly fatal.

Musgrave and Richmond state that breast feeding is probably attempted in almost every case, but the percentage of exclusively breast-fed children certainly is smaller than in many other countries. This is largely attributable to the lack of sufficient and proper food for the mother. They add (p. 364):

> The conditions which have been outlined and many others, bring about the necessity of instituting artificial food for breast milk in infant feeding to an extent, and at an age of the infant, probably not surpassed if it is equaled in any other country.

This naturally leads to a nondescript diet for a large number of children and the menu soon includes a large variety of homemade preparations—rice sticks, potatoes, bananas and other fruits are given at an early age, and sometimes meat is given to the child before the eruption of the temporary teeth. Boluses of meat have been found in the stomachs of such children at autopsy. The character and percentage of diluents are also heavy contributing factors. Such things, of course, are in themselves bad for the children, but the parasitologist who has seen the manner in which this food is prepared and handled looks upon it mainly as the vehicle for the conveyance of parasites.

Another aspect of the problem is presented by McLaughlin and Andrews(41) in their studies on infant mortality. They say:

* * * In the Philippines the mortality is greatest among breast-fed children, possibly because of the poor quality of the mother's milk * * *. It seems probable that there is an intimate relation between beriberi of infants and a mother's milk poor in quality and lacking certain necessary elements which are not included in the mother's dietary.[10] At first glance it might seem advisable to supplant breast feeding by artificial, but under existing conditions this would be a blunder. The children saved from beriberi would be sacrificed to enteric diseases. That small part of our infant population which is artificially fed furnishes 65 per cent of the deaths from enteric diseases, and the breast-fed, much the larger part of the population, furnishes but 35 per cent of the infant mortality from this cause; so that even in Manila, breast-feeding of infants exerts a deterrent influence upon the mortality from gastrointestinal diseases.

This presents, in a few words, the rather embarrassing dilemma that confronts the Filipino child. It must be said, however, that discoveries made in connection with infantile beriberi since the above was written have helped in a measure to obviate much of the danger from that source.

With a view to remedying the situation presented by the lack of fresh milk, Heiser(30) started experiments on the breeding of a hardy variety of milk goats during his period of duty in the Philippines. The idea was not developed, however.

Without for an instant denying that breast-fed children and those fed on properly prepared artificial food will escape intestinal diseases of bacterial origin in a large proportion of instances, we believe these measures limit infections with the animal parasites to a lesser degree, and this conclusion is not based on the present study alone, but on a much more extended series of general observations extending over a considerable period of time.

SUMMARY

One hundred sick Filipino children have been studied with regard to intestinal parasitism. Of the total number 92 per cent were found to be infested with one or more parasites. Under 1 year the incidence was 66.6 per cent; between the first and second years, 73.6 per cent. All the children between the ages of 2 and 13 years were found to be parasitized.

The earliest case of parasitism was encountered in a child 7 months old.

We have not considered the matter of treatment of these cases in this study.

[10] McLaughlin and Andrews wrote in 1910.

Multiple parasitism has been a complicating factor, and the need is shown for the study of the specific symptoms, if any, produced by the individual parasites. This should be done with strict regard to the race involved, for there is a lack of uniformity of action produced by parasites in the different races.

No protozoön of proved pathogenicity has been encountered in the series. Nearly all the protozoan infections were moderate. The absence of obligatory tissue parasites from this series as well as their rarity in children of the Filipinos is regarded as having some significance. It is suggested that an apparent immunity of children to forms such as *Entamœba histolytica* and *Balantidium* may have a physiological basis in the child.

The incidence of infections with *Spirochæta eurygyrata* was high (61 per cent); and, although no significant phenomena are recorded, it is suggested that further investigation of this parasite is called for.

Our experience coincides with that of numerous other workers who have failed to record any definite train of symptoms that can be attributed to intestinal parasites other than those that are specifically pathogenic. Several patients that were not parasitized at the time they came under our observation presented symptoms that might easily be attributed to parasites. At the same time, concomitant infestation with *Trichuris* and *Ascaris* is accompanied by a train of symptoms referable to the digestive tract that present an almost characteristic picture. In several of these cases the clinician gave a diagnosis of ascariasis that was later confirmed by the finding of the ova of *Ascaris* and *Trichuris* in the fæces.

No data were secured that would aid in determining a possible influence of parasitism on the mental development of any of the children studied, and very little information was collected that was suggestive as to effects on the nervous system. The methods employed with regard to these two factors we do not consider adequate, however.

Study of our cases of ileocolitis, likewise, has failed to yield anything satisfactory concerning the influence of parasitism on the incidence or course of ileocolitis.

Infections with *Trichuris* and *Ascaris* we regard as offering a serious problem in pediatrics. The combination of the two helminths is one that is especially serious in as much as the entire alimentary tract is involved.

Children occasionally purge themselves of *Ascaris* infections, particularly if they are complicated by *Trichuris* infection. This occurs through vomiting or defecation of the worms, or both.

Helminthal infections were restricted to the Nematoda. No infections with either Cestoda or Trematoda were encountered.

Respiratory diseases other than tuberculosis, influenza, and pleurisy were met in 33 per cent of the children studied, and in this connection attention is drawn to the recent work of Stewart and others on the life history of *Ascaris*, it being suggested that the lung stages of the worm may be responsible for much of the respiratory disease among Filipino children. The difficulty of diagnosing these cases is pointed out.

It is planned to study the fæces of a series of children admitted to the hospital for treatment of respiratory diseases (other than tuberculosis and influenza). Those children who, on admission, are found to harbor *Ascaris* will be rejected from the series. The stools of the others will be followed for several weeks to discover if the ova appear in the fæces following the pulmonary trouble. Such evidence while not absolutely convincing will, nevertheless, be highly suggestive.

Infection with hookworm was found in 12 per cent of the series. Only one severe case is recorded, but it is suggested that the traditional mildness of hookworm disease among the Filipinos should not bring about a false sense of security with regard to it.

A comparative study of the clinical symptoms attending infections with *Necator* and *Ancylostoma* is suggested with a view to discovering if one is more harmful than the other.

It is also suggested that there should be a reëxamination of the evidence regarding eosinophilia in all the helminthiases.

Sanitary conditions are a heavy factor in the infection of children, but the weak link lies in the failure to educate mothers in the principles of domestic hygiene. A given city may be "clean" to educated people but insanitary with respect to the child. Campaigns through the schools, visiting nurses, and physicians should be instituted and maintained.

Parasitism starts coincidentally with bottle or artificial feeding and even breast-fed children do not escape in all cases.

Domestic animals such as dogs and cats apparently are not an important factor in the spread of parasitism among Filipino children, *so far as our present knowledge goes.*

We believe that intestinal parasitism, both directly and indirectly, contributes heavily toward the high death rate in young

Filipino children. While general sanitary conditions are largely responsible for this, still we believe that so far as the children are concerned the problem is one of education of the masses in the simpler principles of domestic hygiene. This will be a formidable task, but it is one on which the Government may with profit expend large sums of money. It calls for the development of the principles of parasitism and preventive medicine on a particularly high plane in the Philippine Islands where parasitic infestations are more common probably than in any other country from which there are records.

Endolimax nana and *Dientamœba fragilis* are reported for the first time from the Philippine Islands. *Eutrichomastix* is provisionally reported.

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ILLUSTRATION

TEXT FIGURE

FIG. 1. Growth curves for dogs fed on fresh and autoclaved milk.

A TRYPANOSOME ASSOCIATED WITH A FATAL DISEASE IN THE CARABAO

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THREE PLATES AND TWO TEXT FIGURES

The following observations were made on some blood films taken from a male carabao (No. 1893) at the rinderpest immunizing station at San Fernando, Pampanga Province, P. I., in July, 1916. We have delayed the publication of this report in the hope that we should come across other animals infected with the same trypanosome, but up to the time of writing this paper no other cases have come to our notice.

The carabao was inoculated simultaneously on May 28, with virulent rinderpest blood and anti-rinderpest serum. The animal showed no reaction from the inoculation, so another injection of virulent blood was made ten days later. It became evident that the blood employed in the original simultaneous inoculation was not virulent, for a very strong reaction followed the second injection.

In due time the animal recovered from the reaction and seemed perfectly normal until the eighth day when its temperature began to rise and its appetite to decline, and a bloody diarrhœa developed. Later symptoms were hæmaturia, hæmorrhages from the skin, and difficult breathing. The discharge from the nostrils became bloody, and gaseous swellings developed on the back and neck. These swellings, when incised, yielded a fluid that was very offensive in odor. The condition of the animal finally became so bad that it was seen that recovery was out of the question. Accordingly it was destroyed on July 3. As reported to us, the autopsy findings showed the entire carcass to be yellow in color. There was severe hæmorrhage of the heart, and the liver was extremely friable. This chain of clinical symptoms is unlike anything we have heretofore noted in the carabao.

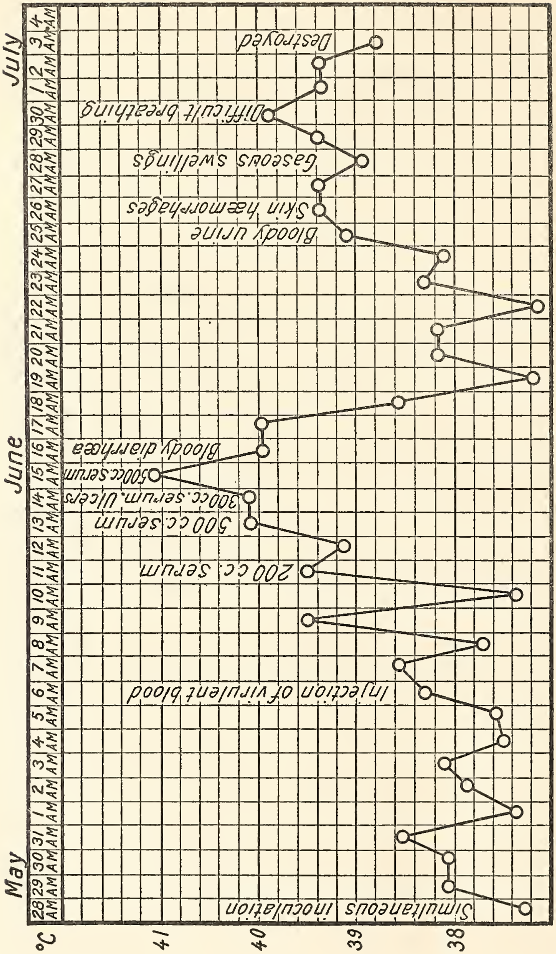

FIG. 1. Temperature curve of carabao 1893.

Several blood smears were made at the time of the autopsy and the slides were later forwarded to Manila where they were stained with Wright's solution and examined. Numerous trypanosomes, much larger and of a different type than *Trypanosoma evansi* were found. In many ways, the trypanosome resembles *Trypanosoma theileri*, but from the preparations at hand we are not prepared to place it definitely in that species.

As might be expected, the material was not particularly suited to a careful cytological study and we were able to find on the slides relatively few trypanosomes that did not show signs of plasmolysis or the untoward effects of delayed fixation and staining characteristic of material collected in the Tropics. Other trypanosomes failed to take the stain properly and attempts to restain them only made a bad matter worse. We were, however, able to find one hundred individuals in a fair state of preservation, some of which are shown in Plates 1 and 2. As will be seen on inspection of fig. 2, the trypanosome is quite polymorphic, its length ranging from 22 μ to 45 μ. These measurements are of the body only, the free flagellum being unstained in all but a few individuals. In those individuals in which the entire free flagellum could be distinguished, it showed a length of from 15 μ to 26 μ. The proportion it bore to the size of the body in individual instances can be seen in Table 1.

TABLE 1.—*Measurements of Trypanosomes, including free flagella.*

Length of body.	Length of free flagellum.	Total length.	Maximum width.
μ	μ	μ	μ
36.0	21.0	57.0	3.0
38.0	19.0	57.0	3.0
34.0	15.0	49.0	2.5
37.5	20.0	57.5	3.0
33.5	21.0	54.5	2.5
37.5	19.0	56.5	2.5
32.0	19.0	51.0	3.0
35.5	18.0	53.5	2.5
33.5	26.0	59.5	2.5
23.5	21.0	44.5	2.5
29.5	20.0	49.5	2.5
32.5	20.0	52.5	3.0
30.5	19.0	49.5	3.0
35.5	19.0	54.5	4.5
22.0	12.0	34.0	2.0
33.5	13.0	46.5	2.0
28.0	14.0	42.0	2.0
30.0	14.0	44.0	2.5
37.0	16.0	53.0	2.5
38.5	15.0	53.5	2.5

The trypanosome is a long, graceful organism, rather pointed anteriorly but usually having a bluntly rounded posterior extremity. The stained preparations show the protoplasm of the main portion of the body to be finely granular with a structure that is more or less alveolar except toward the posterior end, where the cytoplasm is clearer and more hyaline. In those individuals to which we refer, provisionally, as normal forms the round to slightly oval nucleus lies at about the middle of the body. Apparently the nucleus is of the protokaryon type with a rather small karyosome and abundant peripheral chromatin arranged around the internal surface of a nuclear membrane. The parabasal body [1] lies at about the beginning of the posterior fourth of the body. In some individuals we were able to distinguish a finer granule, lying just anterior to the parabasal, which we are inclined to regard as the blepharoplast, for it seems to be associated with the origin of the flagellum. This is shown in Plate 1, figs. 8 and 9. Figs. 10 and 11 on the same plate also show two bodies, apparently in division. We are unable to determine if they represent the early division of a blepharoplast-centrosome, a division of the parabasal, or some wholly fortuitous element. Such interpretations are not to be made with any confidence in material that has undergone the treatment that this did.

In individuals of the more normal type the undulating membrane was seen to be long and thrown into graceful folds. Unfortunately no dividing forms were encountered.

Of especial interest to us, however, was the relation between the nucleus and the parabasal shown in several individuals. In some cases this had brought about the development of what might be termed a pseudo-crithidial form of the parasite. There were instances where the parabasal lay anterior to the nucleus, the flagellum springing from its region and pursuing the usual anterior course as the margin of the undulating membrane and terminating anteriorly as a free lash.

In view of the fact that cultural forms and those that have passed through subinoculation are not involved here, the condition is somewhat novel—at least, it is novel to us in a country where *Trypanosoma evansi* is the only species of importance.

[1] We have adopted the term parabasal as employed by Kofoid and his coworkers in preference to Woodcock's term "Kinetonucleus." For a discussion of the considerations here involved see Swezy, Olive, The kinetonucleus of flagellates and the binuclear theory of Hartmann, Univ. Calif. Pub. in Zoöl. **16** (1916) 185.

Our previous experience with the so-called crithidial forms has been restricted to cultural trypanosomes and to species of *Crithidia* found in arthropod hosts. The picture of *Trypanosoma rhodesiense* as set forth by Stephens and Fantham(8) is already well known to men whose opportunities have made them much more familiar with trypanosomes than we are. It is our impression, however, that in the case of *T. rhodesiense* the posterior nucleated forms are more or less restricted to the short, stumpy trypanosomes that are found in subinoculated animals as rats, guinea pigs, dogs, mice, monkeys, rabbits, and horses, and are not seen in the human host.

Inspection of our figures will show that the posterior-nucleated forms are by no means restricted to the shorter individuals, but are included among the longer trypanosomes often referred to as pre-division forms. Then, too, it must be remembered that our material was drawn direct from the original host. There is, of course, the bare possibility, which must not be overlooked, that our carabao may have become infected with trypanosomes drawn from the blood of the carabao from which the virulent rinderpest blood was obtained.

In connection with their work on *Trypanosoma lewisi*, Minchin and Fantham have shown the production of daughter trypanosomes from a parent rosette. These have a crithidial appearance, the parabasal lying anterior to the nucleus. But their figures show the nucleus lying in about the center of the cell, which is short and stumpy and quite different from the appearance presented by most of the trypanosomes on our slides. Furthermore, we failed to find any evidence whatever of somatella formation.

It may be suggested that we are dealing with the "transvaaliense" type of *Trypanosoma theileri*. This may be true, but we can only say that, while not all the literature on *T. theileri* is available to us, inspection of the figures of *Trypanosoma transvaaliense* in Laveran's paper(4) does not conduce to that belief. The impression given by Laveran's figures is totally different from that given by ours and the relative position of the nucleus and parabasal in *T. transvaaliense* seems to have been brought about by anterior migration of the parabasal.

Macfie in his account of trypanosomes found infecting wild *Glossina tachinoides*(5) figures *Trypanosoma pecaudi* (*T. brucei* of Uganda) from his rat No. 16 (see fig. 10, facing p. 438) with a pair of posteriorly situated nuclei near which is found the parabasal. This is in appearance somewhat similar to our fig. 13, Plate 2. This might be interpreted as evidence of a type of precocious nuclear division along the lines seen in certain of the hypotrichous ciliates. It is hard, however, to reconcile this view with the absence of evidence of division of the blepharoplast, parabasal, and flagellum which should occur before nuclear division. Some of the British protozoölogists, who are quite familiar with the trypanosomes, hold that this appearance, which they have seen in other forms, has nothing to do with fission.

Other species than those already mentioned have been found to possess posteriorly situated nuclei, among them being *Trypanosoma equiperdum*, *T. equi*, and *T. pecaudi*.

Hartmann and Nöller(2) in their recent paper on the cytology of *Trypanosoma theileri* figure (Taf. 14, fig. 1) a trypanosome with the parabasal immediately in front of the nucleus which, however, is situated at the middle of the animal. It was a cultural form, and they report no such appearance in fresh blood.

Wrublewski,(10) so far as we have knowledge, comes nearest to the conditions obtaining in our case. In his description of *Trypanosoma wrublewskii* Vladimiroff and Yakimoff, which is found in the blood of the Lithuanian bison, Wrublewski mentions the finding of trypanosomes, the trophonuclei of which lay in the mid-portion of the body which was broadened at that point, the kinetonucleus (parabasal) lying in front of the trophonucleus in each case. As the trypanosomes Wrublewski studied were found in blood taken from the hosts after death, his conditions will be seen to correspond somewhat with ours.

Martini(6) describes a trypanosome recovered from the blood of cattle in the Philippine Islands which may be identical with the organism discovered by us. Unfortunately, however, he fails to give measurements of the parasite and it is, therefore, impossible to form any definite opinion on this point. Forms he figures showing the parabasal lying anterior to the nucleus were found in blood cultures, and he says nothing concerning their discovery in the blood of the host during the life of the latter.

Whatever the interpretation of these forms, we are not inclined to regard them as crithidial forms in the true sense of the word. They appear to develop by posterior migration of the nucleus rather than by anterior migration of the parabasal with accompanying attenuation of the anterior end of the trypanosome, characteristic of the assumption of the crithidial stage by a trypanosome. It would be futile at this time to speculate at length upon this appearance as representing any definite developmental phase of this particular trypanosome, although it might well be that very thing.

There is an interesting resemblance between these individuals and those figured by Kofoid and McCulloch [2] in plate 15 of their paper on *Trypanosoma triatomae.* Their figures, however, are of forms found in the digestive tract of the hemipteran *Triatoma protracta* and their paper does not deal with the forms found in the blood of the vertebrate host.

It must be borne in mind that certain factors were present in the carabao from which the trypanosomes were obtained that might have altered the morphology of the parasites. It is barely possible that the antirinderpest treatment and the injection of virulent blood might have exerted some influence on the trypanosomes. It must also be recalled that the blood from which our slides were prepared was taken from the animal after death. In view of this, it has seemed to us possible that the appearances we have noted may have been the expression of a more or less abortive effort on the part of the trypanosome to develop a crithidial stage similar to that it might be expected to assume in culture or in its invertebrate host. This might be due to the lowering of the temperature and the initiation in the blood of conditions approaching those found in an artificial culture.

Measurements were made (by the method of Stephens) of one hundred individuals selected at random from the best-preserved and stained trypanosomes we could find on the slides. We have plotted the size distribution of these trypanosomes in fig. 2.

In general, we believe the trypanosome described by us more closely resembles *Trypanosoma theileri* than it does any of the larger trypanosomes we have had under consideration. It approaches the descriptions of Theiler(9) and of Laveran(3, 4) more closely than it does the current descriptions of *Trypanosoma americanum.* Martini's description of his trypanosome gives us no clue whatever. Flies of the genus *Hippobosca,* which are credited with being the vectors of *T. theileri,* are frequently found in the Philippine Islands. Musgrave and Clegg(7) report the infection of Philippine carabaos with *Trypanosoma evansi,* a fact we have many times confirmed, but our parasite certainly

[2] Kofoid, C. A., and McCulloch, Irene, On Trypanosoma triatomae, a new flagellate from a Hemipteran bug from the nests of the wood rat Neotoma fuscipes, Univ. Calif. Pub. in Zoöl. 16 (1916) 113.

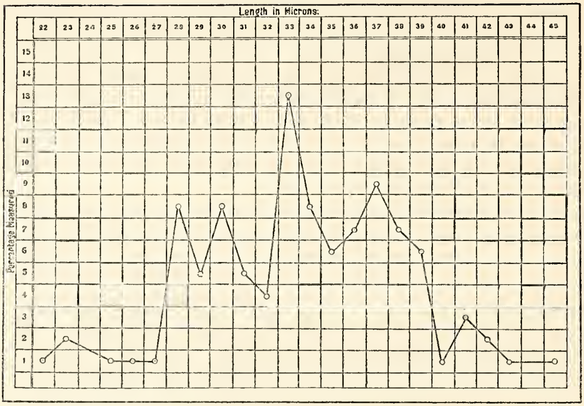

FIG. 2. The distribution according to length of the body, of one hundred specimens of the carabao trypanosome.

is not of that species. Curry(1) has also reported the finding of trypanosomes in Philippine carabaos, but his report, like Martini's, lacks the details that would enable us to make a comparison. *Trypanosoma theileri* has not been reported as occurring in the Philippine Islands.

It is to be regretted that under prevailing conditions we cannot make a systematic search for other cases of this infection. If the trypanosome was actually the cause of the death of our carabao, its presence in the Philippine Islands is likely, sooner or later, to be a serious matter for owners of such animals. If the carabaos, on the other hand, are merely reservoirs for this trypanosome, then we must look for trouble elsewhere. In any event, this particular trypanosome, by reason of its large size and the peculiarities we have described, presents exceptionally attractive material for cytological study which it is to be hoped may be carried out some time in the future. One of the slides which formed the basis of the foregoing description has been deposited in the protozoölogical collection of the Bureau of Science, Manila.

In conclusion, we desire to express our thanks to Dr. W. H. Boynton, of the Bureau of Agriculture, who kindly turned over to us for study the blood preparations of this case.

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ILLUSTRATIONS

[Drawings by Haughwout.]

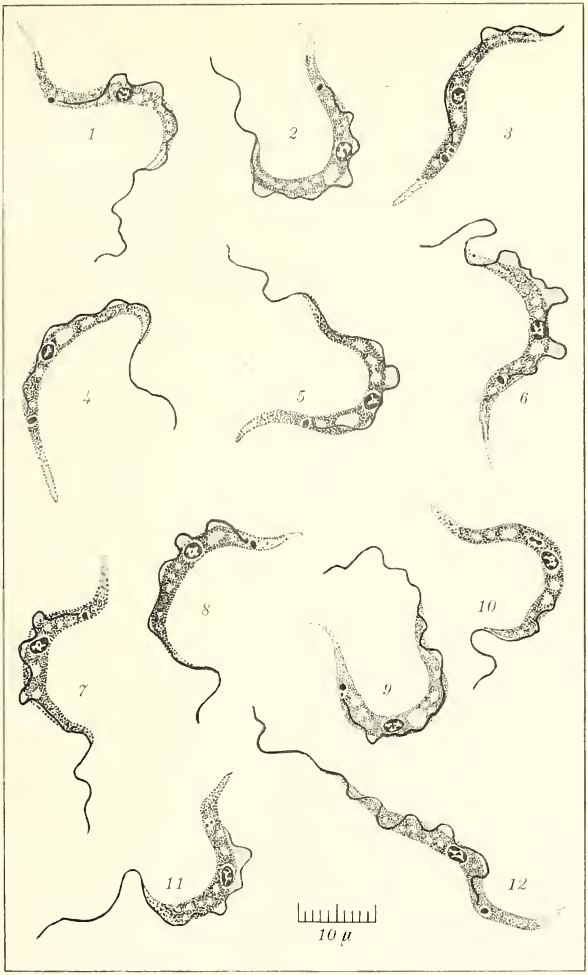

PLATE 1. A TRYPANOSOME OF THE CARABAO.

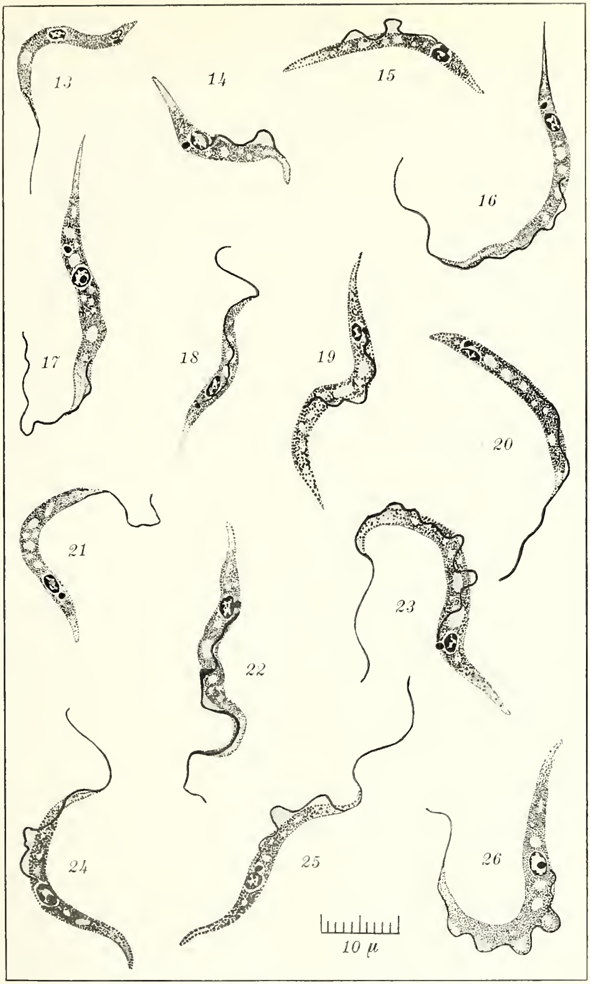

PLATE 2. A TRYPANOSOME OF THE CARABAO.

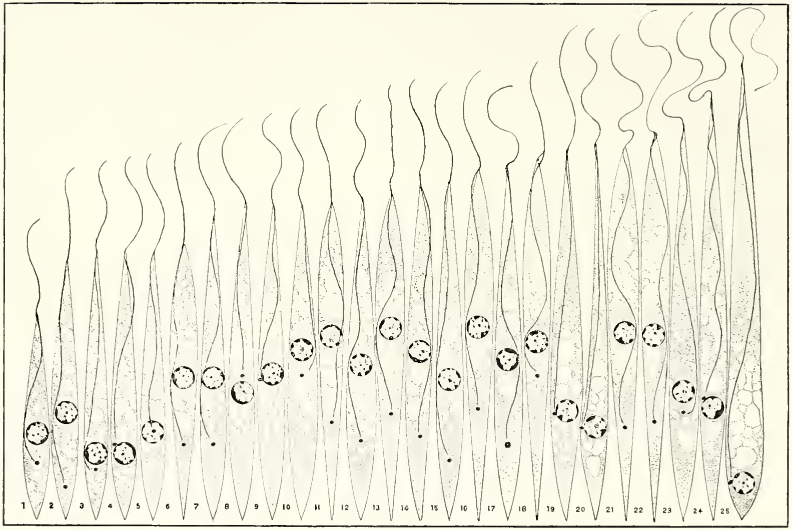

PLATE 3. A TRYPANOSOME OF THE CARABAO.

REMOTE MANIFESTATIONS OF FOCAL DENTAL INFECTIONS, WITH CASE REPORTS [1]

By Ricardo Fernandez

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It is a common practice in the treatment of certain articular and muscular affections of various types to make clinical and laboratory examinations with a view to determine the presence of so-called chronic rheumatism, acute rheumatic fever, or uricidæmia or gout; hence the custom of requesting urine examination to enable the practitioner to determine the total amount of uric acid, and also to estimate the quantity contained in the blood. An elaborate medical and dietetic treatment is then given, coupled sometimes with physical therapy, but in the majority of instances such treatment is a failure.

There is no pretension of originality in my paper; the motive that induced me to prepare it was to suggest to my confrères that in such affections they may depart from the line of investigation heretofore followed.

Sinclair Tousey, in the preface of his monograph on "Roentgenographic diagnosis of dental infection in systemic diseases," mentions the observation on the wife of an eminent jurist, who died as a result of an infection localized in the socket of a tooth; this focal infection was diagnosed rather late by means of X-ray. He says:

> The widest publicity should be given to the fact that greatly varying and sometimes serious or fatal systemic diseases and those affecting remote organs are often due to infection connected with the teeth or with the pneumatic sinuses of the face. The infected foci are discoverable by the X-rays. Some of these cases are cured by treatment of the oral lesion and some require also autogenous vaccination with a bacterial culture from the pus in the oral lesion.

Hardly any importance has been given to alveolar abscesses as possible causes of serious and remote disorders in the body; although it has been always considered important to detect the presence of pus in any region of the body, so as to account for,

[1] Read before the Manila Medical Society December 3, 1917.

sometimes, the whole group of symptoms in certain isolated clinical cases. The reason why due consideration has not been given dental infections is that we have been treating morbid conditions; symptoms and their clinical course we never thought might have an intimate relation with dental lesions.

The researches of E. C. Rosenow and of Frank Billings, confirmed later by Hartzell and by others, as to the relation of various pathological manifestations to chronic dental infections, have been the guide of radiologists, dentists, physicians, and laboratory workers. In consequence the medical literature has been enriched by enough data to enable us to form a clear and exact idea concerning the intimate relation existing between chronic dental infections and certain forms of arthritis, neuritis, neuralgia, various types of rheumatic manifestations, and certain pathological conditions in the stomach, the duodenum, the appendix, the gall bladder, the heart, and the kidney, and blood diseases such as pernicious anæmia, etc.

Taking into consideration the fact that the manifestation of chronic dental infection cannot generally be diagnosed with accuracy by any clinical means without the X-rays—and even with them in certain cases with difficulty—I will first deal with the two main dental infections that commonly bear relation to the morbid manifestations mentioned; namely, the apical and periapical abscess and pyorrhœa alveolaris. As a routine in our dental radiograms we employ the extraoral method with photographic plates and, exceptionally, the intraoral by means of photographic films and plates of proper dimensions to be placed within the mouth. We deem the extraoral method more practical, in as much as it enables us to obtain, not only a large number of teeth, but certain information concerning both maxillæ, especially the upper, in its relation with the nasal cavities and the maxillar sinuses.

With a well-conducted technic, we are able to make a complete exploration of both maxillæ, and their respective teeth, by five exposures, whereas twelve at least are necessary in the intraoral method—six exposures for the inferior—provided that every one of the exposures is satisfactory.

In order to save time on one hand, and to avoid the patient being unduly exposed to the X-ray on the other, we decided to use the extraoral in preference to the intraoral.

We use the oblique projection technic recommended by Drs. E. Speder, J. Belet, and J. D. McCoy.

With this technic we succeeded in exploring all the teeth and the maxillæ, and thus could detect any change from the normal appearance of each particular tooth.

In the interpretation of the X-ray plates, for the detection of apical abscess, one must bear in mind the relation of the natural cavities as, for instance, the antrum of Highmore with the superior molars; the nasal cavity with the superior incisors; and the foramen of the inferior maxilla with the inferior premolars. Otherwise, any one of these natural cavities might be wrongly taken as a shadow produced by an abscess, and thus we might give an erroneous diagnosis, with serious consequences. With the foregoing precaution, it is relatively easy to diagnose with accuracy any abscess that might develop in the dental apex or around it, even though there are no clinical symptoms, if the negative shows a dark area circumscribed in the dental apex or in the alveolar cavity, and if this dark area is well defined and sharply separated from the neighboring tissues by a line of demarcation.

This dark area, a very characteristic radiogram of an abscess, is produced by diminution of density, or decalcification and sometimes destruction of the dental tissue. If the dark area is very pronounced, almost black, we can infer the probable presence of pus in the alveolar cavity. It has been proved that the pus may become fluorescent under the influence of the X-rays, and this fluorescence acts as an intensifier of the radiations acting upon the point or site where the abscess is located, and as a result we observe the very pronounced dark zone in the negative.

Pyorrhœa alveolaris, or Rigg's disease, is clinically demonstrable; it is nevertheless wise to remember that the presence of pus around the external border of the gums is not always due to Rigg's disease. A careful examination will sometimes disclose the cause as being the presence of calcareous deposit around the teeth, which may act as an irritant upon the gums and give rise to suppuration.

Clinical examination, aided by the X-ray, makes diagnosis certain in cases of dental infection, and at the same time the extent of the lesion may be determined in this way.

T. L. Gilmer and A. M. Moody are not in accord with Dr. C. J. Grieves, of Baltimore, and Dr. W. S. Baer, of Johns Hopkins University, that *Staphylococcus albus* or *S. aureus* may be the causative agent of apical and periapical abscesses. Through experiment Gilmer and Moody have been able to identify the preponderance of streptococci in ærobic and anærobic cultures, aseptically obtained from pus in the foci, or the seat of acute, chronic, or latent infections in the maxillæ and teeth. *Streptococcus hemoliticus* was found in acute abscess; *S. viridans*, in chronic; and *S. mucosus* was obtained only once.

Occasionally *Staphylococcus albus* and *S. aureus* have been isolated by some observers in the ærobic cultures, and also *Micrococcus catarrhalis* and some other unidentified saprophytic microörganisms. The streptococci in the anærobic cultures are rarely obtained pure. Some cultures showed the presence in large numbers of *Bacillus fusiformis*, while in a few test tubes there were found pure cultures of this bacillus. C. C. Bass and F. M. Johns give as a specific cause of alveolodental abscess the *Entamœba buccalis* and possibly other species that infect and destroy the peridental membrane.

While Hartzell and Henrici do not claim in their experiments that the streptococcus is an etiological factor in dental abscesses and in *Pyorrhœa alveolaris*, nevertheless from the standpoint of metastatic abscesses they think it is of paramount importance that such microörganisms are constantly present in lesions with ulcerated surfaces; and they probably do invade deeper tissues and gain entrance into the circulatory channels.

Henry L. Ulrich says that out of one hundred seven cases of dental abscesses with bacteriological examination in the Minnesota Hospital, one hundred showed the presence of *Streptococcus viridans;* and out of fifty-two of his private cases, fifty also showed the presence of the same microörganism. There were also found with the above microörganism, *Staphylococcus albus*, *S. aureus*, and *Micrococcus catarrhalis*.

Hartzell, Henrici, and Leonard, in their posterior researches, made the assertion that they found streptococci in periapical abscesses and in pyorrhœa, and that these streptococci give rise in animals to inflammatory lesions in the cardiac muscle, vegetative growth in the valves, articular infection, inflammation of the blood vessels, and focal and diffuse infection of the kidneys. Similar lesions were observed in human beings upon autopsy, and these investigators believe that the lesions mentioned were caused by streptococci.

Recent bacteriological investigations carried out in the department of medicine of the University of Minnesota disclosed the constant occurrence of *Streptococcus viridans* in chronic dental abscess and pyorrhœa; and, although *Entamœba buccalis* was also found in oral infections, this is not recognized as the cause of pyorrhœa, as Bass and Johns claim.

It is a scientifically proved fact that the gastric juice is not a barrier against the passage of bacteria and pus into the stomach and the intestines. Microörganisms in the mouth may be swallowed, as actually happens, and they reach the stomach without all of them being destroyed, and thus gain entrance into the intestines, causing under certain conditions throughout their course local affections such as gastric ulcer, appendicitis, etc.

Another route of dissemination from mouth infection is by way of either the lymphatic or the circulatory channels; hence the presence of focal infections of remote origin, as Hartzell, Henrici, and Leonard have shown in their clinical investigations already referred to.

There are localized infections of the tonsils, and others, that may coexist with pyorrhœa and dental abscess; treatment for their eradication does not cure the disease if not properly attended to.

A thorough treatment of the teeth by the dentist, with extraction if necessary, was enough to eradicate all symptoms and other disturbances observed in patients. In instances where a conjoined local treatment by the dentist and the use of vaccines by the physician were available, improvement was rapid, especially when autovaccines were employed.

L. S. Medalla thinks that there is room for vaccine therapy in all cases of acute and subacute dental abscesses; and that, by the employment of this method, a good deal of suffering among patients and the loss of their teeth have been avoided.

In the use of autovaccine the necessary precautions must be taken to obtain the purulent material aseptically, without contamination. An autovaccine prepared under such conditions almost invariably brings about a surprising and rapid disappearance of the symptoms, which may not be observed if one is careless in the preparation of the vaccine.

Hartzell and Henrici believe that the elimination of the focal oral infection is very much more important than the use of vaccine, and they consider this as a mere adjuvant treatment in some cases.

The limited number of cases observed by me corroborate the facts which I have quoted here, in regard to the treatment.

Case 1.—W. T., adult, American, married, male, suffering for some time from lumbosacral and articular pain, the character and intensity of the former simulating nephritic colic. He looked very pale. Radiograms taken in the lumbosacral region showed the characteristic evidences of beginning *Arthritis deformans*. Radiogram of the teeth showed the evidence of pyorrhœa in the only remaining molar in the lower mandible, right side, and abscess in the second upper bicuspid, left. Under appropiate treatment of the affected teeth, and hygienic care of the mouth, he improved markedly, and the painful symptoms disappeared. Recovery was slow, and there was left some rigidity in the knees on account of the definite lesions observed in the articulations.

Case 2.—F. L., adult, Filipino, male, married, complaining for many months of polyarticular rheumatism with acute exacerbations which prevented him from attending to his ordinary work. The medical and the dietetic treatments as well as the hydrotherapy given him afforded very little relief. Apparently his teeth were in excellent condition, but a radiogram showed the presence of an abscess in the remaining molar in the inferior maxilla, right side. Treatment of the dental abscess without any other medicine caused the gradual disappearance of his symptoms, and in four months he was completely cured.

Case 3.—C. de C., female, Filipino, married; she gave a history of some rheumatic pain; for two months she had been complaining of intense pain in the lumbosacral region, radiating to the left thigh. She was bedridden, and could neither sit nor walk. All previous treatment usually given in such cases was a failure, and the intense pain could be abated only by morphine injection. Radiograms of both kidneys and ureters were negative for stone; the vertebral column and the whole pelvis were entirely normal. Radiogram of both maxillæ showed the presence of abscess in both first molars in the superior mandible. Both molars were extracted under anæsthesia, and cultures of *Micrococcus viridans* and *Staphylococcus albus* were obtained. Autovaccine was prepared and all other treatment previously given was suspended. The first injection given was 33,000,000; on the third day she was given another of 50,000,000. On the day following the first injection there were observed dizziness, nausea, and pain in the teeth, worse on mastication and on drinking cold water. On the sixth day after the first injection she was given another of 50,000,000, and thereafter 100,000,000, at two-day intervals. After the third injection there was abatement of the symptoms observed after the second one and, to her surprise, she was able to sleep and to move her lower extremities freely. After the sixth injection the patient was able to sit up in bed without any trouble; after the eighth, she could walk alone. Her general condition improved, and she was finally cured very rapidly.

Case 4.—M. de F., adult, female, Filipino; with previous history of some rheumatic affection, and complaining of intense pain in the left shoulder. The radiogram of the shoulder showed evidence of *Arthritis deformans*. She received medical, dietetic, and electric treatment with no improvement. I suggested that an X-ray picture be taken of her teeth, and the radiogram showed an abscess in the first bicuspid, right inferior maxilla, and abscess also in both bicuspids, superior maxilla, with pyorrhœa in the lower incisors. Culture taken from the pyorrhœa was positive for *Micrococcus viridans*. Autovaccine was prepared, and injections of it ameliorated her symptoms, and complete improvement is expected when her teeth will be entirely cured as she is at present under the care of a good dentist.

Case 5.—P. J. C., adult, European; suffering from articular manifestations for twenty years. He was always under dietetic and medicinal treatment, without showing real improvement. Radiogram of both maxillæ positive for pyorrhœa in the last molar, left lower maxilla, and abscess in the last two molars, left inferior maxilla, with pyorrhœa in the second false molar and the first molar, superior maxilla, left side. The two inferior molars were extracted and the culture taken was positive for *Micrococcus viridans*. Vaccine was prepared and after the second injection the patient was able to wear his shoes, and he experienced no trouble on walking.

Case 6.—V. de C., adult, Filipino, female; with previous history of rheumatism following an attack of paratyphoid fever. Ever since she has been having fever with temperature between 38° and 39° and occasionally as high as 40°. All the intestinal symptoms of paratyphoid have disappeared, but there is persistence of some articular pain. There is no indication of any tuberculous lesion. Radiogram of the teeth shows evidence of pyorrhœa in the false molar and the molar supporting a bridge in the inferior mandible, right side; pyorrhœa in all the false molars left side, upper mandible, and also in the two false molars and the first molar, right side, upper mandible. Extraction of the false molars and the true molars, which were quite movable in their sockets, was followed by the disappearance of fever, though later the fever recurred, but in a very slight degree. Culture was positive for *Micrococcus viridans*. Autovaccine was prepared and injections were given, with gradual and complete disappearance of fever.

Case 7.—M. V., adult, Filipino; suffering trifacial neuralgia, right side, for some time. All medical and electric treatment given in Europe was of no avail. There was improvement but never a cure. Radiograms taken show evidences of pyorrhœa in the false molar and canine, right side, inferior maxilla. These teeth were extracted, and the culture taken was positive for *Micrococcus viridans*. As a result of injection of the autovaccine the intervals between attacks of the neuralgia are longer and the pains less intense. Patient is at present under treatment and observation.

Case 8.—M., adult, Filipino, male, married; with previous history of rheumatic pain and venereal disease, very suspiciously like syphilis. He has been suffering for a long time from periodical attacks of trifacial neuralgia, severe in character. He received the usual treatment for trifacial neuralgia, and mercury injections for suspected syphilis. Treatment was a failure. On examination, his teeth were found to be in very poor condition. Radiogram shows evidences of pyorrhœa in the upper bicuspids, right side, and an abscess of the first molar, lower right. Once the pyorrhœa and the abscess were treated, he made a complete recovery.

Case 9.—V., adult, Filipino, married; with previous history of rheumatic pains with acute exacerbations, only relieved by salicylate treatment, but the symptoms never disappeared entirely. Radiogram showed the presence of an abscess in the false molar, and pyorrhœa in some of the teeth. Local treatment of the pyorrhœa and the abscess, and autogenous vaccine, resulted in a complete cure.

Case 10.—J. L., adult, Filipino, married; complaining of acute inflammation of the joint of the right shoulder. Mouth in a very bad condition, with evidences of pyorrhœa. Former treatment for arthritis of no avail. He could not use or move his right arm on account of pains. Polyvalent vaccine was prepared, and after three successive injections of 100,000,000 each, there was observed marked diminution of the inflammation. Ten days after treatment the patient was able to use his right arm.

The cases above reported, and those under my observation and treatment, are certainly very few from which to draw conclusions; but examination of the history of the cases reported will show that the results obtained from the therapeutics followed by me fully accord with the outline of treatment discussed. Therefore, as the symptoms disappeared with the disappearance of the focus of infection, the symptomatic manifestations observed were related to the dental infections discovered.

In cases where cultures were made, *Streptococcus viridans* associated with *Staphylococcus* was obtained in one case (3); and in the others, only *Streptococcus viridans* was found. Vaccine of 100,000,000 per cubic centimeter was prepared from the microörganisms obtained from each patient.

Patients treated by the cure of affected teeth or by simple extraction showed gradual recovery, while those who received local treatment, associated with vaccine therapy, recovered more rapidly.

In cases 9 and 10, the use of vaccine therapy, with polyvalent vaccine, gave positive results when associated with local treatment of the infection.

I wish to express my appreciation to Prof. A. G. Sison for his courtesy in making the English translation of this work and for furnishing bibliographical references; to Prof. Jose S. Hilario for the preparation of vaccines; and to Dr. A. de Asis for his valuable coöperation as a dentist.

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A CASE OF HUMAN SYNOPHTHALMIA[1]

By Sixto de los Angeles

Professor and Chief of Department

and

Anastacia Villegas

Assistant

TWO PLATES

The specimen was donated to the College of Medicine and Surgery through the department of legal medicine on May 29, 1919, by the pharmacist Mr. Gallardo, and the district health officer Dr. J. Guidote of Tacloban, Leyte. The fœtus was born dead on May 26, 1919, in the municipality of Tacloban, Barrio of San Jose. According to the report of Doctor Guidote, it was the sixth child of a normal woman, 25 years of age, married to a man 35 years old, a farmer by occupation and likewise of normal and healthy constitution. The five previous children were also normal.

The case is a male synophthalmia bilentica, measuring 350 millimeters in length, and 233 millimeters in chest circumference. The total leg length is 180 millimeters; the foot, 60; the arm, 130; and the hand, 50. The total cephalic circumference is 210 millimeters (anterior 130, and posterior 180); height of forehead, 5.3 millimeters; facial length, 50; facial width, 57.5; and from the inferior palpebral margin to a place over the mental point it measures 22.8. The pinna measures 25 millimeters. The weight was not taken because when the specimen was received in the department it was without viscera.

Eyelids are not adherent but rather widely gaping; membranæ pupilares absent; nails perfectly developed but not reaching to the tips of the fingers; head well covered with hair; testicles partly descended into the scrotum; body perfectly formed but underdeveloped, and covered with abundant lanugo. The size of the creature corresponds to a seven-month intra-uterine

[1] From the department of legal medicine, medical economics, and ethics, College of Medicine and Surgery, University of the Philippines. Read before the Manila Medical Society, October 6, 1919.

fœtus, but everything else in our findings points to an almost full-term fœtus, probably of eight months.

The anomalies of the monster are confined to the head and neck region. The cranium is microcephalic without apparent sagittal suture on palpation; the face has the shape of the breast of a nursing woman. There is only one orbital cavity, apparently fused, but with the median walls totally absent. It measures 25.6 millimeters in transverse diameter, and 20.5 in height; it is situated in the center of the forehead and contains two fused protruding eyeballs. The palpebræ are widely gaping and everted, presenting both superior and inferior ectropion. There are no puncta lachrymalia.

The nose is also absent. The mouth is represented by a small triangular opening about 1.5 millimeters in diameter, and communicates with what may be termed the buccal cavity. Immediately above this opening is a snoutlike structure, grayish black in color, and rigid to the touch.

The external ears or pinnæ are situated almost horizontally at the anterior part of the neck with the square lobules directed medially and slightly downward. The crura, antihelix, and the tragus of both ears are absent. The conchæ are almost flat.

X-ray pictures of the head have been taken, and the absence of the medial walls of the fused orbital cavity, as well as of the nasal bones, is confirmed. The edges of the parietal bones are so closely approximated that the skull becomes scaphoidal. The lower jaw is rudimentary.

So far as we are able to ascertain, our present case has no duplicate in literature with respect to the following peculiarities: The apparent absence of the external nares (there being no proboscis to substitute them); the peculiar shape, size, and position of the mouth; the location of the ears; and the shape of the face.

Medico-legal aspect.—It is a well-known fact that monstrous births not infrequently become the subject of court investigation, particularly in connection with infanticide and the definition of civil rights of newborn babies. As to the first point, a large proportion, if born alive, is killed on account of the hideous or repugnant features, in spite of the legal rule prohibiting the destruction of monsters.

The present case may be included in the class whose existence is undesirable to parents, so the hideous looks of this creature may be invoked as one of the real motives for the commission of infanticide. On the other hand, in the absence of marks of violence which may indicate criminal intention, the suspicion of infanticide, if it were to be applied to the present case, is properly eliminated by the fact that there is lack of development of the organs necessary to maintain life, and by the undersize of the fœtus, which presumes weakness.

On the second point, inquiry may arise as to whether such a monster as this possesses the human shape entitled to civil personality as provided by Article 30 of our Civil Code, which says that "in order to be vested with civil rights a child must have human shape and survive twenty-four hours after birth." The importance of this determination rests upon the fact that, although the newborn infant is medically classified as a monster, yet if it is legally pronounced from the medical evidence to have human shape, and if it is born alive and lives at least twenty-four hours after birth, it may inherit or transmit an estate to its heirs-at-law, as if it were a normally formed child. Assuming that the present case was born alive and lived twenty-four hours, the question therefore may be formulated as to whether it has human shape and is entitled to civil rights. As no case of this kind has as yet been brought before the jurist in the Philippines, we cannot here quote court opinions on this matter; but in other countries conflicting decisions have been given regarding monstrosities, because of the lack of a precise legal definition as to what is meant by "human shape."

According to the meaning of English law, malpositions, transpositions, or defects of the internal organs or any of the cavities do not constitute monstrous births; so that the legal question relates only to external shape, not to internal conformation. However, a mere deformity in any part of the body, such as supernumerary fingers or toes, or twisted or deformed limbs, does not constitute a monster in law. On the other hand, a blighted fœtus or a mole is not legally a child, so far as the succession to property is concerned. It appears from Lord Coke's description of a monster—"which hath not the shape of mankind"—that the law must necessarily be guided in its decision by the description of the monstrous birth given by a medical witness. Hence, each case must be decided by the peculiarities attending it.

In French jurisprudence the circumstance seems to be different; if the monstrosity be such as to cause its death soon after birth, or if it lack capacity to maintain independent life, the child is to be pronounced not viable and therefore not capable of acquiring civil rights.[2]

[2] Taylor's Manual of Medical Jurisprudence, 12th Am. ed. 623 and 624.

Etiology.—Concerning the etiology of monstrosities many theories have been advanced, the oldest being that of maternal impression, which is still regarded by the laity as the true cause of monsters. In the case under discussion the mother in explaining the causation of the malformation believes, as she stated to Doctor Guidote, that she could only attribute such defects to maternal impression; for she remembered that during the early part of her pregnancy she had experienced a peculiar feeling of curiosity in observing a deformed doll made of clothes.

Curiously enough this old-time superstition of maternal impression, which has been so universally adhered to through the centuries, had gained supporters, even among scientists, up to the end of the nineteenth century. Fordyce Barker [3] was one of those who were credited with demonstrating the correctness of the theory of maternal impressions. In a paper, read in 1886 before the American Gynecologists, he established the doctrine that—

> When in the early weeks structural development is proceeding at no tardy rate an interference to nutrition in the mother cannot but impress the fetus detrimentally, and the organ interfered with would be that one in the condition of the most active development, or that which could less easily bear arrest, however transient, with impunity. Then too, although no nervous connection has been demonstrated to exist between the mother and the fetus, yet the latter possesses nerves; and alteration of the nutrient power of the mother cannot but act on the nerves that are governing, though it may be only to a slight extent, the growth of the fetus itself.

Against this theory several arguments have been raised; among others that, though intense emotions and apprehensions are experienced by gestating mothers, yet abnormal births are extremely rare. The impressions may come when the anlage or anlagen of structures claimed to be affected have already been formed.

Norman Bridge [4] in a paper written a few decades ago, strongly refuting the theory of maternal impression, says among other things: "To endow the blood with such a weird intelligence as this would require, is too great a load for our credulity."

Probably this popular belief of cause and effect of marks and defects is largely due to accidental coincidence; although an exceptionally profound emotion, because of the complexity of the human organism, might in some yet unknown way influence the growth and development of the fetus.

[3] American Text-Book of Obstetrics (1907) 306.
[4] Op. cit. 307.

Mall has advocated the theory of insufficient nutrition. He maintains that monstrosity may be due to the imperfect development of some ova on account of inadequate nutrition, owing to faulty implantation in a diseased uterus. This theory is applicable only to pathological embryos aborted during the first two months of pregnancy, for it is inconceivable that an ovum suffering from lack of nutrition can reach the full or nearly full term.

Stockard, after performing a series of experiments on the effects of magnesium salts and alcohol on the ova of certain fish, suggested the hypothesis that cyclopia in man may possibly be due to an excess of magnesium salts in the blood of the mother, or to alcoholism of either or both of the parents. This theory is objected to on the ground that it is true to a negligible percentage only, for many alcoholics bring forth normal offspring without any mark or defect; as regards the excess of magnesium salts in the blood, excess of other chemicals brings about similar results. What part this alcoholic theory has played in our present case we cannot tell for lack of information regarding the habits of the parents and the history of the family.

As to the question of pathogenesis of this particular kind of monstrosity, Stockard attributes the downward displacement of the mouth to the circumstance that the cyclopean eye, being frontally located, has caused the mouth to move downward. The interpretation seems insufficient, in view of the fact that Werber in his experiments has observed this condition to occur, not only in cyclopean monsters, but also in some cases of asymmetric monophthalmia and synophthalmia such as we have in the present case.

Investigators on this subject claim that abnormalities of the olfactory pits are almost invariably found to occur in embryos exhibiting various degrees of median cyclopia as well as asymmetric monophthalmia, and that they usually correspond to the anomalies of the eyes of a given embryo; that is, they are either blended into one median pit or they exhibit various degrees of approximation or fusion in the cyclopean embryos.

Stockard in explaining the cause of cyclopia has advanced the hypothesis that there is only one optic anlage, which normally divides into two, but that by the influence of certain chemicals the division fails and a single eye results. This is refuted on the ground that it lacks sufficient proof to back it up.

Some authors allege that the production of a single eye is due to the fusion of the two optic anlagen, in the course of development, by mechanical injuries. This theory is supported by Lewis who produced various grades of cyclops by pricking the area located between the optic anlagen. He holds that the collapse of the wound surfaces affects the approximation of the two optic anlagen, and the degree of approximation depends on the amount of interocular tissue removed or injured. But objections have been raised to the fusion hypothesis; first, on the ground that cyclopean eyes are rarely equal, in size and extent, to the sum of the two normal eyes combined; second, that experiments made by mechanical injuries cannot account for results produced by chemical means.

The most acceptable theory concerning the etiology of monsters is that of Werber, who concludes from his studies in 1917 on the origin of monsters that parental metabolic toxæmia may be held responsible for the production of monstrosities. He claims that toxic substances resulting from faulty metabolism in the blood of individuals with metabolic disturbances bring about such changes as to produce monsters. But in order to prove the truth of this theory, individuals suffering from such diseases as diabetes, nephritis, etc., should be mated and their offspring studied. Such propositions and conditions are extremely difficult to attain; however, opportunity was afforded the advocate of this theory to imitate the condition by placing ova in a certain percentage of acetone, and he obtained all gradations of monstrosities. The most predominant anomalies he obtained were found in the eyes. He contends that the production of a single eye may be due to a blastolytic injury of a restricted area of the anterior end of the early embryonal stage. This is assumed to be the area most sensitive to toxic action and is the region between the future optic anlagen, or it may even comprise the anlagen themselves. The size of the part affected may be subject to considerable variation: it may include material which would normally correspond to the future interocular region and cause an approximation of the potential optic anlagen; it may extend over the primary optic vesicles, eliminating parts of them, so that by their coalescence and approximation any one of the various degrees of synophthalmic conditions may be formed; or it may comprise the whole of one potential optic anlage and little or no tissue of the future interocular area, causing the embryo to develop into a cyclopean monster if the sound anlage is shifted medianward, or into an asymmetric monophthalmic monster if no such changes of position of the uninjured ophthalmoblastic material takes place. In addition, he asserts that the changes in position and shape of the mouth, as well as those of the olfactory pits, are due to a process of regulation after a blastolytic destruction of this so-called sensitive area at the anterior end of the early embryo's body.

We believe the retention of the external ears in the region of the neck to be due to the downward displacement of the mouth.

Summary.—In conclusion we might say that the condition here presented may be of interest in three points: First, in its rarity, no similar case that we know of having been as yet scientifically reported in the Philippines; second, in its medicolegal significance; third, it offers an opportunity for the physician to consider the causation of monstrosities, and in particular whether or not the popular belief of maternal impression has a place in science.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Synophthalmia bilentica. Note general shape of face and the two fused eyes with two distinct lenses.
2. Synophthalmia bilentica, side view.
3. Synophthalmia bilentica, showing position of ears and mouth.

PLATE 2

FIG. 1. Occipito-frontal, showing one single optic cavity.
2. Side view, left. Note rudimentary lower jaw.
3. Side view, right.

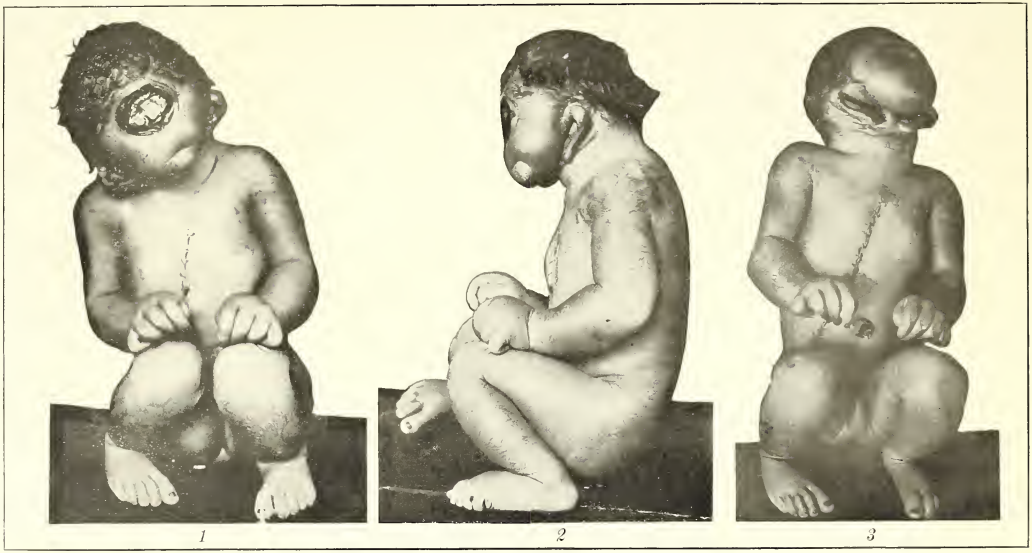

PLATE 1. A CASE OF HUMAN SYNOPHTHALMIA.

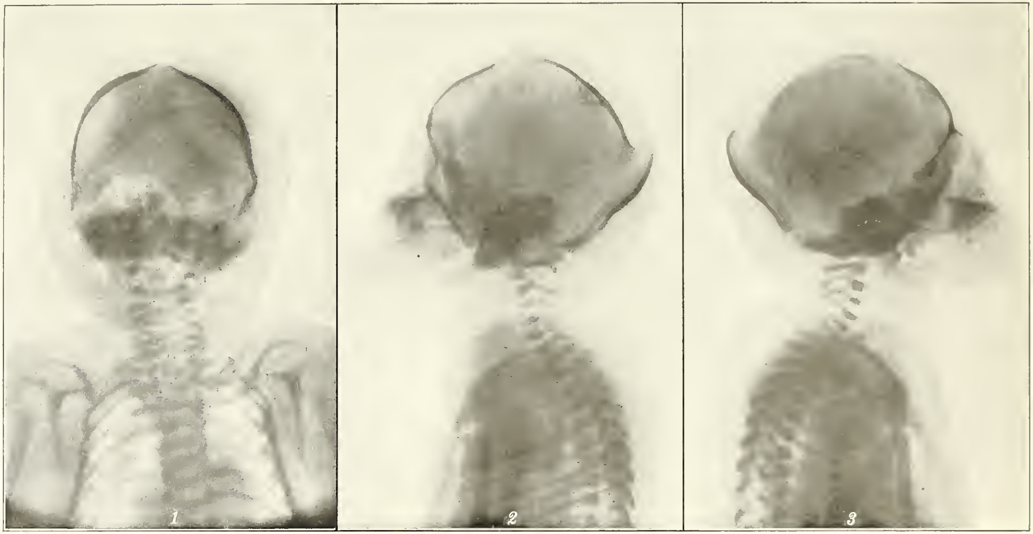

PLATE 2. RADIOGRAPHIC VIEW OF THE SAME CASE OF HUMAN SYNOPHTHALMIA.

REVIEW

The Condensed | Chemical | Dictionary | A reference volume for all requiring quick access to a large | amount of essential data regarding chemicals, and other sub- | stances used in manufacturing and laboratory work | compiled and edited by | the editorial staff | of the Chemical Engineering Catalog | F. M. Turner, Jr., technical editor | assistant editors | D. D. Berolzheimer | W. P. Cutter | John Helfrich | published by | the Chemical Catalog Company, Inc. | One Madison Avenue, New York | first edition, 1919. Cloth, 525 pages, $5.

This handbook is practically a pioneer in its field and is a good indication of the growing importance of chemistry in American business. It is designed especially to meet the needs of business men who encounter questions of a chemical nature.

Brief descriptions of a large number of substances are given, including the formula, physical properties, source, preparation, grades, common containers, uses, fire hazard, and shipping regulations of each. Liberal cross-indexing is furnished and wide margins are left for the insertion of notes.

The dictionary seems to meet a need of purchasing agents, brokers, and other nontechnical men which has hitherto not been satisfied. The chemist, on the other hand, usually prefers a more specialized book with fuller references. The general scope, however, of this dictionary makes it more convenient where only brief information is desired. Many chemists would be at a loss to know just where to look in their libraries for information about names perfectly familiar to other chemists, such as ganister, lewisite, norit.

As is to be expected in the first edition of such a work, occasional mistakes can be found. One can hardly agree with the compilers that kerosene is otherwise known as crude oil, nor that it has a specific gravity of 1.440, boils at 230° to 235° C., and flashes at 150° C. This slip is exceptional, however, and the book on the whole seems to be free from mistakes and misprints.

G. A. P.

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THE PHILIPPINE JOURNAL OF SCIENCE

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PHILIPPINE TURTLES

By EDWARD H. TAYLOR

Of the Bureau of Science, Manila

SEVEN PLATES

INTRODUCTION

As compared with Borneo, Java, Sumatra, or Japan, the Philippine Islands are not rich in either genera or species of terrestrial turtles. In fact only three genera, represented by four species, are positively known; these are *Cyclemys, Heosemys,* and *Pelochelys.* Several species representative of other genera have been reported, but there appears to be no specimen to substantiate any of the records. Borneo has representatives of nine genera and about fifteen species; Java, seven genera and nine species; Sumatra, ten genera and thirteen species; Japan and Formosa, six genera and seven species. On the other hand only two genera and two species are known from Celebes.

One new species, *Heosemys leytensis,* from the southern part of Leyte, is described in this paper. Two specimens were collected there by Gregorio Lopez, together with other turtles to be used for dissecting in the zoölogical department of the University of the Philippines. He obtained forty specimens belonging to three species; namely, *Cyclemys dhor, C. amboinensis,* and *Heosemys leytensis.* It would appear that these land turtles are plentiful in that locality. In most localities they are rare; in collecting during seven years I have found less than a half dozen specimens, all of which belonged to *Cyclemys amboinensis.*

According to Manobo accounts a large turtle with a hard shell occurs in Agusan River. Rewards offered for specimens failed to bring forth this turtle; nevertheless, it is extremely probable that some species of aquatic turtle is present in Agusan River.

The small land turtles already mentioned are seemingly of small economic value. They feed on insects, fruit, what flesh they can find, and sometimes on plants. I do not know that these turtles are ever eaten by man.

The soft-shelled turtle, which occurs in Luzon and very probably in other large islands, is very rare. This is eaten when found, but the number taken is probably so small that its economic food value is scarcely worthy of mention. Individuals of this species are said to attain nearly a meter in length.

Four species of marine turtles are known from Philippine seas. All of these are widely distributed in the Pacific Ocean, the Indian Ocean, and the tropical waters bordering these. The identity of these turtles is in doubt. Boulenger[1] has lumped many of the names, not differentiating between Pacific and Atlantic species. Stejneger and Garman on the other hand recognize the Pacific species as distinct from those in the Atlantic. My treatment of this group is of a preliminary and superficial nature. An examination of numerous carapaces of the green turtle shows three different forms and colors of the shells; but without head, legs, and plastron it is futile to generalize or to attempt a separation of the varieties.

HISTORICAL

One of the earlier writers on the Philippines says:

> There are also very large sea turtles in all the islands. Their shells are utilized by the natives, and sold as an article of commerce to the Chinese and Portuguese, and other nations who go after them and esteem them highly, because of the beautiful things made from them.[2]

Other writers say:

> The fisheries of fine-shelled turtles are also abundant, and they also form a conspicuous product. Some of the shells have markings as deep red as a fine garnet; and the four principal shells are of an extraordinary size.[3]
>
> In this land are very many turtles, of great size; they are larger than a shield. Here is a marvellous thing: when the male and the female have intercourse, they remain thus joined together for twenty or twenty-

[1] Cat. Chel. Rhyn. Croc. Brit. Mus. (1889).

[2] Morga's Sucesos (1609). From Blair and Robertson, The Philippine Islands. The Arthur H. Clark Company, Cleveland, Ohio **16** (1904) 103.

[3] Early Recollect Missions (1624). Translated by Blair and Robertson, op. cit. **21** (1905) 308.

five days. They become so stupefied during this act that the Indians dive into the sea, and tie the feet of the turtles without their perceiving it, and draw these creatures ashore. I have even done this myself.[4]

He went in quest of the father, and carried him as a gift a turtle, the shell of which required two men to lift it—so monstrous in size are the turtles in those seas; some of them I have seen and eaten.[5]

Eschscholtz appears to have been the first writer actually to identify a Philippine turtle. He published in his Atlas in 1835 a drawing of a turtle from Manila Bay under the name *Chelonia olivacea.* Only a few other writers have recorded species of turtles from the Philippine Islands.

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BOETTGER, OSKAR. Ber. Senck. Nat. Ges. (1890) 34.
Lists *Pelochelys cantorii* from the Philippines.

BOETTGER, OSKAR. Ber. Senck. Nat. Ges. (1890) 43.
Lists *Cyclemys amboinensis* from the Philippines.

BOETTGER, OSKAR. Herpetologische Kenntniss der Calamianen Philippinische Inseln. Abh. Ber. König. Zool. Anthr. Eth. Mus. Dresden **7** (1894–95) 1–6.
Lists *Cyclemys amboinensis* Daudin from Mindoro.

BOULENGER, GEORGE ALBERT. On the herpetological fauna of Palawan and Balabac. Ann. & Mag. Nat. Hist. VI **14** (1884) 81–90.
Lists *Cyclemys dhor* Gray from Palawan and Balabac.

BOULENGER, GEORGE ALBERT. Catalogue of the Chelonians, Rhynchocephalians, and Crocodiles in the British Museum (1889) 1–311, pls. 1–6.
Lists a few Philippine specimens.

CASTO DE ELERA. Catálogo sistemático de toda la Fauna de Filipinas conocida hasta el presente, etc. Manila. Vertebrados **1** (1895) 399–407.
Lists *Dermochelys coriacea* Linnæus, *Platysternum megacephalum*, *Callagur picta* Gray, *Ocadia sinensis* Gray, *Damonia reevesii* Gray, *Bellia crassicola* Gray, *Nicoria spengleri* Gray, *Cyclemys trifasciata* Gray, *C. amboinensis* Daudin, *C. flavomarginata* Gray, *C. platynota* Gray, *Chelone mydas* Linnæus, *C. imbricata* Strauch, *Thalassochelys caretta* Linnæus, *Trionyx subplanus* Geoffroy, *T. sinensis* Wiegmann, *Pelochelys cantorii* Gray, and *Chitra indica* Gray. Some of these species, certainly *Cyclemys amboinensis, Pelochelys cantorii,* and the four sea turtles, occur in the Islands; but I do not know of authentic preserved specimens of the other species here listed.

[4] Relation of the Filipinas Islands, Miguel de Loarca. Translated by Blair and Robertson, op. cit. **5** (1903) 167.

[5] Chirino's Relation. Translated by Blair and Robertson, op. cit. **13** (1904) 211.

DE ROOIJ, NELLIE. Reptiles of the Indo-Australian Archipelago 1 (1915) 283–332 (turtles).

Most of the species listed by Casto de Elera are also attributed to the Philippine Islands by de Rooij.

GRAY, JOHN EDWARD. Catalogue of the Tortoises, Crocodiles and Amphisbænians in the collection of the British Museum London (1844).

The following species are attributed to the Philippines: *Caouana olivacea* (= *Chelonia olivacea* Eschscholtz), *Chitra indica* Gray (= *Pelochelys cantorii*), *Testudo stellatus* var. (= *Testudo elegans* Gray), *Cistudo amboinensis* Gray (= *Cyclemys amboinensis* (Gray). *Testudo stellatus* is a doubtful record. Boulenger does not recognize it.[6]

GÜNTHER, ALBERT. List of mammals, reptiles and batrachians sent by Mr. Everett from the Philippine Islands. Proc. Zool. Soc. London (1879) 74–79.

Records *Cuora amboinensis* (= *Cyclemys amboinensis* Daudin) from Dinagat.

SIEBENROCK, F. Synopsis der rezenten Schildkröten. Zool. Jahrb. Suppl. **10** (1909) 427–618.

Attributes a number of species to the Philippine Islands, probably on the strength of Casto de Elera's records.

ECONOMIC IMPORTANCE OF TURTLES

The sea turtles are of distinct economic importance to the Philippines, the export of the shell amounting to several thousand pesos annually. During the fiscal year 1909 the export of tortoise shell reached 2,040 kilograms valued at 34,942 pesos.

The tortoise shell of commerce consists of the hard, bony plates taken from the carapace of the hawksbill turtle, *Eremochelys imbricata* Linnæus. The two largest costals are the most valuable, as they are thicker and heavier than the other shields.

Practically all the Philippine tortoise-shell is brought into the market by native fishermen. Now, while a small number of these turtles is captured by fair means, with hook, net, spear, or trap, by far the greater number is taken when they come ashore to deposit their eggs. The fishermen are so eager to secure their prizes that as a rule they do not give the poor turtle a chance to deposit her eggs before they kill her. This short-sighted policy eventually will result in the destruction of the fisheries unless the turtles are protected during the breeding season, which is from May to August. The turtle fishermen go to small, uninhabited islands, frequently many miles from the large islands surrounding the Sulu Sea, and wait perhaps days for the turtles to come ashore to deposit their eggs.

[6] There is a carapace in the Santo Tomás collection belonging to a species of *Testudo*, and there is a living specimen in the Mehan Gardens in Manila. Very probably these are not Philippine specimens.

If the men are in no especial hurry they may wait until the turtle has deposited her eggs, which sometimes are 150 to 200 in number, and about the size of hens' eggs, with tough leathery shells. The fishermen then kill her before she can reach the water, and dig up the eggs which they use as food. The islands of Bancoran, Lumbucan, Arena, Cavilli, and others in the Sulu Sea, are well-known nesting places of the turtle, and it is only necessary to visit these islands to see the destruction wrought during the nesting period.

The best method of removing the tortoise-shell from the back of the turtle is to immerse the back in boiling water until the shell loosens; another method is to bury the body in the sand for eight days, when the shell becomes loosened; still another is to hold the shell over a slow fire until loosened. This latter process usually is employed. In some countries the live animal is held over the fire until the shell is loosened; it is then turned loose "to grow another shell." This method is barbarous, not only for its cruelty but also for its lack of utility, for the animal promptly dies.

The methods employed in the working of tortoise-shell are quite similar to those used in working horn. As a matter of fact, horn frequently is used as an imitation of tortoise-shell. Slow heat or steam is employed, the shell becoming plastic by immersion in water of 90°C. for two minutes. When cool, it retains any shape given it while hot.[7]

The shell taken from the other marine turtles, *Chelonia japonica* and *Caretta olivacea*, is of little value. It is thin and its only value lies in using it for veneering and inlaying. The flesh of these two species, however, is much more frequently eaten than is that of the hawksbill. There are occasional cases recorded where persons have been poisoned by eating the flesh of these turtles. Sir J. E. Tennent [8] reports a case of poisoning from a specimen of *Chelonia virgata.*

At certain seasons the flesh of the turtle on the southwestern coast of Ceylon is avoided as poisonous, and some lamentable instances are recorded of deaths ascribed to its use. At Pantura, to the south of Colombo, twenty-eight persons who had partaken of turtle in October, 1840, were immediately seized with sickness, after which coma supervened, and eighteen died during the night. Those who survived said there was nothing unusual in the appearance of the flesh except that it was fatter than ordinary.

In November, 1917, there occurred in the Philippines a case of poisoning, from eating the flesh of a large turtle. Fourteen deaths resulting were reported out of thirty-three cases of poisoning. The following is the official communication. It was suspected that the flesh had been poisoned by some one, but an

[7] Seale, A., Philip. Journ. Sci. § D **6** (1911) 293.

[8] The Natural History of Ceylon. London, Longman, Green Longman, and Roberts (1861) 292.

examination of the flesh failed to reveal the presence of any poison.

BANTAYAN, *November 28, 1917.*

Dr. AUGUSTO P. VILLALON,
Oficial Sanitario del Distrito,
Cebú, Cebú.

SEÑOR: Bajo cubierta por separado tengo el honor de remitir a V. un ejemplar de la carne de tortuga, que, según anterior comunicación ha producido 33 envenenamientos, con 14 defunciones. Hemos considerado 33 envenenamientos porque éstos 33 son los únicos, que han tenido síntomas de tal.

Pero ahora estamos descubriendo otros, que sienten los síntomas después de 8 días. Felipa Espina y Cesario Espina han estado sin síntomas del envenenamiento por espacio de 8 días después de la ingestión de dicha carne, pero últimamente han tenido manifestaciones análogas a las de los fallecidos y fallecieron también después de 3 y 6 días respectivamente con gran tendencia al sueño y marcada debilidad.

Otro niño de dos años está en estado grave, pero hay esperanzas de curación.

Refiriéndome a los síntomas observados, consisten en mareos y vomitos persistentes, dolores en la garganta y los labios y somnolencia irresistible parecido al envenenamiento por la morfina. Pero lo más notable es la recidiva después de un tiempo bastante dilatado de curación. También es de notar la repentina tendencia al sueño desde el momento, que se observan las manifestaciones y aunque, al parecer, mejoran bajo los tratamientos empleados, sin embargo, vuelvan otra vez a agravarse hasta que por fin fallecen.

Someto a su consideración las anteriores observaciones y puedo someterle más informes, si fuese necesario.

Muy respetuosamente,

[Fdo.] SEGUNDO ISAAC,
Médico de Distrito Interino,
Sección Sanitaria No. 6.

Whether or not the species is poisonous only at this season (the case reported by Tennent occurred in October) or whether the animal becomes diseased is impossible to say.

Little is known regarding the large leatherback *Dermochelys schlegelii.* It is a very rare visitor to the Philippine coasts. I believe the specimen in the Ateneo de Manila is the only authentic Philippine specimen now preserved.

DISTRIBUTION OF TURTLES

The distribution of the genera of turtles occurring in southeastern Asia, Japan, and the Malay Archipelago is shown in Table 1. It is reasonable to expect that representatives of certain genera occurring in adjoining land masses will be eventually recorded from the Philippine Islands. Three of the species occurring in the Philippine Islands, *Cyclemys dhor, C. amboinensis,* and *Pelochelys cantorii,* are widely distributed in southeastern Asia and the Malay Archipelago. The fourth land species, *Heosemys leytensis,* is known only from Leyte.

TABLE 1.—*Distribution of eastern genera of turtles.*

Genus.	Japan.	Philippines.	Borneo.	Sumatra.	Java.	Malay Peninsula.	Celebes.	New Guinea.	Australia.
Devisia								×	
Ocadia	×								
Clemmys	×								
Callagur			×			×			
Orlitia			×	×					
Batagur				×		×			
Geoclemys	×				×	×			
Bellia			×	×		×			
Geoemyda	×		×	×					
Heosemys	×	×	×	×	×	×			
Cyclemys	×	×	×	×	×	×	×		
Testudo			×	×		×	×		
Chelodina								×	
Emydura								×	×
Carettochelys								×	
Chelonia	×	×	×	×	×	×	×	×	
Caretta	×	×		×	×	×	×	×	
Eretmochelys	×	×	×	×	×	×	×	×	
Dermochelys	×	×	×	×		×			
Dogania			×	×	×	×			
Pelochelys		×	×	×		×		×	
Amyda	×		×	×	×	×			

LOCAL PHILIPPINE NAMES OF TURTLES

Antipa (Tagalog) is *Pelochelys cantorii.*
Bao (Visayan) is *Cyclemys amboinensis* and *C. dhor.*
Bayuyuco (Tagalog) is *Cyclemys amboinensis.*
Cala (Tagalog) is a name applied to marine forms, especially *Eretmochelys imbricata.*
Pagong (Tagalog) is *Cyclemys amboinensis* and *C. dhor.*
Pauican (Tagalog) is a name applied to marine forms.
Pao (Pampanga) is *Cyclemys amboinensis.*
Sisican (Visayan) is *Eretmochelys imbricata.*

CLASSIFICATION OF THE TURTLES

Stejneger's [9] system of classification is followed in this paper.

Class REPTILIA

Reptilia LAURENTI, Synops. Rept. (1768) 19.

Subclass SYNAPSIDA

Synapsida OSBORN, Science 17 (1903) 276.

Order TESTUDINATA

Testudinata OPPEL, Ordn. Rept. (1811) 3.

Key to the Philippine suborders of Testudinata.[9]

a^1. No solid carapace, the vertebræ and ribs being separated from a shell consisting of a mosaic of numerous small polygonal bony plates embedded in a leathery skin; no descending process of the parietal bone; limbs without claws .... **Athecæ.**

a^2. A solid carapace, of a few large symmetrical bony plates, not separated from the underlying vertebræ and ribs; parietals with descending processes; limbs with at least one claw each.

b^1. Body covered with horny scutes arranged differently from the bony plates beneath; epiplastra and hyoplastra in contact, not separated by entoplastron; center of last cervical and first dorsal vertebræ articulating with each other; fourth digit never with more than three phalanges; jaws covered by horny sheaths not concealed under fleshy lips .... **Laminifera.**

b^2. Body covered by an undivided leathery skin without scutes; epiplastra separated by entoplastron from hyoplastra; last cervical vertebra articulating with first dorsal by zygapophyses only; fourth digit with more than three phalanges; jaws concealed under fleshy lips. **Chilotæ.**

Key to the Philippine families of turtles.[10]

a^1. Limbs clawless; skin with very numerous polygonal plates; back with five longitudinal keels or ridges (Athecæ) .... **Dermochelidæ.**

a^2. Limbs with at least one claw each; skin with or without large regular plates; back, if keeled, with at most only three longitudinal keels.

b^1. Outer body covering a soft skin without horny plates (Chilotæ). **Trionychidæ.**

b^2. Outer body covering consisting of symmetrical horny plates (Laminifera).

[9] Bull. U. S. Nat. Mus. 58 (1907) 483 and 484.

[10] A species belonging to the Platysternidæ has been incorrectly reported from the Philippines by Casto de Elera and by Siebenrock.

c^1. Limbs not paddle-shaped; four or five claws on each leg. **Testudinidæ.**

c^2. Limbs paddle-shaped; one or two claws on each leg.......... **Cheloniidæ.**

Suborder ATHECÆ

Athecæ COPE, Proc. Am. Assoc. Adv. Sci. **19** (1871) 235.

DERMOCHELIDÆ

Dermochelidæ STEJNEGER, Bull. U. S. Nat. Mus. **58** (1907) 485.

Genus **DERMOCHELYS** Blainville

Dermochelys BLAINVILLE, Jour. de Phys. **83** (1816) 259; Bull. Soc. Philom. (1816) 119; BOULENGER, Cat. Chel. Rhyn. Croc. Brit. Mus. (1889) 7; Fauna India, Rept. (1890) 50; STEJNEGER, Bull. U. S. Nat. Mus. **58** (1907) 485, figs. 373–376.

Sphargis MERREM, Tent. Syst. Amph. (1820) 19; FITZINGER, Neue. Class. Rept. (1826) 5; DUMÉRIL and BIBRON, Erp. Gén. **2** (1835) 559; GRAY, Cat. Tort. (1844) 51; Cat. Shield Rept. **1** (1855) 71; Suppl. Cat. Shield Rept. (1870) 119.

Coriudo FLEMING, Philos. Zool. **2** (1822) 271.

Scytina WAGLER, Isis (1828) 861.

Dermatochelys WAGLER, Nat. Syst. Amph. (1830) 133; STRAUCH, Chel. Stud. (1862) 58; GÜNTHER, Rept. Brit. India (1864) 55.

Chelyra RAFINESQUE, Atlan. Jour. **1** (1832) 64.

Dorsal shield completely bony, exoskeleton consisting of irregular, juxtaposed, mosaiclike plates. Plastral elements eight; no entoplastron; legs paddle-shaped, clawless, digits of foreleg much elongated; phalanges without condyles; beak with two triangular cusps, between three deep notches; no enlarged alveolar surface, jaws simply sharp-edged; head covered with small shields; carapace with seven keels, plastron with five.

It is extremely difficult to determine whether there is more than one species belonging to this genus. Specimens belonging to the genus are found in temperate and tropical parts of the Atlantic and Pacific Oceans and in the Indian Ocean and the Mediterranean Sea. Certain authors maintain that the Atlantic and Pacific forms are identical. Garman has separated the Atlantic and the Pacific forms and has given the name *D. schlegelii* to specimens found in the Pacific and Indian Oceans, and Stejneger follows him in the retention of this name. R. A. Philippi has described a species, *Sphargis angustata,* from Chili.[11]

[11] Ann. de Univers. Mem. Cient. Lit. (1899) 102–104, 730, 2 plates.

Until it can be proved that *D. schlegelii* and *D. coriacea* are identical, I believe that Garman's name should stand for the species occurring in the western Pacific and Indian Oceans.[12]

Dermochelys schlegelii (Garman).

Sphargis mercurialis TEMMINCK and SCHLEGEL, Fauna Japon., Rept. (1835) 6, pl. 1; pl. 2, figs. 3–5; pl. 3; OKADA, Cat. Vert. Japan (1891) 71.

Sphargis coriacea BLEEKER, Natuurk. Tijds. Neder. Indië **15** (1850) 260; TICKEL, Journ. As. Soc. Bengal **4** (1862) 367; MCCOY, Nat. Hist. Victoria **2** (1885) 1.

Dermochelys coriacea GÜNTHER, Rept. Brit. India (1864) 55; BOULENGER, Cat. Chel. Rhyn. Croc. Brit. Mus. (1889) 10; Fauna Brit. India, Rept. (1890) 50; BURNE, Proc. Zool. Soc. London **1** (1905) 291.

Sphargis coriacea var. *schlegelii* GARMAN, Bull. U. S. Nat. Mus. **25** (1884) 303.

Sphargis schlegelii GARMAN, Bull. U. S. Nat. Mus. **25** (1884) 295; STEJNEGER, Bull. U. S. Nat. Mus. **58** (1907) 485.

Description of species.—Head covered with small horny plates, usually with a transverse row across snout posterior to nostrils; a rather large parietal plate and a row of elongate scales in supra-ocular region; scales on occipital and temporal regions small, irregular; carapace covered with small, irregular, angular shields of nearly equal size; a small supracaudal extension of carapace; five dorsal keels composed of larger quadrangular shields; two lateral keels; plastron continuous with carapace below, composed of small shields; plastron with five keels, outer keels forming an angle near axilla and continuing to anterior point of plastron; legs large, paddle-shaped; forelegs without claws, in young about as long as carapace, shorter in adult; mouth with a strong beak, with two triangular cusps between three deep notches; jaws sharply edged; alveolar region not enlarged.

Color.—Dark brown above, with or without yellow spots; longitudinal keels yellow in the young, and the legs bordered with yellow.

[12] Garman, Bull. U. S. Nat. Mus. **25** (1884) 294, says: "However, there is only one case in which there is any doubt, that of *Sphargis*, of which specimens from the different oceans are so much alike that writers are still undecided whether there is more than one species. Certain respects in which the Pacific "Trunkbacks" differ from those of the Atlantic have induced me to separate them, distinguishing the former by the name *Sphargis schlegelii*, and the latter by that by which it is commonly known, *Sphargis coriacea*."

Measurements of Dermochelys schlegelii (Garman).[13]

	mm.
Total length	1,500
Length of carapace	1,238
Width of plastron	842
Length of foreleg	763
Length of plastron	1,000
Length of hind leg	422
Transverse diameter of eye	52
Length of head	200
Width of head	176

Remarks.—This huge sea turtle, commonly known as *Sphargis coriacea,* is included here on the strength of a large stuffed specimen in the Ateneo de Manila, which was caught at Malabon, Manila Bay, and has been in the museum for a number of years. It is adult and measures more than 2 meters from head to end of carapace.

Suborder LAMINIFERA

Laminifera HEMPRICH, Grundr. Naturg. (1820) 102.

TESTUDINIDÆ

Testudinidæ GRAY, Ann. Phil. **10** (1825) 210.

EMYDINÆ

Emydinæ, GRAY, Ann. Phil. **10** (1825) 210, part.

Turtles without paddle-shaped legs, and with more than two claws on each digit.

Many genera are associated under this subfamily, and these constitute most of the species of known turtles. They are widely distributed in all temperate and tropical countries. They are terrestrial and aquatic and are both vegetable and animal feeders.

There are only two genera positively known from the Philippines; these are *Cyclemys* and *Heosemys.* Representatives of several other genera are attributed to the Philippine Islands by Casto de Elera,[14] Siebenrock,[15] and de Rooij.[16] Among these are *Callagur, Bellia, Geöemyda, Ocadia,* and *Damonia.* It is not impossible that representatives of some of these genera will be found in the Philippine Islands, but I believe there are no authentic specimens preserved in any collection.

[13] After Schlegel, Fauna Japon. (1835) 9.
[14] Cat. Fauna Filipinas **1** (1895) 400, 401.
[15] Zool. Jahrb. Suppl. **10** (1909) 450–508.
[16] Rept. Indo-Aust. Arch. **1** (1915) 288–307.

Key to the Philippine genera of the Emydinæ.

a^1. A temporal arch; plastron not attached solidly to carapace.
Cyclemys.

a^2. No temporal arch; plastron attached solidly to carapace........ Heosemys.

Genus CYCLEMYS Bell

Terrapene MERREM, Tent. Syst. (1820) 27; BELL, Zool. Journ. (1825) 308, part; FITZINGER, Neue Class. Rept. (1826) 6; STRAUCH, Chel. Stud. (1862) 25.

Kinosternon BELL, Zool. Journ. 2 (1825) 302, part.

Sternothærus BELL, Zool. Journ. 2 (1825) 305, part.

Emys WAGLER, Nat. Syst. Amph. (1830) 138, part; STRAUCH, Chel. Stud. (1862) 27; Mém. Acad. Sci. St.-Pétersburg 38 (1890) 14.

Sternothærus WAGLER, Nat. Syst. Amph. (1830) 137.

Cistudo GRAY, Syst. Rept. (1831) 17, part; DUMÉRIL and BIBRON, Erp. Gén. 2 (1834) 207; GRAY, Cat. Tort. (1844) 29.

Cyclemys BELL, Proc. Zool. Soc. London (1834) 17; GRAY, Cat. Shield Rept. 1 (1855) 42; GÜNTHER, Rept. Brit. India (1864) 15; GRAY, Suppl. Cat. Shield Rept. 1 (1870) 22; BOULENGER, Cat. Chel. Rhyn. Croc. Brit. Mus. (1889) 128; Fauna India, Rept. (1890) 28; STEJNEGER, Bull. U. S. Nat. Mus. 58 (1907) 503; SIEBENROCK, Sitzb. Ak. Wiss. Wien 112 (1903) 340; Zool. Jahrb. Suppl. 10 (1909) 500; MOCQUARD, Rev. Colon. Rept. Indo-Chine 10 (1907); DE ROOIJ, Rept. Indo-Aust. Arch. 1 (1915) 301.

Cuora GRAY, Cat. Shield Rept. 1 (1855) 22; GÜNTHER, Rept. Brit. India (1864) 11; GRAY, Suppl. Cat. Shield Rept. 1 (1870) 21.

Pyxidea GRAY, Proc. Zool. Soc. London (1863) 175; GÜNTHER, Rept. Brit. India (1864) 16; GRAY, Suppl. Cat. Shield Rept. (1870) 20.

Pyxiclemys GRAY, Proc. Zool. Soc. London (1863) 176.

Cystoclemmys GRAY, Suppl. Cat. Shield Rept. (1870) 20.

Notochelys GRAY, Suppl. Cat. Shield Rept. (1820) 21; GÜNTHER, Rept. Brit. India (1864) 17.

Head normal, with smooth leathery skin, undivided into plates or tubercles; choanæ between eyes; skull with a bony temporal arch and a broad postorbital arch; neural plates hexagonal; plastron united to carapace by a ligament, divided into two lobes, movable between hyoplastron and hypoplastron; alveolar surfaces without median ridge; entoplastron intersected by humero-pectoral suture; digits webbed or nearly free; four clawed digits on hind foot, five on forefoot; tail short.

The two Philippine species, *Cyclemys amboinensis* and *C. dhor*, are widely distributed from southern and southwestern Asia throughout the Malay Archipelago. Casto de Elera also lists *Cyclemys platynota* Gray, *C. flavomarginatus* Gray, and *C. trifasciata* Gray. I have been unable to verify these records.

Key to the Philippine species of Cyclemys.

a^1. Plastron not completely closing shell; posterior margin of carapace serrated .... C. dhor Gray.

a^2. Plastron nearly completely closing shell in adult; posterior margin of carapace not serrated... C. amboinensis Daudin.

Cyclemys amboinensis (Daudin). Plate 1, figs. 1 and 2; Plate 2, figs. 3 and 4; Plate 3, figs. 2 and 3.

Testudo amboinensis DAUDIN, Rept. 2 (1802) 309.
Emys amboinensis SCHWEIGGER, Prodr. (1824) 45.
Emys couro SCHWEIGGER, Prodr. (1824) 46; SCHLEGEL, Fauna Japon., Rept. (1833) 63.
Terrapene amboinensis MERREM, Tent. Syst. Amph. (1820); STRAUCH, Chel. Stud. (1862) 99; Verth. Schildkr. (1865) 47; SOWERBY and LEAR, Tort. (1872) pl. 23.
Kinosternum amboinensis BELL, Zool. Journ. (1825) 305.
Terrapene bicolor BELL, Zool. Journ. (1825) 484, pl. 16.
Terrapene couro FITZINGER, Neue Class. Rept. (1826) 45.
Cistudo amboinensis GRAY, Syn. Rept. (1831) 19; Ill. Ind. Zool. 1 (1832) pl. 57, fig. 2; DUMÉRIL and BIBRON, Erp. Gén. 2 (1835) 215, pl. 15, fig. 2 (Manila); GRAY, Cat. Tort. (1844) 30 (from Philippines); GEIBEL, Zeit. f. ges. Natur. 27 (1866) 11.
Cuora amboinensis GRAY, Cat. Shield Rept. 1 (1855) 41; GÜNTHER, Rept. Brit. India (1864) 12, pl. 4, figs. *a, b*; GRAY, Suppl. Cat. Shield Rept. 1 (1870) 21; Appendix (1872) 10; THEOBALD, Cat. Rept. Brit. India (1876) 7; GÜNTHER, Proc. Zool. Soc. London (1879) 75 (Dinagat); MÜLLER, I Nachtr. Cat. Herp. Samml. Mus. Basel (1880) 49 (Luzon, Negros); BOETTGER, Ber. Senck. Nat. Ges. (1886) 92.
Cyclemys amboinensis BOULENGER, Cat. Chel. Rhyn. Croc. Brit. Mus. (1889) 133; Fauna India, Rept. (1890) 31, fig. 10; Fascic. Mal. Zool. 1 (1903) 343; FLOWER, Proc. Zool. Soc. London (1896) 859; (1899) 614; WERNER, Zool. Jahrb. Syst. 13 (1900) 482; LAIDLAW, Proc. Zool. Soc. London 2 (1901) 582; BOETTGER, Abh. Senck. Ges. Frankfurt 25 (1901) 364; SIEBENROCK, Sitzb. Akad. Wiss. Wien 112 (1903) 343; Zool. Jahrb. Suppl. 10 (1909) 503; DE ROOIJ, Rept. Indo-Aust. Arch. 1 (1915) 302; BARBOUR, Mem. Mus. Comp. Zool. Harvard Coll. 44 (1912) 143.

Description of species.—(From No. 1460, Bureau of Science collection; collected on Polillo, P. I., October, 1909, by C. Canonizado.) Head moderately large, completely retractile; snout bluntly pointed, nostrils anterior, very close together; eyes diagonally set; upper jaw with only slight hook, finely denticulated; top of head covered with smooth leathery skin, undivided; a very slight elevation on skull just behind eyes; carapace smooth, convex, with a single median keel, dim anteriorly, but distinct posteriorly; five vertebral shields, only third longer than wide, all narrower than costals; latter shields wider than long, four on each side; eleven marginals on each side; a small nuchal, longer than wide; supracaudals small, longer than wide, slightly notched; posterior edge of carapace not or but very slightly serrate; plastron about the size of opening of shell, only slightly pointed behind with notch in posterior part; gular shields small, longer than wide, without notch, suture between them much longer than that between humerals; transverse suture between humerals and pectorals curved, the curve convex anteriorly; pectorals as broad as long, their mutual suture as long as or a little shorter than mutual suture of abdominals; femorals broader than long, suture between them and abdominals curved, the curve convex posteriorly; anals longer than broad, triangular, their mutual suture as long as that between abdominals; hinge between pectorals and abdominals very flexible; sutures between pectorals and marginals about same as that between abdominals and marginals; foreleg moderately long, with five clawed digits, claws more than half the length of digits; a short web between digits; forearm with numerous broadened scales; two large scutes and two small ones on inner side of arm, four large unequal-sized scutes on underside of foreleg; bottom of foot covered with small equal-sized scales; toes covered with imbricate plates, five above longest toe; hind leg longer than foreleg, with four clawed digits; a few enlarged scutes on posterior side of leg; no large scales on upper or anterior side; a few enlarged scales on heel and numerous unequal-sized scales on foot, larger than those on forefoot; tail short, with a double series of subcaudal plates, twelve or thirteen pairs in all; exposed skin of body covered with fine tubercles.

Color in life.—(From a living specimen in the Bureau of Science aquarium.) Brown above, with very indistinct darker areas on back; below, marginals yellow, each with a large black area on outer posterior edge; plastral scales each with a large irregular black blotch covering about one-third of each scute; head uniform dark brown above; a broad brown stripe as wide as head continuing on neck; a yellow stripe from point of snout along canthus rostralis through upper part of orbit and across temporal region where it widens slightly; a dark brown line begins below the yellow one on point of snout, runs through eye, then widens and continues on side of neck to body; a second yellow stripe begins on snout, below the brown line, and passes through eye to ear where it is lost in the yellow of side of neck; below this a brown line crosses lower part of orbit to ear; below this another yellow line with a thin brown line below it; a brown line borders lower jaw and continues to below ear; chin and throat yellow to flesh color; a short black stripe on posterior part of neck on side; legs mottled with gray; forelegs usually with dim light stripes, continuing on toes.

Measurements of Cyclemys amboinensis (Daudin).

	mm.
Total length, head extended	238
Total length of carapace	158
Greatest width of carapace	110
Height of body	70
Length of plastron	150
Width of plastron	78
Length of posterior lobe	84
Length of anterior lobe	65
Length of tail, behind anus	20
Length of head	38
Width of head	24

Variations.—In the Bureau of Science collection there are three other adult specimens from Polillo and five young ones. The adults all agree in the smoothness of the carapace; in two (Nos. 1463 and 1464) the trace of the dorsal keel is almost effaced, and the anal shields are fused into a single large shield. In the specimen described they are only partially fused. In the fourth specimen (No. 1462) the two plates are distinct. This specimen has a broad regular depression along the middle of the plastron, while in the other three the plastrons are gently convex. A specimen (No. 1475) from Laguna Province, Luzon, exhibits a partial fusion of the anal shields and only a dim trace of the dorsal keel. The amount of black on the plastron varies considerably. In certain specimens the black almost covers the entire plastron; in others it is almost wanting.

Young.—The young differ rather markedly from the adults. A very strong, blunt keel from nuchal plate to end of last vertebra; vertebral shields distinctly wider than long, very nearly as wide as costals; two fine distinct keels passing along upper half of costals; marginals very much broader proportionally than in the adult; carapace very finely sculptured; plastron with a distinct, transverse depression across hinge; anal plates distinct, suture of abdominal plate with the marginals larger than that of pectoral with the marginals. Carapace uniform dark brown; dark color on plastron forming a single continuous figure and not reaching outer edge of scutes; dark areas at union of plastron with marginals, and dark spots on underside of marginals.

There are two other adult specimens in the Bureau of Science collection. In a living specimen in the Bureau of Science aquarium the carapace retains the three keels; the shields are roughly sculptured on the upper posterior parts and the concentric growth lines are very distinct, with a few, slight, radiating ridges. The posterior edge of the carapace is distinctly serrate and there is a distinct notch between the supracaudals; there is a small notch in the plastron between the anals. The very important character of the posterior serrations on the carapace suggests a distinct geographic race. The locality from which the specimens came is unknown.

Remarks.—Turtles of this species are fairly common in the Philippine Islands or at least are frequently seen, because they are often kept as pets. The adults are often found at a considerable distance from water; the young, however, are aquatic. The species is known from Luzon, Polillo, Dinagat, and Mindanao. It ranges from southeastern Asia through the Malay Archipelago to Celebes and Amboina. The name for the species in the Visayan dialects is *bao*.

Cyclemys dhor Gray.[17] Plate 2, figs. 1 and 2; Plate 4.

Emys dhor GRAY, Syn. Rept. (1831) 20, part.

Cyclemys orbiculata BELL, Proc. Zool. Soc. London (1834) 17; Mon. Test. (1842) pls. 24 and 25; GRAY, Proc. Zool. Soc. (1863) 178; THEOBALD, Journ. Linn. Soc. 10 (1870) 12.

Emys dentata GRAY, Ill. Ind. Zool. 2 (1834) pl. 58, fig. 2.

Cistudo diardii DUMÉRIL and BIBRON, Erp. Gén. 2 (1834) 227.

Cistudo dentata GRAY, Cat. Zool. (1844) 32.

Emys diardii SCHLEGEL, Verli. Natuurk. Afbeeld. 44 (1849) figs. 6 and 7.

Cyclemys dentata GRAY, Cat. Shield Rept. 1 (1855) 42, pl. 19; JERDON, Proc. As. Soc. Bengal (1820) 68; THEOBALD, Cat. Rept. Brit. India (1876) 8.

Emys dhor STRAUCH, Chel. Stud. (1862) 28; Verth. Schildkr. (1865) 58.

Cyclemys oldhami GRAY, Proc. Zool. Soc. London (1863) 178; GÜNTHER, Rept. Brit. India (1864) 15, pl. 5, fig. 6; GRAY, Suppl. Cat. Shield Rept. 1 (1870) 23.

Cyclemys ovata GRAY, Proc. Zool. Soc. London (1863) 178; Suppl. Cat. Shield Rept. 1 (1870) 23.

Cyclemys bellii GRAY, Proc. Zool. Soc. London (1863) 179.

Cistudo orbiculata GEIBEL, Zeits. f. ges. Natur. 27 (1866) 13.

Cyclemys dhor GRAY, Suppl. Cat. Shield Rept. 1 (1870) 23; BOULENGER, Cat. Chel. Rhyn. Croc. Brit. Mus. (1889) 131; Fauna India, Rept. (1890) 30; Ann. & Mag. Nat. Hist. VI 14 (1894) 82 (Palawan); BARTLETT, Note Book Sarawak 1 (1894) 3; FLOWER, Proc. Zool. Soc. London (1899) 613; CARRUCCIO, Boll. Soc. Zool. Ital. II 1 (1900) 95; WERNER, Zool. Jahrb. Syst. 13 (1900) 482; BROWN, Proc. Acad. Nat. Sci. Philadelphia 54 (1902) 176; SIEBENROCK, Sitzb. Akad. Wiss. Wien 112 (1903) 341; Zool. Jahrb. Suppl. 10 (1909) 501; MOCQUARD, Rev. Col. Paris (1907) 11; DE ROOIJ, Rept. Indo-Aust. Arch. 1 (1915) 302.

[17] Stejneger is of the opinion that the name *dentata* should be retained rather than *dhor*, see Mem. Mus. Comp. Zool. 44 (1912) 143. Gray, in his later work, chose *dhor* as the name for retention.

Description of species.—(From a living adult specimen,[13] belonging to W. Schultze, Manila, P. I., collected in Palawan.) Head moderately large, completely retractile. Snout slightly peaked just above nostrils, curving in profile from nostrils to mouth; nostrils anterior, very close together; upper jaw with a distinct bicuspid hook; top of head covered with smooth skin, skin in temporal region and on side of head distinctly lined and broken; a slight elevation across skull just behind eyes; head somewhat depressed in occipital region; carapace smooth, distinctly flattened on top, with an obscure keel from nuchal along median line to supracaudals, more prominent posteriorly; a slight broad depression on each side of keel; five vertebral shields, all distinctly broader than long, except first, which is as broad as long, all narrower than the three anterior costals; costals distinctly broader than long, except last, which is longer than broad; eleven marginals on each side; nuchal very small, a little longer than broad; supracaudals moderate, not or scarcely notched behind; carapace somewhat serrated on posterior border, smoothly rounded laterally and with an irregular border anteriorly; plastron about as large as opening of shell, anterior part extending a little beyond anterior edge of carapace, posterior part not extending as far as carapace; a transverse hinge between hyoplastron and hypoplastron, this hinge not corresponding to suture between pectoral and abdominal shields; however, plastron flexible on suture between pectorals and abdominal shields; gular shields triangular, their anterior edges truncate, forming a straight line, their mutual suture much longer than that between humerals; a slight but distinct notch between humerals and gulars on edge of plastron; suture between humerals and pectorals forming a wavy line; suture between pectorals and abdominals curving strongly, convex posteriorly; mutual suture of pectorals longer than that of other shields; suture of pectorals with marginals much shorter than that of abdominals with marginals; suture between abdominals and femorals curved slightly convex posteriorly; suture between anals and femorals strongly curved convex anteriorly; anals with a curved notch, their mutual suture longer than that of femorals; intercalary, axillary, and inguinal shields very small; on anterior part of humerals a trace of a straight suture corresponding to hinge; the two elements formed by the suture are entirely coalesced; anterior part of foreleg covered with irregular enlarged shields; digits five, partly

[13] I am under obligation to Mrs. W. Schultze for the privilege of describing this specimen.

webbed, all covered above with transverse scales, each equipped with a strong curved claw; forefoot with small irregular scutes on sole; on underside of foreleg only a few enlarged scutes; hind leg with four digits, each equipped with strong curved claws; hind leg with no enlarged scales except on heel; tail with eight pairs of enlarged subcaudal scales.

Color in life.—Above, carapace light brown, with a few darker spots and a few dim longitudinal spots along keel; plastron and marginals brownish yellow, with distinct radiating lines on each plastral shield; head brownish yellow, with small dark spots on neck with numerous lines of black and yellow; a prominent yellowish line begins in occipitotemporal region, continuing the length of neck; a second prominent line begins immediately behind eye and continues above ear to body; chin and throat lined with black and yellow; upper part of legs somewhat reddish.

Measurements of Cyclemys dhor Gray.

	mm.
Length of carapace	192
Width of carapace	145
Height of carapace	70
Length of plastron	187
Width of plastron	117
Tail, from anus	40

Variation.—Besides the specimen described I have at hand two preserved specimens;[19] one is medium-sized, the other young.

The medium-sized specimen appears somewhat abnormal or diseased, and it is almost impossible to discern the suture between the shields of the carapace; the keel is obliterated save on the posterior part of the carapace. Head brown, strongly mottled with black, markings on side of head and neck somewhat obscured; each abdominal shield divided completely by a straight suture corresponding to hinge of plastron; elements thus formed not contiguous.

The young specimen has a very strong blunt keel the entire length of the carapace; middle costal shields with a small keel on their posterior parts; all shields rugose; marginals distinctly broader proportionally than in adults; posterior part of carapace very strongly serrate, posterior marginals forming sharp points; a very distinct notch between supracaudals; anterior part of carapace serrate; plastron apparently without hinge; no trace

[19] These specimens are unnumbered and belong to the University of the Philippines. They were loaned by Prof. Artemas Day and Dr. R. P. Cowles.

of suture across abdominal shields; a small axillary and a small inguinal shield; no intercalary scutes evident; humerals and abdominals forming direct sutures with marginals; plastral shields rugose. Carapace above olive or yellowish brown, with no dark markings; below very light brown, with dark brown radiating lines around the edges of each shield of plastron and marginals; head with a slight median keel from tip of snout, surface of occipital region finely sculptured; markings on head and neck similar to those of the adult.

There is a carapace of an adult specimen in the Bureau of Science collection which differs from the shell of the adult specimen described, in having the entire outer part of the carapace almost entirely dark blackish brown, and the upper part of the costals and the vertebrals with radiating dotted lines; the carapace is rugose, showing distinctly the lines of growth; the abdominal shields have a strong trace of a suture on their anterior parts.

TABLE 2.—*List of Philippine specimens of Cyclemys dhor Gray.*

No.	Collection.	Locality.	Collector.	Age.
1	W. Schultze	Palawan	W. Schultze	Adult
2	University of the Philippines	Leyte	G. Lopez	do
3	Do	do	do	Young
4	Bureau of Science	Palawan		Adult

No.	Condition.	Carapace.			Plastron.	
		Length.	Width.	Height.	Length.	Width.
		mm.	*mm.*	*mm.*	*mm.*	*mm.*
1	Living	192	145	70	187	117
2	Preserved	154	115	68	146	93
3	Do	75	70	22	64	48
4	Shell	180	148	73	177	120

Remarks.—Individual variation in this widely distributed species is strongly marked. It varies greatly at different ages. One can scarcely find two specimens that are wholly alike. The species is terrestrial in habit, apparently only the young frequenting water. In the Philippines the species is known from Palawan, Balabac, and Leyte. It probably occurs on other large islands. It was first reported from the Philippine Islands by Boulenger [20] in 1894, on the strength of specimens collected by Everett. The species is known from Java, Borneo, Sumatra,

[20] Ann. & Mag. Nat. Hist. VI 14 (1894) 82.

and Nias, Natuna Islands, Banka, Malay Peninsula, Burma, Siam, Annam, and northern India.

Genus HEOSEMYS Stejneger

Geoemyda GRAY, Proc. Zool. Soc. London (1834) 100, part; Cat. Tort. (1844) 14; Cat. Shield Rept. (1855) 16; GÜNTHER, Rept. Brit. India (1864) 18; GRAY, Suppl. Cat. Shield Rept. 1 (1870) 25; ANDERSON, Zool. Res. Yunnan (1879) 716; BOULENGER, Cat. Chel. Rhyn. Croc. Brit. Mus. (1889) 135; Fauna India, Rept. (1890) 23; STRAUCH, Mém. Acad. Sci. St.-Pétersburg **38** (1890) 15; SIEBENROCK, Sitzb. Akad. Wiss. Wien **112** (1903) 340; MOCQUARD, Rev. Colon. (1907) 11; DE ROOIJ, Rept. Indo-Aust. Arch. 1 (1915) 298.

Emys DUMÉRIL and BIBRON, Erp. Gén. 2 (1834) 232, part.

Clemmys STRAUCH, Chel. Stud. (1862) 28, part.

Heosemys STEJNEGER, Proc. Biol. Soc. Washington **15** (1902) 238; SIEBENROCK, Zool. Jahrb. Suppl. **10** (1909) 506.

Neural plates mostly hexagonal, short-sided behind; plastron extensively united to carapace by suture; entoplastron intersected by humeropectoral suture; skull lacking a bony temporal arch; anterior part of head covered with undivided smooth skin, posterior occipital and temporal regions with skin divided into scale-like elements; triturating surface of upper jaw rather narrow, without a median ridge; digits fully or partly webbed; five clawed digits on forefoot, four on hind foot; tail very short.

The generic name *Heosemys* was made by Stejneger to include the three species long known under the generic name *Geoemyda*. The latter name, as shown by Stejneger, must stand for the species associated under the name *Nicoria* Gray.

There are three well-known species belonging to the genus *Heosemys;* namely, *H. spinosa* Gray, widely distributed from Burma to the Malay Peninsula and Archipelago; *H. grandis* Gray, found in Burma, the Malay Peninsula, and French Indo-China; and *H. depressa* Anderson, known from Arrakan. A fourth species, from Leyte, Philippine Islands, is here described.

Key to the species of Heosemys Stejneger.

a^1. Anterior margin of carapace serrated.
- b^1. Plastron strongly narrowed in front, with a strong notch between gular and humeral shields; plastron uniform yellow or reddish brown .... **H. leytensis sp. nov.**
- b^2. Plastron moderately narrowed in front, with no notch or only a slight one between gular and humeral shields; plastral shields with radiating lines........ **H. spinosa Gray.**

a^2. Anterior margin of carapace not serrated.
- b^1. Carapace arched or tectiform in a transverse section. **H. grandis Gray.**
- b^2. Carapace depressed, flat on vertebral region. **H. depressa Anderson.**

Heosemys leytensis sp. nov. Plate 1, figs. 3 and 4; Plate 3, fig. 1.

Type.—An unnumbered specimen in the zoölogical laboratory, University of the Philippines; collected at Cabalian, southern Leyte, P. I., by Gregorio Lopez.

Description of type.—Adult male. Head large, anterior part covered with smooth undivided skin; skin on posterior part of head and in temporal region divided into scalelike elements; snout bluntly pointed, nostrils anterior, separated by a distance equal to or greater than diameter of a single nostril; eye rather small, slit diagonally, diameter of orbit distinctly less than length of snout; upper jaw with a distinct hook, slightly bicuspid; triturating surface of upper jaw narrow, with an indistinct short ridge or keel near inner edge; choanæ between eyes; ear slightly farther from eye than eye from end of snout; carapace smooth above, rather flattened, with no trace of a keel; vertebral shields all wider than long (fifth anomalous and very irregular and broken, forming an extra costal between it and fourth costal on left side) ; costals four on each side normally, much broader than long, much broader than vertebrals; eleven marginals on each side; nuchal triangular, broadest posteriorly; anterior marginals touching nuchal, extending far anterior to nuchal and about five times as large as nuchal; supracaudal plates not or but slightly notched, partially fused; anterior part of carapace deeply notched and serrate; laterally smooth, rounded; posteriorly moderately serrate; plastron narrower, very much smaller than opening of shell, not as long as carapace and not extending as far anteriorly, narrowed in front; plastron joined to carapace by strong bony suture; no intercalary shields; a small axillary and an inguinal shield; narrowest part of bridge contained in total length of plastron a little more than two and one-half times; gular shields quadrilateral, outer sides parallel for a distance equal to about half the length of shield; a large angular notch between gular shields and another between gulars and humerals; mutual suture of gulars longer than that of humerals, the latter somewhat less than suture between pectorals; abdominal shields large, not as broad as pectorals, their mutual suture longer than pectoral or femoral; a deep, more or less semicircular notch between anal shields, suture between anals abnormal; foreleg with transversely somewhat enlarged irregular scales; four prominent scales on upper edge of arm, the two median much the largest; a large transverse scale on heel of forefoot and a few small scales on back part of scale; five digits, each with a strong curved claw, digits fully webbed, foot cushionlike; one or two small scales at base of claws; four digits on hind foot with strong curved claws; enlarged scutes on upper edge of hind leg and a few small ones on heel, none on sole; two or three enlarged scutes above digits near ends; tail very short, without enlarged scales above or below; skin on legs, body, and neck with minute tubercles, giving it a feel like sandpaper.

Color in alcohol.—Above reddish rusty brown, darker on anterior marginals; uniform reddish brown on plastron, darkest on bridge and on anterior part; head uniform dark brown, slightly lighter posteriorly; a narrow transverse yellow line crossing posterior part of head and continuing to posterior border of ear; upper part of neck dark; lighter, more or less reddish brown on sides and underside of neck; legs dark above, lighter below.

Measurements of Heosemys leytensis sp. nov.

	mm.
Total length, tip of snout to end of tail	330
Length of carapace	210
Width of carapace	145
Height of carapace	70
Length of plastron	180
Width of plastron	115
Length of head	55
Width of head	42
Depth of head	31
Eye to ear	15
Eye to tip of snout	13

Variation.—A second specimen from the same locality is medium-sized and differs in a number of characters from the adult. A dim keel in posterior part of carapace; distinct diagonal grooves in upper part of costal shields, parallel to their sutures with vertebrals; all shields of carapace showing lines of growth; carapace dimly serrate anteriorly, nuchal notch rather shallow; marginals bordering nuchal not extending anterior to nuchal more than half its length (in the adult they extend beyond the nuchal a distance about equal to its length); a distinct notch between supracaudals; plastron similar to that of adult; carapace brown; plastron yellow; top of head brown, dimly mottled in temporal region; two very distinct transverse yellow lines on sides of head which barely fail to meet dorsally, these lines continuing below ear; a yellow spot on each side of lower jaw. Length of carapace, 126 millimeters; of plastron, 118.

Remarks.—Only these two specimens are known. Both are from the same locality in Leyte. The species can be readily distinguished by the absence of the temporal arch and by the yellow ring on the posterior part of the head.

CHELONIIDÆ

Cheloniidæ Cope, Proc. A. Philos. Soc. 20 (1882) 143.

Large turtles with paddle-shaped legs; nine plastral bones covered with epidermal horny shields; caudal vertebræ procœlous; neck not completely retractile; temple roofed over, parietal bone in contact with squamosal; one or two claws on each leg.

Genus **ERETMOCHELYS** Fitzinger

Caretta Ritgen, Nova Acta Acad. Leop.-Carol. 14 (1828) 270 (not of Rafinesque).
Eretmochelys Fitzinger, Syst. Rept. (1843) 30.
Onychochelys Gray, Proc. Zool. Soc. London (1873) 397.

Marine turtles, having paddle-shaped legs, each with two claws; carapace with four pairs of costals and two pairs of prefrontal scales; scales of carapace imbricating, with three keels; two keels on plastron.

The turtles of this genus furnish the precious tortoise-shell of commerce, which is an important article of export from the Philippine Islands.

Eretmochelys imbricata (Pennant). Plate 5, figs. 1 and 2; Plate 6, figs. 5 and 6.

Testudo imbricata Pennant, Ind. Zool. (1769) 87.
Chelonia Eretmochelys imbricata Fitzinger, Syst. Rept. (1843) 30.
Eretmochelys imbricata Agassiz, Contr. 1 (1857) 381; Stejneger, Report U. S. Nat. Mus. for 1902 (1904) 719.
Chelonia imbricata Schweigger, Prodr. Mon. Chel. (1814) 21.
Caretta imbricata Merrem, Syst. Amph. (1820) 19.
Onychochelys kraussii Gray, Proc. Zool. Soc. London (1873) 398.
Chelonia virgata Wagler, Icon. et Desc. Amph. (1833) pl. 29.
Chelonia multiscutata Kuhl, Beitr. (1820) 78.
Chelone imbricata Boettger, Ber. Senck. Nat. Ges. (1886) 93 (Jolo).
Eretmochelys squamata Agassiz, Contr. Nat. Hist. U. S. Am. 1 (1857) 382; Garman, Bull. Mus. Comp. Zool. Harvard Coll. 25 (1883) 300.
Caretta imbricata Kelaart, Rept. Ceylon 1 (1852) 180.
Caretta squamosa Girard, U. S. Expl. Exp., Rept. (1858) 442.
Caretta rostrata Girard, U. S. Expl. Exp., Rept. (1858) 446.
Eretmochelys squamosa Stejneger, Bull. U. S. Nat. Mus. 58 (1907) 511.

Description of species.—(From No. 1474, Bureau of Science collection; collected at Aparri, Luzon, November, 1908.) Snout beaked, somewhat projecting over lower jaw; nostrils small, vertical; postnasal shields moderate, five-sided, entering orbit;

prefrontals much larger than postnasals, pentagonal, forming a straight median suture; azygous prefrontal hexagonal; frontal large, eight-sided, with a small suture entering anteriorly, forming its longest sutures with supra-ocular, wider than long; two equal-sized parietals, distinctly shorter than frontal; a large temporal scale bordering frontal; supra-ocular and parietal on each side; three postocular shields entering orbit, two lower largest; these bordered by temporals; two upper temporal elements larger than lower; a large elongate shield on either side of lower jaw; region above eye with small irregular scales; lower lid with tubercular scutes; carapace covered with large imbricating shields; five vertebral shields; four pairs of costal shields; eleven marginal shields on each side; a single nuchal shield; a pair of supracaudal shields; vertebrals with a strong vertebral keel; two lateral keels on upper part of costal; posterior edge of each shield with a thornlike point; posterior edge of carapace strongly serrate; plastral elements normal; a single azygous scute between gulars; pectoral and abdominal shields largest; plastron separated from carapace by a series of four enlarged intercalary shields; a few small axillary shields, largest between humeral and first intercalary; a single small inguinal scale; plastron with two strong keels with a prominent depression between them; legs paddlelike, anterior much larger than posterior; inner side of leg with eight shields, broader than long; tip of leg with two enlarged shields, separated by a smaller shield; outer side of leg with sixteen scutes, two of which bear distinct claws; hind legs with eleven scutes on anterior edge, two of which bear small claws; tail very short, not extending to tip of carapace.

Color in alcohol.—Above deep brown, streaked or mottled with amber of varying shades; legs similar; head shields blackish brown, lighter on sutures; lateral shields amber, with brown spots; plastron yellow to amber, with a brown spot on posterior part of each shield.

Measurements of Eretmochelys imbricata (Linnæus).

	mm.
Total length	244
Length of carapace	173
Width of carapace	130
Length of plastron	134
Width of plastron, across pectorals	81
Length of foreleg	98
Length of hind leg	53
Length of head	47
Width of head	30

Variation.—A very young specimen, measuring 105 millimeters to end of carapace, is dark blackish brown to black; tips of marginals and outer edges of legs yellowish; plastron black; body skin blackish; scutes of head, carapace, and plastron identical with those of the described specimen. A carapace in the Bureau of Science collection measures 395 millimeters. There are three specimens living in the Bureau of Science aquarium.

Remarks.—The turtle here described appears to be of the species figured by Stejneger[21] under the name *Eretmochelys imbricata*. Between Stejneger's drawing and the described specimen in the Bureau of Science collection there is no appreciable difference.

Genus **CARETTA** Rafinesque

Caretta RAFINESQUE, Specchio Sci. Palermo 2 (1814) 66.
Thalassochelys FITZINGER, Ann. Wien Mus. 1 (1835) 121.
Caouana COCTEAU in Sagra's Hist. Fis. Pol. Nat. Cuba, Rept. 4 (1838) 31.

Marine turtles with paddle-shaped legs; two pairs of prefrontals present; five or more pairs of costal shields; shields on back not imbricate.

Caretta olivacea (Eschscholtz). Plate 6, figs. 1 and 2.

Chelonia olivacea ESCHSCHOLTZ, Zool. Atlas 1 (1829) pl. 3 (Manila Bay).
Caouana olivacea GRAY, Cat. Tort. (1844) 53 (Philippines); GÜNTHER, Rept. Brit. India (1864) 52 (seas of Philippines).
Caretta olivacea GARMAN, Bull. Mus. Comp. Zool. Harvard Coll. 52 (1908) 9.
Thalassochelys olivacea BOETTGER, Ber. Senck. Nat. Ges. (1886) 93.
Thalassochelys caretta CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 404 (Manila Bay).

Description of species.—(From a specimen living in the Bureau of Science aquarium.) Anterior pair of prefrontals distinctly smaller than second pair; a small, rather elongate azygous prefrontal between the two supra-oculars; frontal large, much wider than long, followed by four parietals; a large temporal (or parietal) element follows supra-ocular shield and borders frontal and outer parietal; three postocular shields, upper smallest, middle largest, lower elongate; postoculars bordered by four temporals, second from top largest; a distinct median keel on carapace, more prominent posteriorly; six pairs of costals; nuchal divided; six vertebral shields, fifth very small; thirteen marginals on each side; two supracaudals; plastron normal;

[21] Report U. S. Nat. Mus. for 1902 (1904) 718, figs. 193–197.

four large shields between carapace and plastron; a small inguinal shield and a group of eight axillary shields, four of which touch pectorals and humerals; a small round shield behind anal shields.

Color in life.—Above olive drab to gray, rather lighter about suture; sides and underside of neck whitish; plastron whitish.

Measurements of Caretta olivacea (Eschscholtz).

	mm.
Length of carapace	340
Width of carapace	325
Height of carapace	110
Length of foreleg	260
Width of foreleg	70
Length of hind leg	180
Width of hind leg	70
Length of plastron	275
Width of plastron	280
Length of tail, from anus	15
Length of head, to end of parietals	90
Depth of head	55

Variation.—This species is known to be subject to a great amount of variation. Thus the usual number of costals is five; but in the Manila specimen figured by Eschscholtz there appear to be seven on one side and six on the other, with seven vertebrals; there are thirteen marginals on each side. I am uncertain whether the nuchal is divided. There are several characters about Eschscholtz's figure that differ markedly from my specimen, but these may be due to poor drawing. The squamation of the neck, the position of the nostrils, the shape of the occipital region, and the squamation of the legs—all appear to differ greatly.

Remarks.—This species and an agamid lizard appear to be the first recorded Philippine reptiles. The species is not rare and is taken frequently in Manila Bay.

Genus CHELONIA Latreille

Chelonia BRONGNIART, Bull. Soc. Philom. Paris 2 (1800) 89 (*nomen nudum*); LATREILLE, Hist. Nat. Rept. 1 (1802) 22; WAGLER, Syst. Amph. (1830), 132, part; GRAY, Syn. Rept. (1831) 51; DUMÉRIL and BIBRON, Erp. Gén. 2 (1835) 530; Cat. Zool. (1844) 54; Cat. Shield Rept. 1 (1855) 74; GIRARD, U. S. Expl. Exped., Herp. (1858) 452; GÜNTHER, Rept. Brit. India (1864) 52; GRAY, Suppl. Cat. Shield Rept. (1870) 119; STEJNEGER, Bull. U. S. Nat. Mus. 58 (1907) 509.

Chelone BRONGNIART, Mem. Sav. Etrang. 1 (1806) 610; STRAUCH, Chel. Stud. (1862) 59; BOULENGER, Cat. Chel. Rhyn. Croc. Brit. Mus. (1889) 180.

Chelonias RAFINESQUE, Specchio. Sci. Palermo 2 (1814) 66.

Caretta MERREM, Tent. Syst. Amph. (1820) 19, part; GRAY, Cat. Tort. (1844) 53; Cat. Shield Rept. (1855) 73.

Mydas COCTEAU, in Sagra's Hist. Fis. Pol. Nat. Cuba 4 (1838) 22; GRAY, Suppl. Cat. Shield Rept. (1870) 119.

Chelonia japonica (Thunberg). Plate 7, figs. 1 to 4.

Testudo japonica THUNBERG, Svensk. Vetensk. Acad. Nya Handl. **8** (1787) 178, pl. 7, fig. 1.

Chelonia japonica SCHWEIGGER, Prodr. Mon. Chel. (1814) 21.

Chelonia virgata SCHWEIGGER, Prodr. Mon. Chel. (1814) 21.

Chelonia viridis TEMMINCK and SCHLEGEL, Fauna Japon., Rept. (1835) pl. 4, figs. 4, 5, 6; pl. 6, figs. 1, 2.

Chelonia japonica STEJNEGER, Bull. U. S. Nat. Mus. **58** (1907) 509; GARMAN, Bull. Mus. Comp. Zool. Harvard Coll. **52** (1908) 8.

Description of species.—(From a living specimen in the Bureau of Science aquarium.) Head large; beak somewhat hooked; a single pair of large prefrontals, longer than wide, that on right side partially broken; a small azygous hexagonal prefrontal between supra-oculars, which are larger; four postoculars on left side, five on right side, lowest largest; frontal large, somewhat notched in front, bordered behind by five parietals; frontal and parietals bordered by two temporals; postoculars bordered by four shields, two upper largest; this series of temporals followed by five or six unequal-sized shields and two or three very small ones, making a total of about twenty shields in temporal region behind eye; supra-ocular region with a series of small shields; lower jaw with narrow mental followed by a large elongate shield which is followed by several smaller ones; carapace smooth; five vertebral shields; four pairs of costals; eleven pairs of marginals, first pair in contact with first vertebral on either side of nuchal, which is single; a pair of supracaudals; legs long, with a single claw, anterior edge of front leg with fifteen shields, about ten on posterior edge; a round isolated shield near upper part of underside of leg not bordering outer edge; anterior part of hind leg with eight shields; a single claw present; plastron smooth, attached to carapace by four large intercalary plates; six distinct axillary scales; pectoral shields widest on plastron.

Color in life.—Above rusty reddish brown, each shield streaked with amber, head shields distinctly reddish, each edged with black; shields on side of head dark, with yellow along sutures; shields on legs with black centers; plastron yellow.

Measurements of Chelonia japonica (Thunberg).

	mm.
Total length	735
Length of carapace	555
Width of carapace	470
Height of carapace	180
Length of plastron	448
Width of plastron, across pectoral	290
Length of head	125
Width of head	90
Depth of head	100
Tail, behind anus	28

Variations.—The head shields of this species are subject to more or less variation. In a second specimen living in the aquarium there is a second pair of prefrontals bordering the nasal area but not touching the beak. These shields are small and irregular.

Remarks.—The species is common in the Philippine Islands. Specimens have been kept alive in the aquarium. They are very frequently taken in Manila Bay. They are fed on fish.

Suborder CHILOTÆ

Chilotæ WIEGMANN, Handb. Zool. (1832) 167.

This suborder consists of one family.

TRIONYCHIDÆ

Trionychidæ BELL, Zool. Journ. 3 (1828) 515.

Carapace and plastron without outer scales or shields and not entirely ossified, covered with leathery skin; head completely retractile; no external ear; bony part of jaws concealed under thick lips; three digits with claws; nostrils at end of a flexible proboscis.

Only a single genus of this family is positively known from the Philippine Islands. Species of three other genera have been reported but probably erroneously. They are the following:

Dogania subplana (Geoffroy Saint Hilaire.) Reported by Casto de Elera[22] as *T* [*rionyx*] *subplanus*, from Mindanao and Palawan, with specimens in the Santo Tomás Museum and in turn listed from the Philippines by Siebenrock[23] and de Rooij,[24] on the strength of Casto de Elera's record. No specimen is now in the Santo Tomás Museum.

Chitra indica Gray. This species was first reported from the Philippine Islands by Gray, who later made the specimen the type

[22] Cat. Fauna Filipinas 1 (1895) 407.

[23] Zool. Jahrb. Suppl. 10 (1909) 606.

[24] Rept. Indo-Aust. Arch. 1 (1915) 326.

of *Pelochelys cumingii*, which is now regarded as synonymous with *P. cantorii*. Casto de Elera also reports the species from the Philippines, locality Palawan, with a specimen in the Santo Tomás Museum. This specimen is no longer extant.

Trionyx sinensis Wiegmann. Reported by Casto de Elera from the Batan Islands, and later by Siebenrock on the strength of the former record. The specimen reported as present in the Santo Tomás Museum is no longer extant.

Dogania subplana occurs in Java and Borneo; Stejneger regards its presence in Formosa as doubtful. *Chitra indica* is known only from India. *Trionyx sinensis* occurs in Formosa, and a specimen has been reported from Timor.

Genus **PELOCHELYS** Gray

Chitra GRAY, Cat. Shield Rept. 1 (1855) 70, part; GÜNTHER, Rept. Brit. India (1864) 50.

Pelochelys GRAY, Proc. Zool. Soc. London (1864) 89; (1873) 40; Suppl. Cat. Shield Rept. 1 (1870) 90; BOULENGER, Cat. Chel. Rhyn. Croc. Brit. Mus. (1889) 262; Fauna India, Rept. (1890) 15; STRAUCH, Mém. Acad. Sci. St.-Pétersburg VII 38 (1890) 34; BAUR, Ann. & Mag. Nat. Hist. VI 7 (1891) 445; Proc. Am. Phil. Soc. 31 (1893) 221; OGILBY, Proc. Roy. Soc. Queensland 19 (1905) 29; SIEBENROCK, Zool. Jahrb. Suppl. 10 (1909) 606.

"Outer extremities of the nuchal plate overlying the second dorsal rib; neural plates well developed. Limbs completely exposed. Hyoplastron distinct from hypoplastron; not more than five plastral callosities. Bony choanæ between the orbits; jaws weak; postorbital arch as broad as the diameter of the orbit; pterygoids posterior border free, without ascending process." (*Boulenger.*)

Only one species of the genus is known.

Pelochelys cantorii Gray. Plate 6, figs. 3 and 4.

Chitra indica GRAY, Cat. Tort. (1844) 49, part; Cat. Shield Rept. (1855) 49; GÜNTHER, Rept. Brit. India (1864) 50, pl. 6, fig. C.

Gymnopus indicus CANTOR, Cat. Mal. Rept. (1847) 10.

Pelochelys cantorii GRAY, Proc. Zool. Soc. London (1864) 90, figs. 9 and 10; (1869) 215; THEOBALD, Journ. Linn. Soc. (1868) 10; Cat. Rept. Brit. India (1876) 28; BAUR, Proc. Am. Phil. Soc. 31 (1893) 221; OGILBY, Proc. Roy. Soc. Queensland 19 (1905) 29; SIEBENROCK, Zool. Jahrb. Suppl. 10 (1909) 607.

Pelochelys cumingii GRAY, Proc. Zool. Soc. London (1864) 90; Cat. Shield Rept. Suppl. (1870) 91 (type locality Philippines).

Pelochelys bibronii GRAY, Proc. Zool. Soc. London (1864) 90; Cat. Shield Rept. Suppl. (1870) 91.

Pelochelys cantoris BOULENGER, Cat. Chel. Rhyn. Croc. Brit. Mus. (1889) 263; Fauna India, Rept. (1890) 15; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 406; FLOWER, Proc. Zool. Soc. London

(1899) 621; WERNER, Zool. Jahrb. 13 (1900) 483; SIEBENROCK, Sitz. Ber. Wiss. Wien 111 (1902) 832, fig. 12; 112 (1903) 350; Zool. Jahrb. Suppl. 10 (1909) 607.

Pelochelys cantori DE ROOIJ, Rept. Indo-Aust. Arch. 1 (1915) 331.

Description of species.—"Costal plates eight pairs, the last well developed and forming a median suture; a single neural between the first pair of costals; plates coarsely pitted and vermiculate. Dorsal skin of young tuberculate. Epiplastra small and widely separated; entoplastron forming a right or an acute angle; plastral callosities largely developed. Head moderate; snout very short and broad; proboscis very short; interorbital space broader than the greatest diameter of the orbit; mandible narrowest at the symphysis, olive above, uniform or spotted with darker; lips and throat of young olive, speckled with whitish; plastron whitish." (*Boulenger.*)

A living specimen in the Bureau of Science aquarium has the following measurements:

Measurements of Pelochelys cantorii Gray.

	mm.
Length of carapace	350
Width of carapace	315
Height of carapace	76
Length of plastron	295
Width of plastron	290
Total length, head extended	630

The following characters are evident in the living aquarium specimen: Carapace moderately flat, composed of a bony inner part surrounded by a wide, soft, cartilaginous rim, the part above the neck bending down strongly, more or less covered with fine sculpturing and rounded tubercles; bony part sculptured and more or less pitted; soft part of carapace posteriorly with lines crisscrossed at nearly right angles; on the sides these lines longitudinal and not crossing; a depressed area running lengthwise of carapace medially; three inner toes of fore and hind legs with long, strong claws, the claw of inner toe largest; the two outer toes not extending beyond the edge of the strong web which extends along the leg; a small callosity at base of inner toes on both feet; a strong scalelike callosity across outer part of foreleg, three callosities in the web on outer side of foreleg; one large, elongate callosity in the web on posterior side of hind leg, a heavy widened scalelike callosity on heel; head very large, much widened in temporal region; proboscis short; lips very thick; eye small, with a dark line in front and behind pupil; tail very short behind anus.

Color in life.—Head above olive, with minute black dots; carapace olive, with a few darker and lighter striations along the median dorsal part; outer edge olive, with small spots of darker and lighter color; plastron flesh color, with a few white dots on anterior part; chin and throat with minute dots of black and white.

Remarks.—The specimen [25] in the aquarium was captured in 1918 at San Miguel, Bulacan Province, Luzon, by Mr. Genesio Páting, and was presented to the aquarium by Mr. George Symmonds, of Manila. The turtle does very well in captivity and takes food regularly. The food given is small dead fish. In the same tank are kept specimens of *Cyprinus carpio* (Chinese carp), and *Megalops cyprinoides* (buan-buan), and these living fish are not molested. When living specimens of *Ophiocephalus striatus* (the mud fish, or *dalag*), were placed in the same aquarium they were frequently killed. In Luzon the species is known as *antipa;* it appears to be rare. Individuals grow to be more than a meter long.

[25] The turtle here mentioned died since this paper was written.

ILLUSTRATIONS

[Photographs by E. Cortes.]

PLATE 1

FIG. 1. *Cyclemys amboinensis* (Daudin); a medium-sized specimen, showing serrations on posterior part of carapace.
2. *Cyclemys amboinensis* (Daudin); an old specimen, without serrations and with differently shaped carapace.
3. *Heosemys leytensis* sp. nov.; from the type, dorsal view.
4. *Heosemys leytensis* sp. nov.; from the type, ventral view.

PLATE 2

FIG. 1. *Cyclemys dhor* Gray; young, dorsal view, somewhat reduced.
2. *Cyclemys dhor* Gray; young, ventral view.
3. *Cyclemys amboinensis* (Daudin); young, dorsal view, somewhat reduced.
4. *Cyclemys amboinensis* (Daudin); ventral view.

PLATE 3

FIG. 1. *Heosemys leytensis* sp. nov.; head of the cotype, from Leyte, enlarged.
2. *Cyclemys amboinensis* (Daudin); ventral view of an old specimen, showing no serrations on the posterior border of the carapace.
3. *Cyclemys amboinensis* (Daudin); ventral view of a variety with the posterior border of the carapace serrated; reduced.

PLATE 4

FIG. 1. *Cyclemys dhor* Gray; dorsal view of a carapace in the Bureau of Science collection, with rather distinct posterior serrations.
2. *Cyclemys dhor* Gray; ventral view.
3. *Cyclemys dhor* Gray; a living specimen owned by Mr. W. Schultze, of Manila; dorsal view, reduced.
4. *Cyclemys dhor* Gray; ventral view, reduced.

PLATE 5

FIG. 1. *Eretmochelys imbricata* (Pennant); a young specimen from Aparri, Luzon; dorsal view.
2. *Eretmochelys imbricata* (Pennant); ventral view.

PLATE 6

FIG. 1. *Caretta olivacea* (Eschscholtz); a young specimen in the Bureau of Science aquarium; dorsal anterior view, reduced.
2. *Caretta olivacea* (Eschscholtz); ventral posterior view.
3. *Pelochelys cantorii* Gray; a living specimen, in the Bureau of Science aquarium; dorsal anterior view, reduced.
4. *Pelochelys cantorii* Gray; ventral posterior view.

FIG. 5. *Eretmochelys imbricata* (Pennant); a living specimen, in the Bureau of Science aquarium; dorsal anterior view, reduced.

6. *Eretmochelys imbricata* (Pennant); ventral posterior view.

PLATE 7

FIG. 1. *Chelonia japonica* (Thunberg); a living specimen, in the Bureau of Science aquarium; dorsal anterior view, reduced.

2. *Chelonia japonica* (Thunberg); ventral anterior view.

3. *Chelonia japonica* (Thunberg); young dorsal view.

4. *Chelonia japonica* (Thunberg); ventral view.

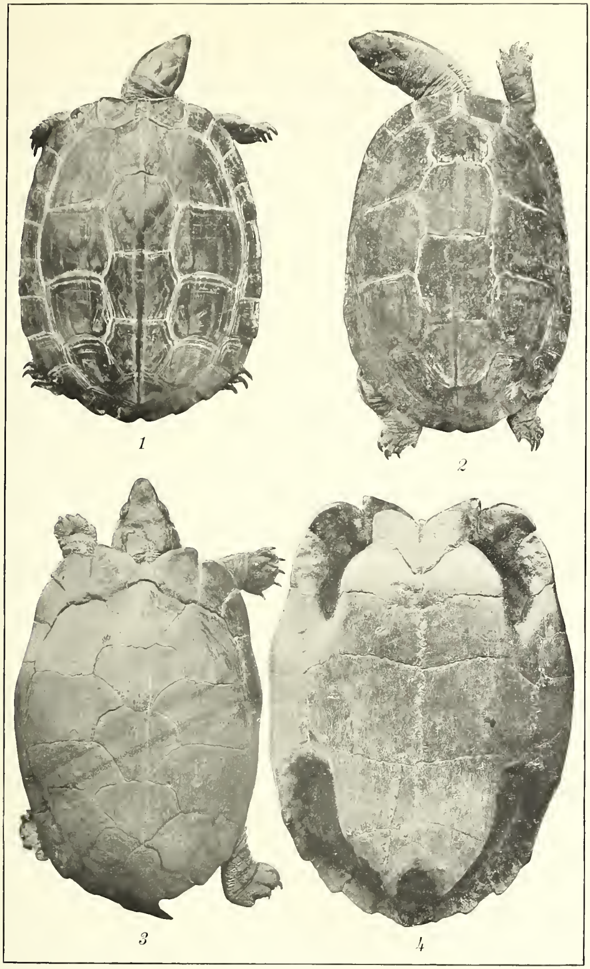

PLATE 1. PHILIPPINE TURTLES.

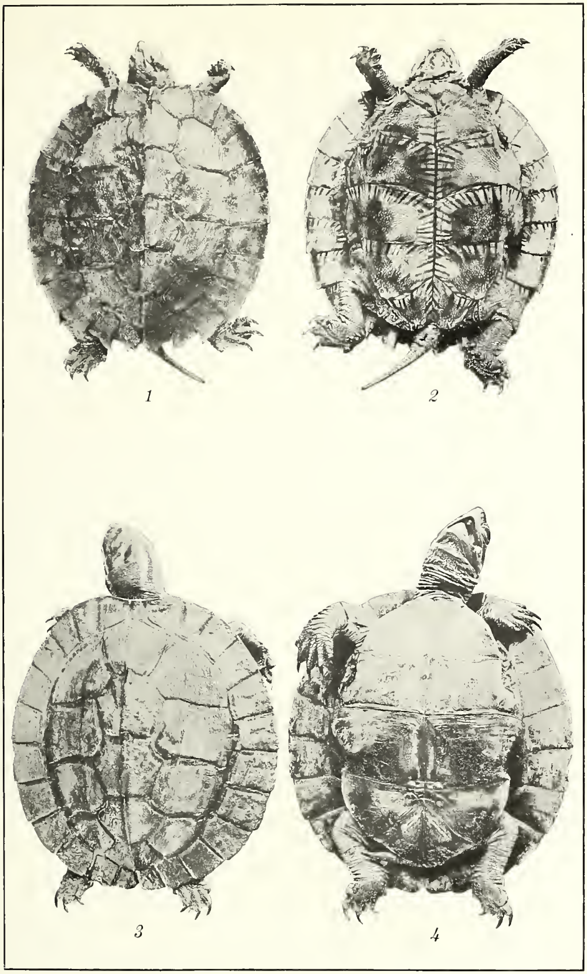

PLATE 2. TWO SPECIES OF CYCLEMYS.

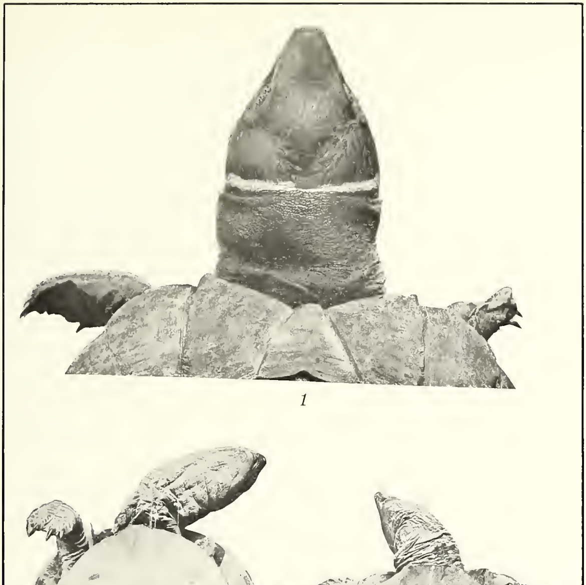

PLATE 3. PHILIPPINE TURTLES.

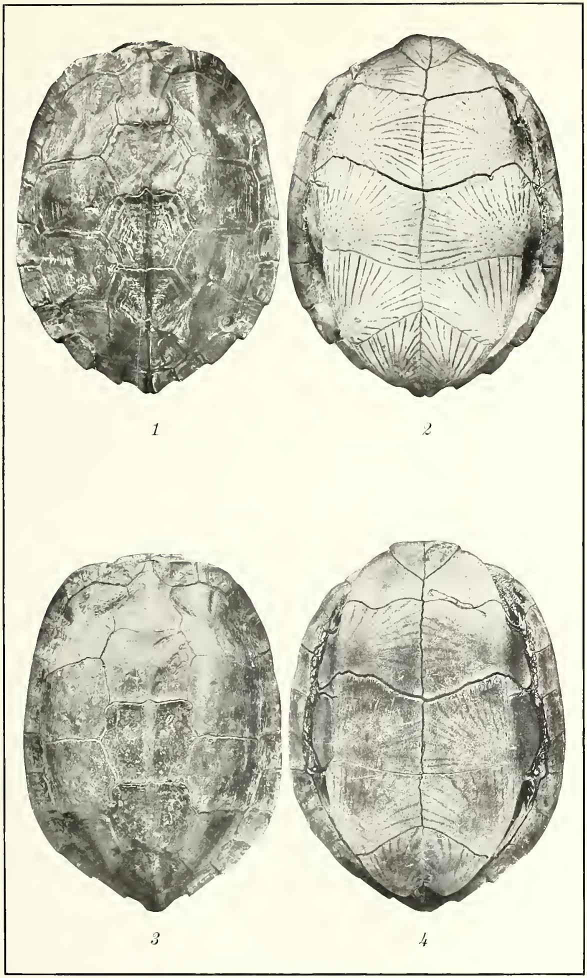

PLATE 4. CYCLEMYS DHOR GRAY.

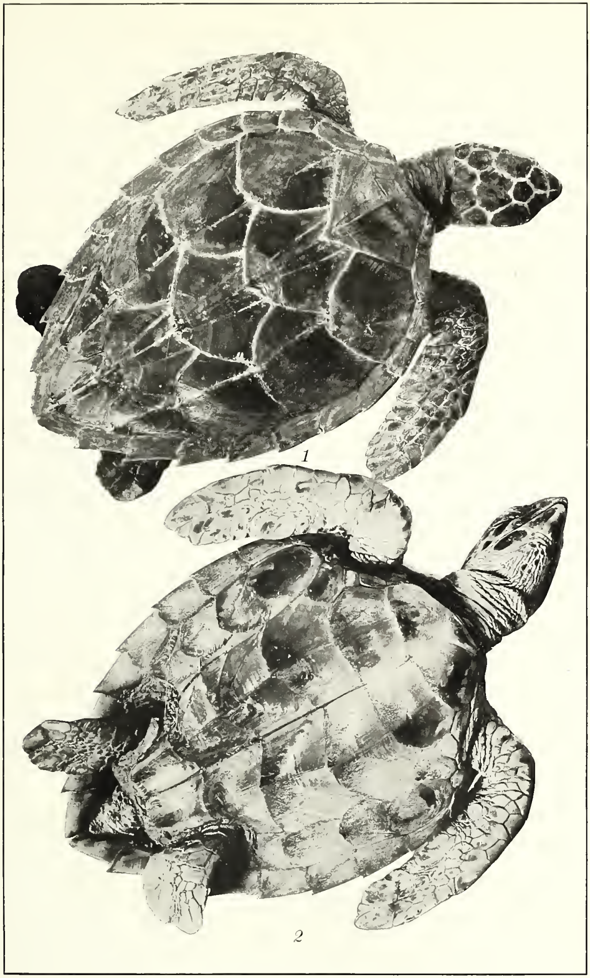

PLATE 5. ERETMOCHELYS IMBRICATA (PENNANT).

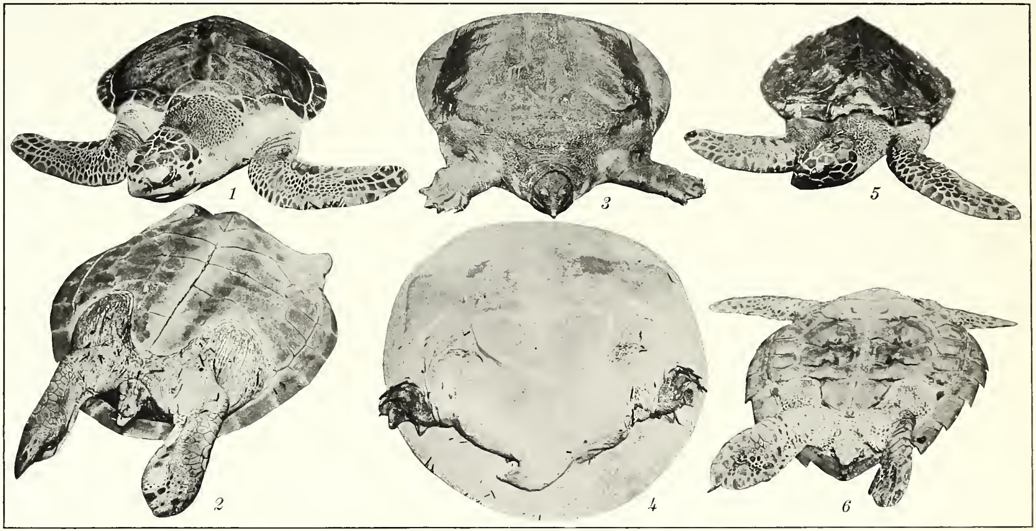

PLATE 6. PHILIPPINE TURTLES.

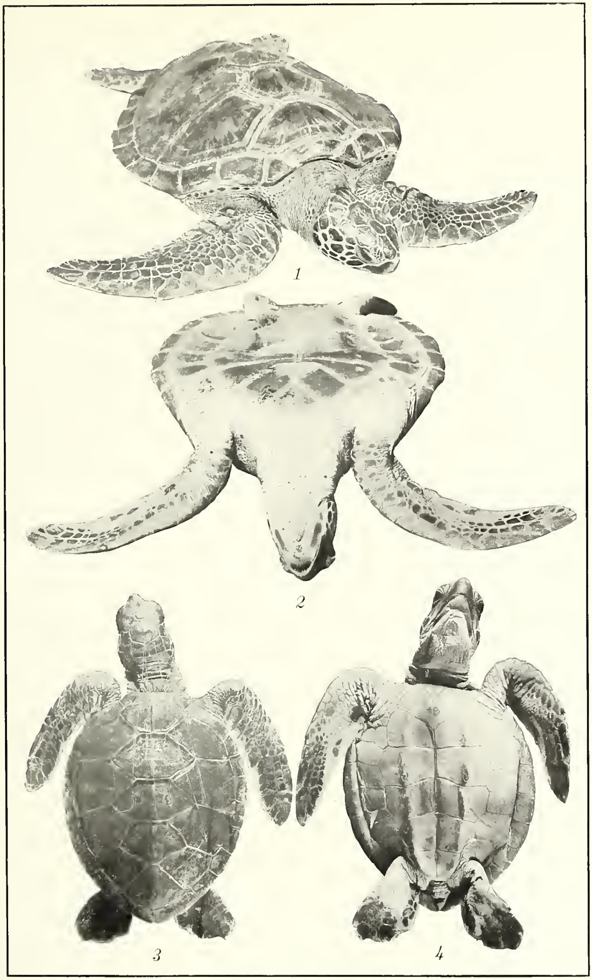

PLATE 7. CHELONIA JAPONICA (THUNBERG).

SOME BEES FROM PANAY

By T. D. A. Cockerell

Of the University of Colorado

During May, June, and July, 1918, Mr. R. C. McGregor collected insects at Culasi, on the west coast of Panay, and on Batbatan Island, off Panay. Many species of various orders were found, but the present report deals only with the bees.[1] Since no bees had been collected on Panay or Batbatan, the collection was examined with a lively expectation of novelties. It has been rather surprising to find only one new species, a very fine and distinct *Nomia* from Culasi. A *Megachile* from Culasi represents a new variety or subspecies, but with these two exceptions the insects all agree with those previously found in other islands of the Archipelago. Among the previously known forms, however, was the striking carpenter bee *Mesotrichia cuernosensis,* of which I had only a single female, from Negros. It is evidently common on Panay, and the male, previously unknown, was obtained. As in the case of several other species of *Mesotrichia,* it is very unlike the female in appearance; the thorax with orange-fulvous hair, and the abdomen appearing blackish green.

All that we know of Philippine bees shows that the lowland faunæ of the several islands are very much alike, and suggests that most of the islands have been connected in comparatively recent times. Even the apparent differences in the faunæ are probably due largely to the imperfection of our knowledge, though there are undoubtedly species which do not extend all over the Archipelago, and probably some at least are really peculiar to particular islands. It should be added that we know very little, comparatively speaking, of the upland bees, and these may be expected to show more precinctive types.

CULASI

Apis indica nigrocincta (Smith).

Thirteen workers.

[1] One of the most interesting of the other insects is a remarkable orthopteron looking like a small piece of wood, collected at Culasi. Mr. Rehn has kindly identified it for me as *Misythus cultatrix* (Walker).

Mesotrichia cuernosensis Cockerell.

Eighteen females; the anterior wings from 19 to 23.4 millimeters long. The smallest specimens, compared with the largest, look very different, but there are many intermediate sizes. Previously known from Negros. There are also three males which I can only associate with this species, of which the male has not been previously known. They are extremely like the male which I have referred to *M. bakeriana,* but are larger (anterior wing, about 20 millimeters), with rich orange-tawny hair on thorax above, median band on clypeus not reaching transverse band (which is narrow in middle), a well-defined tubercle just below clypeal margin, and labrum with yellow hair (tubercle absent and labrum fringed with copper-red hair in *bakeriana*). One female of this species was collected at Flores, a barrio near Culasi, at flowers of *Stachytarpheta jamaicensis* (Linn.) Vahl.

Mesotrichia latipes (Drury).

Seven females and three males. The wings are purple and green, the amount of purple varying. This species is widely distributed in tropical Asia. It nests in wood and may have been introduced in the Philippine Islands by man.

Mesotrichia major (Maidl).

Two males.

Ceratina tropica Crawford.

Two females.

Ceratina philippinensis Ashmead.

Ten females and nine males.

Ceratina sexmaculata Smith.

Two males and fourteen females. One female was taken at flowers of *Melastoma polyanthum* Blume on May 26.

Allodape marginata Smith.

Three females. One has the clypeal mark as in *A. mindanaonis,* and all have the hair of hind legs reddish. I think they all belong to the same species, but males are needed to make certain.

Crocisa crucifera Cockerell.

Twenty-one specimens. The abdominal markings vary from blue to greenish.

Anthophora korotonensis Cockerell. (*A. stantoni* Cockerell.)

Eleven females and ten males. One male at flowers of *Stachytarpheta jamaicensis* (Linn.) Vahl.

Nomada mindanaonis Cockerell.

One female. Previously known from Mindanao and Palawan. The abdomen of the Panay example is clear red, and the insect is larger than those from Mindanao.

Megachile subrixator Cockerell.

Three females.

Megachile hera Bingham.

Three females.

Megachile valdezi Cockerell.

Two females. One has long black hair at extreme sides of third and fourth abdominal segments, in the other this is hardly noticeable. The specimens agree with the type of *M. valdezi* in being considerably larger than *M. hera* or *M. subrixator*.

Megachile chlorura Cockerell.

One female.

Megachile metallescens Cockerell.

Two females.

Megachile mcgregori Cockerell.

One male. Differs from the type by having the hair bands at sides of abdominal segments 2 to 4 suffused with fulvous. This may be the male of *M. metallescens,* which occurs in the same two localities. The abdomen is not at all metallic; but otherwise, aside from the usual sexual differences, the insects are very much alike.

Megachile rufofulva Cockerell var. **panayensis** var. nov.

One female. Compared with the unique type from Mindanao, this is much more robust, with much broader thorax and abdomen, and with more black hair on front and scutellum. Probably a distinct subspecies is indicated, but more specimens are needed to prove the case. For the present we may designate the Culasi insect variety *panayensis* var. nov. The abdomen is like that of the Bornean *M. sandacana* Cockerell, but the thorax, seen from above, appears shining black.

The halictines from Culasi have been recorded in a previous paper but I add the names to complete the list.

Nesohalictus robbii (Crawford).

Halictus philippinensis Ashmead.

Halictus thoracicus sublustrans Cockerell.

Halictus thoracicus merescens Cockerell.

Halictus mcgregori Cockerell.

Nomia thoracica stantoni (Ashmead).

Fourteen specimens.

Nomia longitarsis Cockerell.

One female. The specimen has opaque pale yellowish bands on abdominal segments 1 to 4, and the stigma ferruginous. It thus differs both from the type and variety *eboris*, and possibly represents a distinct race.

Nomia levicauda Cockerell.

Two females.

Nomia quadrifasciata Ashmead.

Five males and twenty-seven females. Three of the five males are typical *N. quadrifasciata;* the other two have more dusky hind legs and approach var. *notha* (Cockerell). It is certain that *notha* is only a variation of *N. quadrifasciata.*

Nomia iridescens Smith.

One female. On *Melastoma polyanthum* Blume, May 27.

Nomia strigata (Fabricius) var. **ridleyi** Cockerell.

One female.

Nomia mcgregori sp. nov.

Female.—Related to *N. quadrifasciata,* but larger and more robust (anterior wing, 8 millimeters; width of thorax, about 4 millimeters); the blue-green bands on hind margins of abdominal segments 2 to 4 very narrow (hardly or not half as wide as in *quadrifasciata*); lobes of postscutellar process large, broad and obtuse; tegulæ entirely black; prothorax and tubercles with black hair, but conspicuously fringed with white tomentum; mesothorax with strong dense punctures (not of two sizes as in *N. incerta*), and with very short black hair, with a little intermixture of white, especially at sides; wings very strongly blackened, the stigma and nervures black; scutellum between the large scattered punctures dull; hind tibiæ with much black hair posteriorly; middle tibiæ beneath, and their femora beneath at base, with shining red hair.

One female. By the form of the postscutellar process related to *N. incerta* Gribodo, from Java, but the mesothorax is different.

BATBATAN ISLAND

The following were collected on Batbatan Island, June, 1918:

Ceratina philippinensis Ashmead.

Five females and one male.

Allodape marginata Smith.

One female. Pale clypeal band unusually broad.

Allodape cupulifera bakeri Cockerell.

One female.

Crocisa crucifera Cockerell.

One female.

Anthophora korotonensis Cockerell.

Two males.

Nomia quadrifasciata Ashmead.

One female and one male.

LOW-SUN PHENOMENA IN LUZON

By Willard J. Fisher

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TWO TEXT FIGURES

I. ZENITH OBSERVATIONS OF DAWN, MANILA, 1918–1919

By "low-sun phenomena" I mean those aspects of the sky and the atmosphere which are seen during the period of oblique or nearly horizontal illumination within a short time before and after sunrise or sunset; as the Zodiacal Light, dawn and twilight, crepuscular rays and shadows, colors of sky and clouds, and the color and form of the low sun itself. Related to these, though not all exactly solar in the origin of their light, are the phenomena of moonrise and moonset, of low stars, of the eclipsed moon, the Gegenschein, and atmospheric refraction at low altitudes—particularly horizontal refraction at sea level, when the rays of light are parallel to the ocean surface.

For the study of low-sun phenomena Luzon possesses certain advantages. It is subject to steady and well-studied tropical oceanic conditions of pressure and temperature; it is not so large but that the horizon, seen toward east or west from heights that are small compared with the air depths, would be a sea horizon; it has good roads and railway communications; it has been geodetically and topographically surveyed and mapped; there is a good meteorological and telegraphic standard time service centering in the Manila Observatory; many of its mountain peaks are considerably above the hazy low altitudes which extend to the strato-cumulus level, and some are reached by good trails—in one case, Santo Tomas, Benguet, there is a modest summit hotel.

The observations following were made mostly in Manila; where the point of observation was elsewhere, it is noted. This city, being the center of civilization and government, with excellent scientific libraries, has advantages in some ways over any other point in the Philippines; the open sea is only about forty miles away east or west, though the physical horizon east or west is mountainous; the sun, however, during a few weeks about the winter solstice sets in the water between Corregidor Island and Bataan Province; most stars of declinations between south

20° and south 40° always set in a sea horizon. The low situation of the city, formerly swamp land near the level of Manila Bay, subjects it to a maximum of atmospheric absorption; the factory and power-plant chimneys along Pasig River and the steamers in the harbor send out vast volumes of sooty smoke; during the dry season dust often fills the air; and a very good electric street-lighting system brightly illuminates smoke, dust, and low clouds overhead; so that opportunities for satisfactory observation of the delicate pale dawn, the Zodiacal Light, or the Gegenschein are none, and evening observations of twilight are usually worthless.

Nevertheless, being in the University of the Philippines at Manila, and finding that early rising in the balmy morning air is not the sad discomfort of 4 o'clock in New England, and finding also that the complete series of dawn phenomena is over in a fraction of the time it takes in latitude 42°, I have made observations during a year's clear weather on low-sun phenomena at Manila, hoping that even such amateur work may prove of some use in adding to our knowledge of the earth's atmosphere.

The "darkness of night" is of course only a relative term. The night is sometimes "as dark as a pocket" when the sky is overcast with rainy storm clouds; yet an overcast sky, in which no stars are visible and during the "dark of the moon," sometimes is bright enough for comfortable walking along a country road. The solely starlit sky, in clear weather, is far from dark; on the Benguet plateau, in April, 1919, I have been able to read the seconds dial of my watch, with the help of a pocket lens, by the light of the Galaxy and the stars from Scorpio to Cygnus. The total light of starlit hemisphere is quoted by Kimball [1] as somewhat in excess of that of a thousand stars of the first magnitude, or one two-hundred-and-fiftieth of the brightness of the full moon. Of course, this brightness is not evenly distributed, the Galaxy emitting a disproportionate amount, and atmospheric absorption cutting off much light of stars at low altitudes.

This starlit sky is not, however, always of the same dimness between the stars; there are times when it is distinctly pale.[2] This is not attributed to any terrestrial cause, but is as if the earth at times passes through regions of space which are lu-

[1] Kimball, H. H., Mo. Weath. Rev. 44 (1916) 620.

[2] Simon Newcomb quotes Barnard's word "milky." Zodiacal Light, Encyc. Brit. 11th ed. 28 (1911) 998–1000.

minous, either by emission or by the reflection (or scattering) of sunlight.

Near the plane of the ecliptic this brightness of the sky is concentrated in the Zodiacal Light. Under favorable circumstances this is seen clear across the heavens as an arch or band of light; at Manila and Batangas, both near sea level, I have seen it as far as the zenith with the sun an hour below the horizon. The Gegenschein is a faintly brighter spot in the Zodiacal Light, 180° away from the sun; I doubt if it is ever to be seen against the artificially bright sky of Manila. The Zodiacal Light widens toward the sun; it completely surrounds this, as is known by observations of Simon Newcomb and others, looking northward from suitable stations in the northern hemisphere, at about midnight near the summer solstice.

As the hour of dawn at Manila approaches, the Zodiacal Light broadens and brightens in its lower parts, so that stratus clouds show distinctly as dark bands across it. Then a pale light spreads upward from the east; in Manila this does not seem to start even at the physical horizon of mountains and clouds, but higher up, where atmospheric absorption exerts a less weakening effect on the Zodiacal Light. Whether this pale light is distinguishable from the Zodiacal Light or has a definitely terrestrial origin, I think cannot be settled at Manila; I watched carefully at Batangas, after sunset, February 22, 1919, but could not decide; I have had no other good opportunity. Some observers say the transition is continuous.

As this "pale dawn" rises toward the zenith the lower eastern sky begins to be brighter and even ruddy, and above that bluish. The pale dawn passes the zenith, and the blue dawn follows it over the heavens. Then there pass upward and sidewise the familiar and often-described colored arches and bands of morning twilight,[3] frequently with the bright streaks and blue bands radiating from the sun's position, known as crepuscular rays and shadows, followed by the appearance of the sun itself, and the daylight changes of the atmosphere.

Since the days of the Arabian Alhazen attempts have been made by various observers to determine a lower limit for the height of the atmosphere by observing the time when the pale light of twilight first appears or last disappears at the horizon.

[3] Mo. Weath. Rev. 44 (1916) 614 and following pages, contains full descriptions of these phenomena, original, translated, or abstracted; so also do the numerous books on meteorology.

The theory is given, for example, by Young,[4] who shows that if the observations give an altitude $-18°$ for the sun at this stage of twilight, then the sensible reflecting power of the atmosphere vanishes at a height of about 40 miles, taking account of refraction. But this, he says, is lower than the limit given by the ignition of meteors, about 100 miles.

Wegener [5] says:

Most observations of this sort have been made on the principal twilight arch, and give, as previously mentioned, a height of 70 km. for the boundary layer here considered. The individual values are brought together in the following table; the numbers give the angular depression of the sun for the moment at which the twilight arch just sinks below the horizon or rises above it.

TABLE 1 [6]

Schmidt (Athens)	15.9°
Behrmann (Atlantic)	15.6°
Bravais (France)	16.0°
Hellmann (Spain)	15.6°
Liais (Atlantic)	17.8°
Möller (Atlantic)	17.5°
Bailey (Arequipa, Peru)	17.5°
Miethe and Lehmann (Assouan)	16.1°
Carlheim-Gyllenskjöld (Spitsbergen)	17.7°

On a critical consideration of these numbers it becomes very probable that most of them are affected by a not unimportant systematic error; for the vapor laden lowest air strata, lying yet in shadow, cover the upper edge of the twilight arch when it is nevertheless above the horizon. In this connection it is very instructive to see that observations in the morning, when the lowest layers are usually more transparent than in the evening, give much more accordant results, as the following table shows.

	Evening	Morning
Spain	15° 20′	17° 52′
Assouan	14 54	17 21
Atlantic	18 18	17 22

Consequently, if we assume about 17.4° as the most probable value, we get by approximate calculation a height of 74 km. for the upper limit of the light reflecting layers.

The nature of the systematic error is apparent when one considers that the sunlight received by the eye has first entered the atmosphere, passed obliquely downward to tangency at the earth's surface, then obliquely upward to high regions where it is reflected or deviated obliquely downward again through the at-

[4] Young, C. A., General Astronomy (ed. 1898) 67–69.

[5] Wegener, A., Zeitschr. f. anorg. Chem. 75 (1912) 112; Beiträge z. Geophysik 11 (1912) 104; and, somewhat fuller, Phys. Zeitschr. 12 (1911) 170–178 and 214–222.

[6] This is Table 1 of the present paper, not so numbered by Wegener.

mosphere to the eye of the observer, who sees it on its second tangency at the surface—three passages through the lower atmosphere, with a total absorption many times that in one such passage, even though there did not intervene the weak reflection by the upper air. In fact, the light actually observed passes along paths considerably higher and more transparent than those of the elementary theory, and the computed lower limit is based on an angular depression of the sun considerably too small.

Horizon observations of dawn are impossible at Manila, on account of all sorts of local conditions described above. But, on watching the passage of the various stages of dawn across the sky, I thought that the zenith passage of each stage might be observed with reasonable accuracy, a value deduced for the corresponding altitude (or depression) of the sun, and hence a better lower limit for the atmospheric extent.

Besides the fact that the zenith is more generally visible than the horizon, zenith observations have the evident superiority over horizon observations that they involve one less absorption during tangential passage of light through the lower air. The light deviated vertically downward passes the absorbing layer by the shortest possible path, though probably a deviation or scattering of 90° produces less intensity than one which is very small.

On the morning of April 18, 1919, looking in all directions from the summit of Mount Santo Tomas, Benguet, the low haze layer was fairly well defined. Arayat, an isolated volcanic cone in Pampanga Province, 1,024 meters high, did not project through it. The two eastmost peaks in Zambales Province, between the central plain and the sea, thrust dark blue summits above the haze, one only a little, the other quite a good deal. They are Negron, 1,590 meters, and Pinagtabo, 1,781 meters. So that, on this morning, the haze layer ceased at a height of about 1,500 meters. Assuming it uniform in height and turbidity—it really seemed somewhat more turbid in its upper parts—calling the earth's radius 6,371 kilometers (this is the mean of two equatorial radii and one polar), and neglecting refraction, light reaching a point on the surface horizontally would have traversed the haze a distance of

$$\sqrt{2 \times 1.5 \times 6{,}371} = 138.3 \text{ kilometers};$$

and if it is reduced to the fraction n of its intensity by absorption when passing through vertically, it would be reduced after horizontal passage to $n^{138.3/1.5}$ of its original intensity. For the whole atmosphere it has been estimated that vertically incident light is 79.4 per cent to 89.0 per cent transmitted;[7] to anyone looking down at the lower haze from a mountain, it seems as if most of the absorption must occur in the last 2 kilometers. Looking from Santo Tomas northwest over the China Sea on the morning mentioned, cumulus clouds were forming low over the water, and some of these were growing large enough to push their summits through the haze. The contrast in brightness between these white summits and the ruddy banks in the haze was extraordinary.

Suppose that 85 per cent is transmitted vertically by the whole atmosphere, and that one-third of the 15 per cent absorption occurs in the haze layer; the latter I will assume of uniform absorbing power and negligible refraction. Then the haze layer transmits n=94.45 per cent of any light normally incident upon it, and horizontal light, from incidence to tangency, is 0.5 per cent transmitted. Light passing in and out clear through the haze layer and tangent to the earth's surface is 0.003 per cent transmitted. The effect of refraction is to lengthen the path of absorption and so diminish the proportion transmitted.

Attempts to observe the passage of the pale dawn led to discordant results, as is natural, considering the artificial illumination of the Manila sky and the uncertain relation of this phase to the Zodiacal Light. But I found that the appearance of the first tint of blue at the zenith gave solar depressions which were variable, to be sure, but for similar conditions of the sky were fairly concordant; and this is quite surely a terrestrial phenomenon.

The only apparatus used was a watch, whose error was regularly determined at noon by the fall of the time ball of the Manila Observatory. This ball is dropped at 12 noon on signal from the standard clocks of the observatory, which are regularly compared with the transits of stars. In 1916 the maximum error in starting the time ball is reported[8] as 0.5 second, and the average error as less than 0.2 second, which shows what precision to expect in general. The going of this watch was

[7] Kayser, Handbuch der Spectroscopie 3 (ed. 1905) 341, gives a table of nine such values. More modern data would alter the following computations considerably, but they may serve for illustrations.

[8] Annual Report of the Weather Bureau for 1916. My own star observations, entirely independent of the Observatory, justify confidence in this time ball.

also carefully studied at various times by comparison with the large clock of the University physics department, which was also regularly compared with the time ball. I think that uncorrected errors in the standard time of an observation were never over 5 seconds. For reading the watch at night a pocket lens and the light of a distant street lamp were used. This simple equipment is precise enough for the determination of so unsharp a phenomenon as the appearance of a recognizable blue in the neighborhood of the zenith.

While precision in the determination of the zenith is in the nature of the case unnecessary, nevertheless I experimented to see how accurately I could determine it. Thus, I faced northward and looked upward and estimated the position of the zenith among known stars; then faced southward and estimated again. Halfway between two such estimated positions was used to compute the latitude of the observing point, by finding the declination of the zenith on star maps in Winslow Upton's Star Atlas. The results of various trials were as follows:

		°	′
(1)	α Pegasi indistinguishably near zenith	14	46
(2)	γ Pegasi indistinguishably near zenith	14	44
(3)	Interpolation, Saturn and η Leonis	15	13
(4)	Interpolation, ε Virginis and 42 Comae	14	39
(5)	Interpolation, α Tauri and c Tauri	14	18
(6)	Interpolation, ζ Tauri and λ Orionis	14	52
(7)	β Leonis indistinguishably near zenith	15	1
	Mean declination of zenith	14	48
	True latitude, about	14	35.4

Table 2 shows the year's results for the zenith passage of the blue dawn, computed with the American Nautical Almanac and four-place logarithms for a point in Manila, latitude north 14° 35.4′, longitude east $8^h\ 3^m\ 54^s$. The accuracy of tenths of minutes, or even minutes, is of course illusory; but an attempt to apply principles of the precision of measurements was not regarded worth the trouble. No observations were attempted with the moon up. Under approximately similar conditions, within a few days of one another results would agree within 15′ or 20′, about the sun's semidiameter.

Fault may be found with zenith observations of twilight, that the blue light may come, not from exceedingly high air directly illuminated by sunlight, but from air indirectly illuminated by light reflected from the distant atmosphere and also from high clouds beyond the horizon.

TABLE 2.

Date.	Hour E. 120°.			Altitude of sun (center).		Side-real time.		Remarks.
1918.	*H.*	*m.*	*s.*	°	′	*H.*	*m.*	
October 7	4	53	26	−13	33.8	6	0	
October 8	4	58	38	−12	10.4	6	9	
October 9	4	53	2	−13	42.1	6	7	
October 14	4	53	53	−13	37.2	6	28	Full moon, October 20.
November 4	4	57	43	−13	38.0	7	55	Full moon, November 18.
December 9	5	18	48	−12	9.6	10	34	
December 10	5	18	21	−12	23.2	10	37	
December 11	5	19	7	−12	20.0	10	42	
December 16	5	18	14	−13	45.0	11	1	Full moon, December 18.
1919.								
January 8	5	28	5	−13	15.4	12	38	
January 11	5	28	32	−13	22.1	12	50	Full moon, January 16.
February 10	5	23	35	−14	44.3	14	43	
February 12	5	24	28	−14	24.1	14	52	Full moon, February 15.
February 22	6	56	16	−13	41.8	5	6	Evening, Batangas.
March 4	5	16	53	−13	59.6	16	2	Full moon, March 16.
April 4	4	53	25	−14	34.1	17	42	
April 5	4	54	32	−14	8.0	17	47	
April 10	4	54	17	−13	16.8	18	5	Baguio. Full moon, April 15.
April 30	4	34	21	−14	46.7	19	5	
May 1	4	36	48	−14	4.1	19	12	
May 2	4	36	43	−13	57.3	19	12	
May 4	4	37	53	−13	26.0	19	26	
May 5	4	33	56	−14	12.8	19	25	
May 8	4	34	12	−13	47.9	19	37	
May 11	4	34	57	−13	18.3	19	49	Full moon, May 15.
May 30	4	28	51	−12	30.7	20	58	
June 2	4	26	3	−13	54.1	21	7	
June 4	4	24	19	−14	6.1	21	3	Full moon, June 14.
October 1	4	50	42	−14	5.9	5	29	
October 2	4	50	49	−14	6.7	5	33	Full moon, October 9.

Of course this objection applies also to horizon observations of dawn, and with even greater force, because light is passed on by scattering with greater intensity if the deviation is small, as stated by Rayleigh.[9] The reflecting power, as well as the absorbing power, of the air is of course greatest in the lower region, up to the strato-cumulus level, in most latitudes about 2 kilometers high. The time of first visibility of cirrus clouds near the zenith, and their height—much greater than 2 kilometers—may assist in evaluating this objection, for their reflecting power is much greater than that of the thin air where they float or that of the much thinner and dryer air above them

[9] Phil. Mag. VI 36 (1918) 445, quoted in a critical note by J. Larmor, Phil. Mag. VI 37 (1919) 161.

in the isothermal region and higher, and they catch light sooner than anything at 2 kilometers.

The importance of this sort of observation did not occur to me at first. But the following notes were made and are here recorded in Table 3. The times given are watch times, uncorrected.

TABLE 3.

Date.	Time.	Remarks.
1919.	*H. m. s.*	
April 5	4 54 45	Zenith blue.
Do	5 00 40	Could see a pale cirrus about 30° elevation about halfway in the W. side of the Square of Pegasus.
May 2	4 34 30	Zenith pale blue.
Do	4 51 00	Cirrus evident as pale spot in east at estimated 45° altitude.
May 4	4 38 20	Zenith pale blue.
Do	4 50 00	Cirrus visible in east up to estimated 45° altitude.
May 5	4 34 15	Zenith pale blue.
Do	4 37 30	Cirrus visible in east up to estimated 20°.
May 30	4 29 40	Zenith pale blue.
Do	4 37 00	Cirrus streak between α and γ Cassiopeiæ. Altitude computed 30° 23′.
June 2	4 27 20	Zenith pale blue. A little before this (perhaps a minute, my attention was on the zenith), the high overflow in the east from a cumulo-nimbus was dimly visible as brighter than the sky at one edge, about 2° lower than α Arietis, or about 18° computed altitude.

It would seem then that cirrus and cirro-stratus clouds, whose average height at Manila is 10.9 kilometers (extremes, 4 and 18 kilometers), become visible as brighter than the sky at altitudes of 20° to 40° in the east from 6 minutes to 16.5 minutes later than the blue appears at the zenith; but that the very dense overflow from a cumulo-nimbus may become visible as brighter than the sky at about the same altitudes nearly simultaneously with the zenith blue. Hence I conclude that probably the blue of the zenith comes from direct sunlight, not from twilight reflected from air much higher than cirrus clouds, and certainly not from the hazy lower air.

The mean of all the values of the sun's altitude given in Table 2 is 13° 38.1′. I do not, however, consider this the most probable value, as the effect of most elements involved in a morning observation—such as fall of the time ball, comparison with the watch, hesitation over the appearance of the blue tint, delay in reading the watch, the nearness of the Galaxy and the Zodiacal Light, the existence of thin clouds or haze unobservable in the dark—is to *postpone*. The year's experience shows that the more favorable the conditions, the greater the computed depression of the sun. Fig. 1 attempts to show some of the relations graphically. The abscissas are the sidereal times corresponding to the standard (east 120°) times of observation; the ordinates are, for curve 1, minimum distances of the ecliptic from the zenith of Manila, expressed crudely by measuring in millimeters on the star map accompanying the American Nautical Almanac; for curve 2, distances of the Galaxy east of the zenith of Manila, taken from Winslow Upton's Star Atlas, and expressed roughly

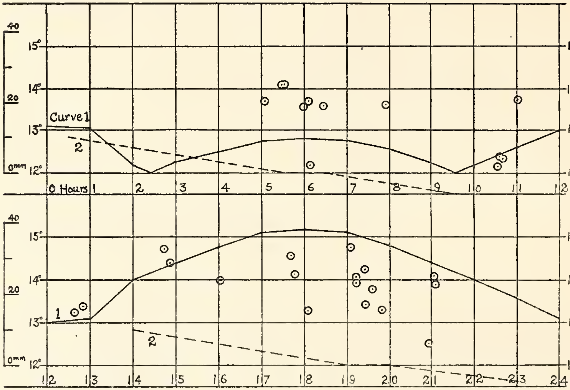

Fig. 1. Relation of computed results to zenith distances of the Zodiacal Light and the Galaxy.

in hours of right ascension. The plotted points show the depression of the sun in degrees. Since the axis of the Zodiacal Light lies near the ecliptic, the ordinates of curve 1 express roughly the distance of this from the zenith. It was found that greater distances of the Zodiacal Light, and clear weather free of cirrus clouds, gave large values of depressions; the nearness of the Galaxy had not so much importance.

These large depressions, over 14°, were quite unexpected; in fact, before computing in two or three cases I had supposed my recognition of the blue color to be tardy. For all these reasons I consider them more probable than any others, and the largest of them, 14° 46.7′, as the most probable.

In applying this result to the question of atmospheric height, a value of horizontal refraction at sea level must be used, as the sunlight, which passes overhead at the moment of passage of the blue dawn, has been refracted and its lowest rays have been tangent to the sea surface some 700 sea miles east of Manila, and have suffered refraction nearly equal to twice the horizontal refraction at the point of tangency. On account of the near constancy of pressure and temperature conditions east and west in the Tropics, the most scientific way would be to observe the sun rising from the ocean and thence compute the refraction. As this is impossible, I have had recourse to monthly and yearly means of pressure and temperature at Manila, and have computed mean values of the horizontal refraction from them, hoping that the effect of land may be partly neutralized by the nearness of Manila Bay and Laguna de Bay.

TABLE 4.

Month.	Pressure.[a]	Shade temperature.[a]	Relative humidity.[a]	Vapor pressure.[a]	Horizontal refraction.	
					Pulkowa.[b]	Radau.[c]
	mm. Hg.	*°C.*	*Per cent.*	*mm.*	′	′
January	761.15	24.9	78.1	18.1	32.1	31.4
February	61.25	25.3	73.9	17.5	31.9	31.4
March	60.54	26.6	71.5	18.1	31.3	31.1
April	59.42	28.1	69.7	19.4	30.7	30.8
May	58.35	28.4	76.0	21.6	30.4	30.7
June	57.92	27.9	80.8	22.3	30.4	30.9
July	57.24	27.0	84.8	22.4	30.4	30.9
August	57.33	27.0	85.0	22.4	30.5	30.9
September	57.42	26.8	85.8	22.4	30.7	30.9
October	56.85	26.7	83.7	21.6	31.4	31.0
November	59.36	25.9	82.5	20.3	31.8	31.2
December	60.35	25.2	81.3	19.2	32.1	31.4
Year	759.08	26.6	79.4	20.4	31.37	31.04

[a] Averages over the period from 1885–1916, taken from the Annual Report of the Weather Bureau (1916).

[b] Computed from the abridged Pulkowa refraction tables contained in Campbell's Elements of Practical Astronomy, second edition.

[c] Computed from the refraction tables contained in Connaissance des Temps (1917). It will be noted that the Radau values are more uniform than the Pulkowa. In computing I use the former.

The pressures given in Table 4 are reduced to standard gravity before computing by subtracting from each 1.72 millimeters.

A formula for the calculation is derived as follows: In fig. 2, O is the earth's center, R its radius, Z the zenith of the observer, ST the direction of a ray before refraction, TV its direction after refraction, r the horizontal refraction; so that the angle ZTV, the deviation of the ray, is $2r$. The ray of course passes in a curve through the atmosphere and is tangent to the earth's surface immediately under T; but its initial and final directions intersect at T, at height p above the earth; the ray passes under Z at a height H above the earth; h is then the geometrical altitude of the sun's upper limb (here negative, a depression).

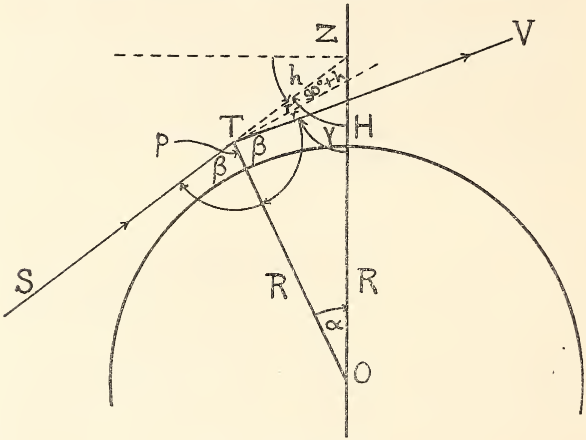

FIG. 2. Geometrical relations.

Clockwise arrows indicate positive angles, α, β, γ; the arrow for h, a negative angle, is counterclockwise.
From the figure

$$2\beta=180°-2r,\ \gamma=2r+90°+h,\ \alpha+\beta+\gamma=180°;$$

whence

$$\beta=90°-r,\ \gamma=90°+h+2r,\ \alpha=-(h+r),$$

and the angles of the triangle are determined. Of the sides none is given, but

$$(R+H)/(R+p)=\sin\beta/\sin\gamma,$$

or

$$(1+H/R)/(1+p/r)=\cos r/\cos\ (h+2r).$$

Now it is evident that the straight line TV is nowhere in contact with the earth; the perpendicular to it from the center is greater than the radius, or

$$(R+p)\ \sin\beta > R, \text{ or } (1+p/R) > \csc\beta,$$

which makes $1+p/R=\csc\beta$ a condition for a minimum value of $1+H/R$.

Substituting, $1+H/R \geqq \sec(h+2r)$, and $H \geqq R\ [\sec(h+2r)-1]$.

Taking now

	Average, year.		Best, IV 30.	
	°	′	°	′
Altitude of sun's center	−13	38.1	−14	46.7
Semidiameter of sun		16.0		15.9
Twice horizontal refraction	1	2.1	1	1.5
$h+2r=$	−12	20.0	−13	29.3
Taking R 3,959 miles	$H \geqq$ 92.8 miles		112.9 miles	
Taking R 6,371 kilometers	$H \geqq$ 149.3 kilometers		181.6 kilometers	

The heights thus obtained are evidently the heights at which the lowest sunlight passes above the observer, or minimum values for the lower air at the point of tangency free of turbidity and clouds. The actual turbidity complicates matters somewhat, as practically no light passing tangent to the earth's surface is transmitted clear through a 1.5 kilometer haze layer with 94.45 per cent vertical transmission, as shown above; and so the light visibly illuminating the high air has passed horizontally through the atmosphere at a variable and uncertain elevation in or above the haze, with refraction also variable. Variability in these conditions probably helps to explain [10] variability in the computed depressions of the sun.

Further, light passed through the haze layer is weak in short wave lengths, being yellow or rose (or even redder, as often seen in the eclipsed moon), so that it can cause little scattering of blue when it goes on through the upper air.

For every reason it is probable that the computed solar depressions are appreciably smaller than would be obtained with an unturbid lower atmosphere and a starless, dark firmament.

Conclusions based on the optical properties of the atmosphere may be compared with those derived from the ignition of shooting stars, as they come plunging from the high vacuum of inter-

[10] I make this remark purposely somewhat indefinite, having in mind the change in color of mountain snow and cumulo-nimbus summits from rose to gray, which frequently occurs in a few seconds.

planetary space into the outer air. Various observers have deduced for the height at which they appear values ranging from 112 kilometers, for the slow Perseids of August, to 155 kilometers, for the swift Leonids of November; 180 kilometers is given as the average result of work at the Berlin Observatory, and even 200 kilometers by an English observer. These heights may be compared with the heights of 149.3 kilometers (average) and 181.6 kilometers (best) found above.

Neither the optical nor the meteor results give the extent of the atmosphere. The observations on dawn show that above the computed height there are enough molecules to scatter light in total sufficient to influence the eye; the meteors go a long way through the vacuumlike outer atmosphere before they become incandescent. But it would seem that the amount of the outer air which is competent to produce the one effect is also competent to produce the other.

For the loan of books and for friendly criticism of this paper thanks are due to Father J. Comellas, of the astronomical department of the Manila Observatory.

ILLUSTRATIONS

TEXT FIGURES

HIGHER BASIDIOMYCETES FROM THE PHILIPPINES AND THEIR HOSTS, II

By Otto A. Reinking

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The following list of fungi is a continuation of the identifications of the higher Basidiomycetes collected on Mount Maquiling and in the vicinity of Los Baños, Laguna Province, Luzon, in Mindanao, and in Sulu, as indicated in the text, these collections having been made with special reference to the identity of the host plants. Numerous extremely important timber-destroying forms are included. The collections have been made either by me or by my students under my direction. The determinations of fungi given in this list were made by C. G. Lloyd, of Cincinnati, Ohio. The species of fungi are grouped according to the classification of Engler and Prantl, with the host and the collector under each species of fungus. The numbers refer to the College of Agriculture fungus herbarium.

AURICULARIACEAE

AURICULARIA Bulliard

AURICULARIA AURICULA-JUDAE (Linn.) Schroet.

Alstonia scholaris R. Br., Mount Maquiling, *Reinking 2850*, on dead wood.

Caesalpinia sappan Linn., Mount Maquiling, *Reinking 2796*, on dead wood.

Capparis sp., Mount Maquiling, *Reinking 2737*, on dead wood.

Evodia sp., Mount Maquiling, *Reinking 2765*, on dead wood.

Melia azedarach Linn., Mount Maquiling, *Reinking 2819*, on dead wood.

Pterocarpus echinatus Pers., Mount Maquiling, *Reinking 2839*, on dead wood.

Streblus asper Lour., Mount Maquiling, *Reinking 2769*, on dead wood.

AURICULARIA CORNEA Ehrenb.

Alangium chinense (Lour.) Rehd. (*Alangium begonifolium* Baill.), Los Baños, *Reinking 3789*, on dead wood.

Mallotus moluccanus (Linn.) Muell.-Arg., Los Baños, *Reinking 3725*, on dead wood.

Pterocarpus indicus Willd., Mount Maquiling, *Reinking 2789*, on dead wood.

Vitex negundo Linn., Los Baños, *Reinking 3682*, on dead wood.

AURICULARIA DELICATA Fr.

Los Baños Falls, *Ocfemia 3560*, on rotting log.

AURICULARIA MESENTERICA (Dick.) Fr.

Mount Maquiling, *Cazeñas 973*, on dead wood.

AURICULARIA MOELLERI Lloyd.

Mount Maquiling, *Baybay 3404*, *Marquez 3313*, on dead wood.

AURICULARIA ORNATA Pers.

Mount Maquiling, *Cazeñas 801*, on dead wood.

AURICULARIA POLYTRICHA (Mont.) Sacc.

Parkia javanica (Lam.) Merr. (*Parkia timoriensis* Merr.), Los Baños, *Reinking 3672*, on dead wood.

TREMELLACEAE

SEBACINA Tulasan

SEBACINA sp.

Crescentia cujete Linn., Mount Maquiling, *Reinking 3132*, on dead wood.

TREMELLA Dillineus

TREMELLA FOLIACEAE Fr.

Macaranga tanarius (Linn.) Muell.-Arg., Mount Maquiling, *Santos 2602*, on dead wood.

TREMELLA sp.

Mount Maquiling, *Cazeñas 3307*, on dead wood.

DACRYOMYCETACEAE

GUEPINIA Fries

GUEPINIA SPATHULATA Schw.

Parashorea plicata Brandis, Mount Maquiling, *Reinking 2981*, on bridge railing.

THELEPHORACEAE

CORTICIUM Persoon

CORTICIUM sp.

Alangium chinense (Lour.) Rehd., Los Baños, *Reinking 3790*, on dead wood.

Lagerstroemia speciosa Pers., Los Baños, *Reinking 3727,* on dead wood.

Psychotria manillensis Bartl., Los Baños, *Reinking 3721,* on dead wood.

Tectona grandis Linn. f., Los Baños, *Reinking 3678,* on dead wood.

PENIOPHORA Cooke

PENIOPHORA sp.

Mallotus philippensis Muell.-Arg., Los Baños, *Reinking 3747,* on dead wood.

HYMENOCHAETE Léveillé

HYMENOCHAETE sp.

Evodia sp., Los Baños, *Reinking 3698,* on dead wood.

Lagerstroemia speciosa Pers., Mount Maquiling, *Reinking 2746,* on dead wood.

ASTEROSTROMA Massee

ASTEROSTROMA sp.

Elaeis guineensis Jacq., Mount Maquiling, *Reinking 2754,* on dead wood.

STEREUM Persoon

STEREUM CINERESCENS Schw.

Mount Maquiling, *Reyes 2974,* on dead wood.

STEREUM HIRSUTUM Fr.

Shorea guiso Blume, Mount Maquiling, *Reinking 3000,* on bridge flooring.

STEREUM INVOLUTUM Kl.

Gliricidia sepium (Jacq.) Steud., Mount Maquiling, *Nantes 2605,* on dead wood.

STEREUM NIGROPUS Lloyd.

Mount Maquiling, *Pañganiban 3379,* on dead wood.

STEREUM OSTREUM Nees (or *Stereum lobatum* Swartz).

Cryptocarya sp., Zamboanga, *Babao 447,* on decaying wood.

STEREUM SPECTABILE Kl.

Mount Maquiling, *Esguerra 875,* on dead wood.

THELEPHORA Ehrhart

THELEPHORA RADICANS Berk.

Bambusa sp., Mount Maquiling, *Reyes 2565,* on dead roots.

CLADODERRIS Persoon

CLADODERRIS INFUNDIBULIFORMIS Kl.

Mount Maquiling, *Baybay 749*, on dead wood.

CYPHELLA Fries

CYPHELLA FUSCO-DISCA Cooke.

Arenga pinnata (Wurmb) Merr., Los Baños, *Reinking 3719*, on dead petiole.

Casuarina equisetifolia Linn., Mount Maquiling, *Reinking 3067*, on dead wood.

CYPHELLA MELLEA Burt.

Erythrina fusca Lour., Mount Maquiling, *Reinking 2856*, on dead wood.

CLAVARIACEAE

PISTILLARIA Fries

PISTILLARIA sp.

Mount Maquiling, *Mendoza 3301*, on dead wood.

CLAVARIA Vaill

CLAVARIA sp.

Mount Maquiling, *Divinagracia 3394*, on dead wood.

PTERULA Fries

PTERULA ACICULAE Lloyd.

Mount Maquiling, *Baybay 3330*, on dead wood.

HYDNACEAE

PHLEBIA Fries

PHLEBIA REFLEXA Berk.

Parashorea plicata Brandis, Mount Maquiling, *Reinking 2979*, on bridge railing.

HYDNUM Linnaeus

HYDNUM OCHRACEUM Pers.

Mount Maquiling, *Reyes 3373*, on dead wood.

IRPEX Fries

IRPEX sp.

Mount Maquiling, *Nantes 3308*, on dead wood.

GRAMMOTHELE Berkeley et Curtis

GRAMMOTHELE MAPPA Berk. et Curt.

Mount Maquiling, *Cazeñas 991*, on dead wood.

POLYPORACEAE

PORIA Persoon

PORIA SETULOSA P. Henn.

Mount Maquiling, *Marquez 3358*, on dead wood.

PORIA sp.

Mallotus ricinoides Muell.-Arg., Mount Maquiling, *Reinking 2779*, on dead wood.

FOMES (Fries) Cooke

FOMES APPLANATUS Pers.

Ceiba pentandra (Linn.) Gaertn., Mount Maquiling, *Reyes 2943*, on dead wood.

FOMES AUSTRALIS Fr.

"Lawaṅ colorado," probably *Shorea* sp., Zamboanga, *Tecson 459*, on decaying branches.

FOMES CALIGNOSUS Berk.

Mount Maquiling, *Baybay 2590*, on dead wood.

FOMES PACHYPHLOEUS Pat.

Ficus sp., Mount Maquiling, *Collado 463*, on dead branch.

GANODERMA Karsten

GANODERMA AUSTRALE (Fr.) Pat.

Mount Maquiling, *Collado 473*, on dying tree.

POLYPORUS Micheli

POLYPORUS ADUSTUS Willd.

Terminalia comintana Merr., Mount Maquiling, *Reinking 2957*, on dead wood.

POLYPORUS AMBOINENSIS Fr.

Bambusa sp., Mount Maquiling, *Collado 2920*, on dead stem.

POLYPORUS ANEBUS Berk.

Bambusa spinosa Roxb., Mount Maquiling, *Reyes 2604*, on dead roots.

POLYPORUS CONCHOIDES Mont.

Parkia javanica (Lam.) Merr. (*Parkia timoriensis* Merr.), Mount Maquiling, *Reinking 2989*, on dead wood.

POLYPORUS DORSALIS Lloyd.

Mount Maquiling, *Nantes 655*, on dead wood.

POLYPORUS GRAMMOCEPHALUS Berk.

Mount Maquiling, *Marquez 3314*, on dead wood.

POLYPORUS LIGNOSUS Kl.

Ficus sp., Mount Maquiling, *Catalan 2919*, on dead branches.

POLYPORUS LUCIDUS Leys.

Bambusa sp., Mount Maquiling, *Collado 469*, *Baybay 2921*, on dead stump.

POLYPORUS MEGALOPORUS Mont.

Mount Maquiling, *Pañganiban 2571*, on dead wood.

POLYPORUS NITIDUS Murr.

Mount Maquiling, *Baybay 2591*, on dead wood.

POLYPORUS PERVERSUS Lloyd.

Mount Maquiling, *Pañganiban 3442*, on dead wood.

POLYPORUS RIGIDUS Lév.

Bambusa spinosa Roxb. (*Bambusa blumeana* Schultes), Mount Maquiling, *Reinking 3005*, on dead stumps.

Cyclostemon sp., Mount Maquiling, *Reinking 2959*, on dead wood.

POLYPORUS RUGULOSUS Lév.

Annona squamosa Linn., Mount Maquiling, *Reyes 2954*, on dead wood.

POLYPORUS SEMILACCATUS Berk.

Mount Maquiling, *Nantes 661*, on dead wood.

POLYPORUS SUBSTYGIUS Berk.

Gliricidia sepium (Jack.) Steud., Mount Maquiling, *Reinking 3006*, *Reyes 2942*, on weakened branches and on dead wood.

POLYPORUS VINOSUS Berk.

Mount Maquiling, *Mendoza 2559*, on dead wood.

POLYPORUS WILLIAMSIANUS Murr.

Arenga pinnata (Wurmb) Merr. (*Arenga saccharifera* Labill.), Mount Maquiling, *Reyes 2949*, on dead wood.

Cocos nucifera Linn., Mount Maquiling, *Reyes 2955*, on dead stump.

POLYPORUS ZONALIS Berk.

Cyclostemon sp., Mount Maquiling, *Reinking 2958*, on dead wood.

POLYPORUS sp.

Mount Maquiling, *Cazeñas 3421*, on dead wood.

POLYSTICTUS Fries

POLYSTICTUS AFFINIS Nees.

Mount Maquiling, *Marquez 2589, Cazeñas 3484, Ocfemia 3562,* on dead wood.

POLYSTICTUS CERVINO-GILVUS Jungh.

Mount Maquiling, *Baybay 979,* on dead wood.

POLYSTICTUS CRYPTOMENIAE P. Henn.

Theobroma cacao Linn., Mount Maquiling, *Baybay 751,* on dead branches.

POLYSTICTUS FLAVUS Jungh.

Elaeis guineensis Jacq., Mount Maquiling, *Reinking 2752,* on dead wood.

Ficus hauili Blanco, Mount Maquiling, *Reyes 2946,* on dead wood.

Leucaena glauca (Linn.) Benth., Mount Maquiling, *Reyes 2940,* on dead branches.

POLYSTICTUS LUTEUS Nees.

Mount Maquiling, *Marquez 3364,* on dead wood.

POLYSTICTUS MELEAGRIS Berk.

Los Baños Falls, *Ocfemia 3568,* on rotting log.

POLYSTICTUS MEYENII Kl.

Cordia myxa Linn., Mount Maquiling, *Reyes 2927,* on dead wood.

POLYSTICTUS MICROLOMA Lév.

Los Baños Falls, *Ocfemia 3567,* on decaying log.

POLYSTICTUS MURINUS Lév.

Los Baños Falls, *Ocfemia 3570, 3571,* on rotting log.

POLYSTICTUS OCCIDENTALIS Kl.

Canarium villosum (Blume) F.-Vill., Mount Maquiling, *Reinking 2871,* on dead wood.

POLYSTICTUS SANGUINEUS Linn.

Shorea sp., Mount Maquiling, *Reyes 2928,* on dead wood.

Shorea guiso Blume, Davao, Pantucan, *Reinking 2977,* on dead wood.

POLYSTICTUS SETULOSUS Lloyd.

Mount Maquiling, *Pañganiban 3397,* on dead wood.

POLYSTICTUS SUBCROCATUS Murr.

Mount Maquiling, *Collado 3481,* on dead wood.

POLYSTICTUS SUBREFLEXUS Lloyd.

Mount Maquiling, *Marquez 3382*, on dead wood.

POLYSTICTUS TABACINUS Mont.

Tabernaemontana pandacaqui Poir., Mount Maquiling, *Collado 2925*, on dead wood.

POLYSTICTUS XANTHOPUS Fr.

Quercus sp., Mount Maquiling, *Collado 2923*, on dead branches.

POLYSTICTUS ZELANICUS Berk.[1]

Shorea guiso Blume, Mount Maquiling, *Reyes 2951*, on dead stump.

POLYSTICTUS sp.

Mount Maquiling, *Divinagracia 1062*, *Cazeñas 804*, on decaying wood.

TRAMETES Fries

TRAMETES ACUTA Berk.

Mount Maquiling, *Cazeñas 3428*, on dead wood.

TRAMETES BADIA Berk.

Anisoptera sp., Mount Maquiling, *Reyes 2944*, on dead wood.

TRAMETES BURCHELLII Cooke.

Shorea guiso Blume, Mount Maquiling, *Reinking 2982*, on bridge flooring.

TRAMETES DEVEXA Berk.

Delonix regia (Boj.) Raf., Mount Maquiling, *Reinking 2924*, on weakened branches.

TRAMETES MEYENII Kl.

Annona reticulata Linn., Mount Maquiling, *Reyes 2926*, on dead wood.

TRAMETES PERSOONII Mont.

Erythrina indica Lam., Mount Maquiling, *Nantes 2497*, on dead wood.

Cordia myxa Linn., Mount Maquiling, *Reyes 2927*, on dead branches.

Ficus hauili Blanco, Mount Maquiling, *Reyes 2946*, on dead wood.

Ficus sp., Mount Maquiling, *Nantes 2530*, on dead wood.

Parkia javanica (Lam.) Merr. (*Parkia timoriensis* Merr.), Mount Maquiling, *Reinking 3007*, on dead wood.

[1] The determination was questionable, but since the fungus occurs on an important wood it seemed desirable to note it.

DAEDALEA Persoon

DAEDALEA FLAVIDA Lév.

Xanthostemon verdugonianus Naves, Mount Maquiling, *Luna 2352*, on dead wood.

Ficus sp., Mount Maquiling, *Collado 463, 466*, on dead wood.

DAEDALEA TENUIS Berk.

Ficus sp., Mount Maquiling, *Reyes 466*, on dead wood.

LENZITES Fries

LENZITES ALBIDA Berk.

Shorea guiso Blume, Mount Maquiling, *Reyes 2938*, on dead wood.

LENZITES REPANDA Pers.

Ficus sp., Mount Maquiling, *Collado 2346*, on dead wood.

LENZITES STRIATA Swartz.

Shorea guiso Blume, Mount Maquiling, *Reinking 2991, 3000*, on bridge flooring.

LENZITES TENUIS Lév.

Mount Maquiling, *Marquez 885*, on dead wood.

HEXAGONA Fries

HEXAGONA ALBIDA Berk.

Shorea guiso Blume, Mount Maquiling, *Reinking 3004*, on bridge flooring, *Reyes 2950*, on dead wood.

HEXAGONA FLAVIDA Lév.

Mount Maquiling, *Nantes 681*, on dead wood.

HEXAGONA TENUIS Hooker.

Mount Maquiling, *Collado 136*, on dead branch of a tree.

FAVOLUS Fries

FAVOLUS ALBUS Lloyd.

Mount Maquiling, *Marquez 1029*, on dead wood.

FAVOLUS PLATYPORUS Berk.

Mount Maquiling, *Cazeñas 3423*, on dead wood.

AGARICACEAE

CANTHARELLUS (Adans.) Linnaeus

CANTHARELLUS INFUNDIBULIFORMIS Berk.

Mount Maquiling, *Pan̄ganiban 3452*, on dead wood.

SCHIZOPHYLLUM Fries

SCHIZOPHYLLUM COMMUNE Fr.

Ficus ulmifolia Lam., Mount Maquiling, *Reyes 2933*, on dead wood.

Mangifera indica Linn., Los Baños, college ground, *Reyes 2945, Reinking 3722*, on dead wood.

XEROTUS Fries

XEROTUS NIGRITUS Lév.

Shorea guiso Blume, Mount Maquiling, *Reinking 3003*, on bridge flooring.

Theobroma cacao Linn., Mount Maquiling, *Cazeñas 3322*, on dead wood.

LENTINUS Fries

LENTINUS CONNATUS Berk.

Mount Maquiling, *Collado 3485*, on dead wood.

LENTINUS SAJOR-CAJU Fr.

Mount Maquiling, *Marquez 997*, on dead wood.

LENTINUS SQUARROSULUS Mont.

Mangifera indica Linn., Jolo, *Reinking 2159*, on dead wood.

LENTINUS STRIGOSUS Schw.

Cocos nucifera Linn., Mount Maquiling, *Alas 2907*, on dead trunk.

MARASMIUS Fries

MARASMIUS EQUICRINIS Muell.

Mount Maquiling, *Marquez 3427*, on dead wood.

PLEUROTUS Fries

PLEUROTUS STRIATULUS Fr.

Urena lobata Linn., var. *sinuata* (Linn.) Gagnep., Mount Maquiling, *Reinking 2710*, on dead wood.

LYCOPERDACEAE

GEASTER (Micheli) Fries

GEASTER MIRABILIS Mont.

Mount Maquiling, *Cazeñas 3348, Marquez 3377*, on dead wood.

NIDULARIACEAE

CYATHUS Hallier

CYATHUS MONTAGNEI Tul.

Streblus asper Lour., Mount Maquiling, *Reinking 2770*, on dead wood.

CYATHUS PLICATUS Poeppig.

Mount Maquiling, *Pañganiban 3445,* on dead wood.

FUNGI LISTED ACCORDING TO HOSTS

ALANGIUM CHINENSE (Lour.) Rehd. (*Alangium begonifolium* Baill.)
Auricularia cornea Ehrenb., dead wood.
Corticium, dead wood.

ALSTONIA SCHOLARIS (Linn.) R. Br.
Auricularia auricula-judae (Linn.) Schr.

ANISOPTERA sp.
Trametes badia Berk., dead wood.

ANNONA RETICULATA Linn.
Trametes meyenii Klotz, dead wood.

ANNONA SQUAMOSA Linn.
Polyporus rugulosus Lev., dead wood.

ARENGA PINNATA (Wurmb) Merr. (*Arenga saccharifera* Labill.)
Cyphella fusco-disca Cke., dead petiole.
Polyporus williamsianus Murr., dead wood.

BAMBUSA sp.
Polyporus amboinensis Fries, dead stem.
Polyporus lucidus Leys., dead stump.
Thelephora radicans Berk., dead roots.

BAMBUSA SPINOSA Roxb. (*Bambusa blumeana* Schultes).
Polyporus anebus Berk., dead roots.
Polyporus rigidus Lev., dead stumps.

CAESALPINIA SAPPAN Linn.
Auricularia auricula-judae (Linn.) Schroet., dead wood.

CANARIUM VILLOSUM (Blume) F.-Vill.
Polystictus occidentalis Klotz, dead wood.

CAPPARIS sp.
Auricularia auricula-judae (Linn.) Schroet., dead wood.

CASUARINA EQUISETIFOLIA Forst.
Cyphella fusco-disca Cooke, dead wood.

CEIBA PENTANDRA (Linn.) Gaertn.
Fomes applanatus Pers., dead wood.

COCOS NUCIFERA Linn.
Lentinus strigosus Schw., dead stem.
Polyporus williamsianus Murr., dead stump.

CORDIA MYXA Linn.
Polystictus meyenii Klotz, dead wood.
Trametes persoonii Mont., dead branches.

CRESCENTIA CUJETE Linn.
Sebacina, dead wood.

CRYPTOCARYA sp.
Stereum ostreum Nees (or *Stereum lobatum* Swartz), decaying wood.

CYCLOSTEMON sp.
Polyporus rigidus Lév., dead wood.
Polyporus zonalis Berk., dead wood.

DELONIX REGIA (Boj.) Raf.
Trametes devexa Berk., weakened branches.

ELAEIS GUINEENSIS Jacq.
Asterostroma sp., dead wood.
Polystictus flavus Jungh., dead wood.

ERYTHRINA FUSCA Lour.
Cyphella mellea Burt., dead wood.

ERYTHRINA INDICA Linn.
Trametes persoonii Mont., dead wood.

EVODIA.
Auricularia auricula-judae (Linn.) Schroet., dead wood.
Hymenochaete sp., dead wood.

FICUS spp.
Daedalea flavida Lév., dead wood.
Daedalea tenuis Berk., dead wood.
Fomes pachyphloeus Pat., dead branch.
Lenzites repanda Pers., dead wood.
Polyporus lignosus Klotz, dead branches.
Trametes persoonii Mont., dead wood.

FICUS HAUILI Blanco.
Polystictus flavus Jungh., dead wood.
Trametes persoonii Mont., dead wood.

FICUS ULMIFOLIA Lam.
Schizophyllum commune Fr., dead wood.

GLIRICIDIA SEPIUM (Jacq.) Steud.
Polyporus substygius Berk., weakened branches and dead wood.
Stereum involutum Kl., dead wood.

LAGERSTROEMIA SPECIOSA Pers.
Corticium sp., dead wood.
Hymenochaete? dead wood.

LEUCAENA GLAUCA (Linn.) Benth.
Polystictus flavus Jungh., dead branches.

MACARANGA TANARIUS (Linn.) Muell.-Arg.
Tremella foliacea Fries, dead wood.

MALLOTUS MOLUCCANUS (Linn.) Muell.-Arg.
Auricularia cornea Ehrenb., dead wood.

MALLOTUS PHILIPPENSIS (Lam.) Muell.-Arg.
Peniophora sp., dead wood.

MALLOTUS RICINOIDES Muell.-Arg.
Poria sp., dead wood.

MANGIFERA INDICA Linn.
Lentinus squarrosulus Mont., dead wood.
Schizophyllum commune Fr., dead wood.

MELIA AZEDARACH Linn.
Auricularia auricula-judae (Linn.) Schroet., dead wood.

PARASHOREA.
Stereum sp., dead wood.

PARASHOREA PLICATA Brandis.
Guepinia spathulata Schw., bridge railing.
Phlebia reflexa Berk., bridge railing.

PARKIA JAVANICA (Lam.) Merr. (*Parkia timoriensis* Merr.)
Auricularia polytricha (Mont.) Sacc., dead wood.
Polyporus conchoides Mont., dead wood.
Trametes persoonii Mont., dead wood.

PSYCHOTRIA MANILLENSIS Bartl.
Corticium sp., dead wood.

PTEROCARPUS ECHINATUS Pers.
Auricularia auricula-judae (Linn.) Schroet., dead wood.

PTEROCARPUS INDICUS Willd.
Auricularia cornea Ehrenb., dead wood.

QUERCUS sp.
Polystictus xanthopus Fr., dead branches.

SHOREA sp.
Polystictus sanguineus Linn., dead wood.

SHOREA GUISO (Blanco) Blume.
Hexagona albida Berk., dead wood, bridge flooring.
Lenzites albida Berk., dead wood.
Lenzites striata Swartz, bridge flooring.
Polystictus sanguineus Linn., on logs.
Polystictus zelanicus Berk. ?, dead stump.
Stereum hirsutum Fr., bridge flooring.
Trametes burchellii Cke., bridge flooring.
Xerotus nigritus Lév., bridge flooring.

STREBLUS ASPER Lour.
Auricularia auricula-judae (Linn.) Schroet., dead wood.
Cyathus montagnei Tul., dead wood.

TABERNAEMONTANA PANDACAQUI Poir.
Polystictus tabacinus Mont., dead wood.

TECTONA GRANDIS Linn.
Corticium, dead wood.

TERMINALIA COMINTANA Merr.
Polyporus adustus Willd., dead wood.

THEOBROMA CACAO Linn.
Polystictus cryptomeniae P. Henn., dead branches.
Xerotus nigritus Lév., dead wood.

URENA LOBATA Linn. var. SINUATA (Linn.) Gagnep.
Pleurotus striatulus Fr., dead wood.

VITEX NEGUNDO Linn.
Auricularia cornea Ehrenb., dead wood.

XANTHOSTEMON VERDUGONIANUS Naves.
Daedalea flavida Lév., dead wood.

A BIOCHEMICAL STUDY OF COPRA MEAL [1]

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INTRODUCTION

In 1917 the Philippines produced about 186,900 tons of copra (21) which, after the oil was extracted, gave a by-product of 74,760 tons of copra meal. If all of this meal could be sold as feed, the additional return to the manufacturers would reach the respectable sum of 1,569,960 pesos.[2] Unfortunately, the nutritive value of the meal is not well known, and perhaps for this reason it is not used extensively as feed. Just now most of it is being used for fuel; but, when the price of coal becomes normal again, it could probably be used to greater advantage as feed. At present, the oil factories in the Islands are in a prosperous condition. This will naturally cause an increase in the demand for copra and in the amount of by-product obtained. It is, therefore, of the highest importance to know the real feeding value of this by-product.

A review of the literature on this subject will show that the biochemistry of copra meal has been studied to a limited extent only. The one work reported on the subject is that of the Hausmann number on the globulin of coconut determined by Osborne and Harris and included by Plimmer (18) in his table of nitrogen partition into three groups for different proteins.[3] Why this feeding stuff has been neglected by chemists is not known; it is probably due to the fact that only in recent years has the need

[1] Published with the permission of the Director of the Experiment Station of the College of Agriculture, University of the Philippines.

[2] Copra meal was sold (1918 and 1919) at 21 pesos a ton by the Philippine Oil Products Company, of San Pablo, Laguna. In May, 1919, the price of copra meal in Manila was 40 pesos a ton. At this rate 74,760 tons would cost 2,990,400 pesos.

[3] Since the manuscript for this paper was written C. O. Johns, A. J. Finks, and E. F. Gersdorff, Journ. Biol. Chem. 37 (1919) 149, have published data on the distribution of the basic nitrogen in coconut globulin. The average data of the analysis by the Van Slyke method given by these authors on page 152, have been included in Table 2.

for definite knowledge of the nature of the proteins in feeds been felt. Ten or fifteen years ago chemists were satisfied if they knew their crude-protein content, and they did not consider it important or necessary to get a more definite knowledge of its nature. The present work was intended as a preliminary study of this great problem and it was decided, first, to apply the Van Slyke method to the protein of copra meal taken as a whole and, second, to determine the proteins soluble in different solvents, both qualitatively and quantitatively.

Analyses of other feeding stuffs have been made by Grindley, Joseph and Slater(7) and by Grindley and Slater.(8)[4] Gortner,(4) who is emphatically against the idea of making a direct comparison between the analysis of protein unseparated from the feeding stuff and that of a pure protein, nevertheless admits that much comparative data can be obtained from the work of these authors. At present, the department of agricultural chemistry of the Philippine College of Agriculture is perfecting a plan for conducting a series of nutrition experiments with copra meal; and, because a more intimate knowledge of the protein of copra meal is necessary for this work, the carrying on of the experiments reported in this paper is believed to be justified. Individual proteins will be isolated and studied later.

DETERMINATION OF NITROGEN DISTRIBUTION IN COPRA MEAL

The copra meal, which was kindly furnished by Chesley, Conde and Company through Dr. Baldomero L. Roxas, of Manila, was ground fine, and on analysis showed the following composition:

TABLE 1.—*Composition of copra meal.*

	Per cent.
Moisture	11.3
Oil	12.2
Crude protein	20.1
Ash	5.5
Crude fiber	13.2
Carbohydrates	37.0

The ground meal was then dried under vacuum by Browne's method(3) and extracted with ether for eight hours. Two-gram samples were treated with hot water (at about 90° C.) for one

[4] Since the manuscript for this paper was prepared, H. C. Eckstein, and H. S. Grindley, Journ. Biol. Chem. 37 (1919) 373, have published a decidedly improved method "to determine directly the combined amino-acids of feedingstuffs by the application of the Van Slyke Method for the determination of the characteristic groups of amino-acids of proteins."

hour and then filtered. This treatment removed the water-soluble protein and a part of the salt-soluble, together with the starch and other soluble carbohydrates. The residue was washed thoroughly with hot water. The filtrate together with the washing was treated quantitatively for total nitrogen, and the residue hydrolyzed with 20 per cent hydrochloric acid (14) for forty-eight hours. The distribution of nitrogen in the hydrolysate was determined according to the directions in Plimmer's monograph (19) with certain modifications, stated below. The residue from hydrolysis was treated quantitatively for hydrochloric acid insoluble humin nitrogen in accordance with the method of Gortner and Holm. (6)

TABLE 2.—*Distribution of nitrogen in copra meal (two-gram samples).*

	Nitrogen in each sample.	Nitrogen average.	Different forms of hydrochloric-acid-soluble nitrogen.	Nitrogen in each sample.	Nitrogen average.	Total nitrogen insoluble in hot water.
	mg.	*mg.*		*mg.*	*mg.*	*Per cent.*
Nitrogen in hot water extract.[a]	14.1 12.6	13.35	----------	----------	----------	----------
Hydrochloric acid-insoluble humin nitrogen.	1.41 1.27	1.34	----------	1.41 1.27	1.34	2.24
Nitrogen soluble in hydrochloric acid.	61.14 55.52	58.33	Humin nitrogen soluble in hydrochloric acid.	2.90	2.90	4.87
			Amide nitrogen	15.50 15.20	15.35	25.72
			Arginine nitrogen	7.00 7.00	7.00	11.73
			Histidine nitrogen	2.35	2.35	3.94
			Lysine nitrogen	1.31	1.31	2.19
			Cystine nitrogen	4.05 3.82	3.93	6.58
			Mono-amino nitrogen	25.52 24.57	25.04	41.96
			Non-amino nitrogen	1.24	1.24	2.08
Total nitrogen	----------	73.02	----------	----------	60.46	101.31

[a] The distribution of this nitrogen was not determined.

Hydrochloric acid insoluble humin nitrogen (mg.)	1.34
Hydrochloric acid soluble nitrogen (mg.)	58.33
Total nitrogen insoluble in hot water (mg.)	59.67
Nitrogen in hot water extract (mg.)	13.35
Total nitrogen by direct analysis (mg.)	73.02
Total nitrogen accounted for (per cent)	99.75

All of the total nitrogen determinations were made by the Kjeldahl-Gunning-Arnold method (22) using 1 gram of copper sulphate instead of mercury, and boiling for four hours (2) after the solution turned clear. The Claisen flasks of 1-liter capacity were found to be inadequate and 2-liter distilling flasks, modified for the purpose, were used instead. In the estimation of arginine Folin's improved absorption tubes (11) dipping into the standard acid were used instead of Folin bulbs, and 20 per cent sodium hydroxide (20) instead of 50 per cent. The absorption tubes were kindly loaned by the department of physiology of the College of Medicine and Surgery. The amino-nitrogen determinations were made at no fixed temperature, since the laboratory of agricultural chemistry of the College of Agriculture has no means for controlling this factor. Alizarine sodium monosulphonate was used as indicator in all of the titrations, and it was found more satisfactory than methyl orange. The results are recorded in Table 2, and are compared with the analyses of some known proteins in Table 3.

TABLE 3.—*Comparison of nitrogen distribution in the hot-water-insoluble portion of copra meal with that in some other products.*

Nitrogen.	Lactalbumin[a] plus equal weight of dextrose.[b]	Copra meal.	Cottonseed meal.[c]	Coconut globulin.[d]	Coconut globulin.[e]
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Amide	8.37	25.72	10.45	7.36	7.99
Humin	3.70	7.11	7.78	0.76	[f]1.41
Cystine	1.05	6.58	0.65	----------	0.96
Arginine	8.10	11.73	19.52	32.79	29.50
Histidine	3.22	3.94	5.47	----------	3.68
Lysine	12.54	2.19	4.78	----------	6.41
Mono-amino	58.79	41.96	42.82	59.09	45.44
Non-amino	3.58	2.08	5.43	----------	4.60
Total	99.35	101.31	96.90	100.00	----------

[a] Gortner, R. A., Journ. Biol. Chem. **26** (1916) 182.

[b] The presence of tryptophane was tested in the water-soluble protein by the Hopkins-Cole and Benedict modified Hopkins-Cole reactions. (12)

[c] Grindley, H. S., Joseph, W. E., and Slater, W. E., Journ. Am. Chem. Soc. **37** (1915) 1779.

[d] Hawk, P. B., Practical Physiological Chemistry. Philadelphia, P. Blakiston's Son & Co. (1914) 400.

[e] See footnote 3.

[f] Humin absorbed by lime. 0.11 humin nitrogen in amyl alcohol extract.

Table 2 shows that the distribution of nitrogen in copra meal is fairly even. As stated above, the hot-water-soluble substances were eliminated before the copra meal was hydrolyzed with hydrochloric acid, thus removing starch and other soluble carbohydrates, and the water- and part of the salt-soluble protein. The results are compared with the nitrogen distribution of lactalbumin plus an equal weight of dextrose as reported by Gortner.(5) When compared with this protein (Table 3) copra meal is found to be richer in amide, humin, cystine, arginine, and histidine, and poorer in lysine, mono-amino, and non-amino-acid nitrogen. Compared with cottonseed meal, it is found to be richer in amide and cystine nitrogen, and poorer in arginine, lysine, and non-amino-acid nitrogen. The humin and mono-amino-acid nitrogen of both are practically the same.

In short, copra meal, while rather poor in the sum total for lysine,(16) is rich in arginine, histidine,(1) and cystine.(17) The preliminary feeding experiments conducted by the animal husbandry department of the College of Agriculture seem to show that copra meal, when fed alone, cannot promote growth in hogs; but, when fed with green leaves, it furnishes a fairly perfect feed. It is possible that copra meal is lacking in "unknown accessories"(10) which here appear to be supplied by the green leaves.

The nitrogen partition in the hot-water-soluble proteins has not been studied. It is hoped that this will be done in the near future. Some idea of the distribution of nitrogen in these proteins may be gained by reference to the results with coconut globulin obtained by Osborne and Harris, and given in Plimmer's monograph.(18) These results calculated to percentage of total nitrogen have been included in Table 3.

DETERMINATION OF PROTEINS SOLUBLE IN DIFFERENT SOLVENTS

The fat-free copra meal, dried at room temperature, was treated according to the method proposed by H. H. Snyder and reported by Harcourt.(9) The meal was treated with water and then with salt solution before extracting it with alcohol. Chloroform was added to prevent decomposition. In the first trial only about 30 per cent of the protein was extracted by the different solvents. This was thought to be due to the inability of the solvents to penetrate the particles of the copra meal, the sample used being a mixture of meals that had been passed through 40-, 60-, 80-, and 100-mesh sieves, respectively. In the second trial only the sample passed through the 100-mesh sieve was used. It is regrettable that a finer sieve could not be obtained. The two samples gave the same amount of total nitrogen; so it trial only the sample passed through the 100-mesh sieve was was at first thought that they had the same composition. This was proven not to be the case, as shown by the difference in their protein distribution. The results with the 100-mesh sample were still low. The method was then slightly modified, using the sample employed in the second trial. The mixture of sample and solvent was shaken repeatedly in a shaking machine, filtered and washed until the washing no longer gave a reaction for protein. Twelve hours were found to be sufficient to finish the extraction. This trial, although decidedly better than the first two, extracted only 47.55 per cent of the total protein. Since this laboratory has no facilities for very fine grinding, it was decided to discontinue the work for the present, and to report the results obtained.

A comparison of the results of trials 1 and 2 shows that the two samples, one composed of the materials passed through the 40- to 100-mesh sieves, and the other composed of the portion passed through the 100-mesh sieve, were not the same in general composition. The difference in protein distribution may be due to the fact that the sample used in trial 2 was composed of that portion of the copra meal which could be pulverized more easily; and it is not surprising to find, as in this case, that its composition was different from that of the portion harder to pulverize.

The results of trial 3 show that the modified method used is better for copra meal than the one proposed by H. H. Snyder. In this trial, the percentage of salt-soluble protein is lower than in trial 2. Most of the water-soluble protein is also salt-soluble; and, therefore, an increase in the water-soluble extract naturally causes a decrease in the salt-soluble fraction. When the percentages of the water- and the salt-soluble moieties are combined, the results in trial 3 show an improvement as compared with those in trial 2

Calculated in percentage of protein that went into solution, the mixed sample yielded more water- and salt-soluble than did the 100-mesh sample. The water- plus the salt-soluble in trial 3 is lower than in trial 2 by about 5 per cent in the alkali-soluble fraction of the former, which might explain the difference.

There is practically no alcohol-soluble protein. This partly agrees with the observation of Osborne(13) that alcohol-soluble protein is not found in any seed but cereals.

All the trials show that the alkali-soluble protein is the most abundant in copra meal.

Although this work is incomplete, it is believed that it may serve as a guide in the study of the biochemistry of copra meal.

TABLE 4.—*Distribution of proteins soluble in different solvents.*

TRIAL 1. MIXED SAMPLE.

Copra meal.	Nitrogen found in solvent.	Average nitrogen.	Nitrogen in meal taken.	Total nitrogen.	Solvent.	Protein dissolved.
gms.	*gms.*	*gms.*	*gms.*	*Per cent.*		*Per cent.*
10	0.03270					
10	0.03213	0.03268	0.33474	9.76	Water	33.54
10	0.03446					
10	0.03142					
10	0.02944					
10		0.02840	0.33474	8.48	10 per cent sodium chloride.	29.14
10	0.02916					
10	0.02661					
5	0.01847					
5	0.01769	0.01819	0.16737	10.86	0.2 per cent potassium hydroxide.	37.32
5	0.01840					
5						
5	trace					
5	trace	trace	0.16737	trace	70 per cent alcohol.	
5	trace					
5	trace					
Total				29.10		
Total nitrogen in residue (taken as check)				70.27		
Sum total				99.37		

TRIAL 2. 100-MESH SAMPLE.

Copra meal.	Nitrogen found in solvent.	Average nitrogen.	Nitrogen in meal taken.	Total nitrogen.	Solvent.	Protein dissolved.
10	0.02484					
10	0.02746	0.02613	0.33799	7.73	Water	20.76
10	0.02526					
10	0.02696					
10	0.01486					
10	0.01486	0.01604	0.33799	4.74	10 per cent sodium chloride.	12.73
10						
10	0.01839					
5	0.04260					
5	0.04271	0.04186	0.16900	24.77	0.2 per cent potassium hydroxide.	66.51
5						
5	0.04028					
5	trace					
5	trace		0.169 00	trace	70 per cent alcohol.	
5	trace					
5	trace					
Total				37.24		

TABLE 4.—*Distribution of proteins soluble in different solvents*—Continued.

TRIAL 3. 100-MESH SAMPLE, MODIFIED METHOD.

Copra meal.	Nitrogen found in solvent.	Average nitrogen.	Nitrogen in meal taken.	Total nitrogen.	Solvent.	Protein dissolved.
gms.	*gms.*	*gms.*	*gms.*	*Per cent.*		*Per cent.*
10	0.03680	0.03620	0.33799	10.71	Water	22.53
10	0.03590					
10	0.03590					
10						
10	0.00835	0.00935	0.33799	2.77	10 per cent sodium chloride.	5.82
10	0.00948					
10	0.01023					
10						
5	0.05426	0.05758	0.16900	34.07	0.2 per cent potassium hydroxide.	71.65
5	0.05348					
5						
5	0.06500					
5	trace		0.16900	trace	70 per cent alcohol.	
5	trace					
5	trace					
5	trace					
Total				47.55		

The separation and purification of the alkali-soluble protein will be undertaken soon and a study made of its amino-acid content.

SUMMARY

1. The nitrogen partition in that portion of copra meal insoluble in hot water has been studied; it has been found that copra meal is rich in the amino-acids necessary for maintenance and growth.

2. It has been found that the alkali-soluble protein is the most abundant in copra meal.

3. The maximum amount of total protein nitrogen dissolved is only 47.55 per cent of the actual amount present in copra meal. This result seems to be rather low when compared with that obtained by Osborne and Campbell.(15) They were able to dissolve a total of 96.6 per cent of the protein nitrogen found in lupine seeds.

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EIGHTH CONTRIBUTION TO THE COLEOPTERA FAUNA OF THE PHILIPPINES

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ONE COLORED PLATE AND ONE BLACK PLATE

In this paper I wish to make known among others a series of new and rather conspicuous Philippine Cerambycidæ. Our present knowledge of the identified longicorns of the Philippine Islands, aside from those herein described, comprises some two hundred eighty species of which about one-third was originally described by Newman [1] from material collected by Hugh Cuming during 1836 to 1840. Several other series of cerambycids, as well as other Coleoptera, of the Cuming material were described by Westwood, G. R. Waterhouse, Pascoe, and various other authors; and in no instance is the exact locality for the species given, except in some cases "Manilla," and for obvious reasons this locality name should be disregarded unless verified by new records. Concerning the localities of, as well as other data on, H. Cuming's collections from the Philippine Islands, useful references are given by Merrill.[2]

The following species are herein described:

CERAMBYCIDÆ

Megopis sanchezi sp. nov.
Nemophas rosenbergii ramosi subsp. nov.
Pachyteria ilocana sp. nov.
Aphrodisium luzonicum sp. nov.
Aphrodisium panayarum sp. nov.
Bicon luzonensis sp. nov.
Clytellus benguetanus sp. nov.
Neocollyrodes macgregori g. et sp. nov.
Pharsalia mindanaoensis sp. nov.
Euclea panayana sp. nov.
Euclea variolosa sp. nov.
Chlorisanis benguetanus sp. nov.

CURCULIONIDÆ

Pachyrrhynchus erosus sp. nov.
Calidiopsis affinis sp. nov.

DYNASTIDÆ

Xylotrupes mindanaoensis sp. nov.

[1] Newman, Edward, Cerambycitum Insularum Manillarum Dom. Cuming captarum enumeratio digesta, The Entomologist (1840–2) 243.

[2] Merrill, E. D., Genera and species erroneously credited to the Philippine flora, Philip. Journ. Sci. § C 10 (1915) 171; page 183 (an account of the localities of H. Cuming's collections in the Philippine Islands).

Megopis (Baralipton) sanchezi sp. nov. Plate 1, fig. 6, ♂.

Grayish brown, head, prothorax, and elytra covered with very fine pubescence. Head with a dimplelike depression on the front from which a well-pronounced medial line issues, reaching on to vertex. Antennary bases strongly produced. Antennæ of male slightly longer than body; of female one-fourth shorter than body. First joint twice as long as broad; first, third, and fourth joints closely granulated, finely and rather sparsely pubescent; last seven joints somewhat glossy. Third joint of male as long as fourth, fifth, and sixth joints together; third joint of female longer than fourth, fifth, and sixth joints together. Extreme apical part of each joint, except the last, blackish. Prothorax constricted anteriorly, gaining in width toward the base. Posterior-lateral angles produced, forming a flattened toothlike projection. Discal area with an irregular broad swelling toward the posterior margin. Elytra with inner and middle costæ strongly raised, castaneous brown, connected by a cross branch at the apical fourth. Outer costa faintly indicated in the basal half, but shortly before the middle it is more distinct, continued in two branches, the inner one of which runs into the medial costa, the outer one ending near the apex. A short spine at the apical termination of the suture. Abdominal segments and legs less densely pubescent. Last ventral segment of male strongly emarginate.

Male, length, 42.5 millimeters; width, 10.8. Female, length, 51.5 millimeters; width, 15.

LUZON, Benguet, Baguio (*W. Schultze*). Types in my collection.

This species is very destructive to the Benguet pine. On several visits to the pine-clad mountains of Benguet around Baguio and on the trail to Mount Santo Tomas I came across a number of old trees of *Pinus insularis* Endl., which were badly infested by a species of cerambycid. In 1917 I succeeded in rearing an adult of *Megopis sanchezi* from some larvæ that were kept in a piece of pine log.[3]

[3] In my Catalogue of the Coleoptera of the Philippine Islands, page 106, the above new species was erroneously identified as *Megopis cingalensis* White; therefore, the latter name should be eliminated from the Philippine list, and *M. sanchezi* is to be added.

Nemophas rosenbergii ramosi subsp. nov. Plate 2, fig. 2.

Head, prothorax underside, and legs densely covered by ocherous pubescence. Elytra dark metallic green, very coarse, confluent and somewhat granulate, deeply impressed punctures basally, which become less and less pronounced toward the apex. A narrow irregular pale ocherous band at the base, another creamy white, somewhat broader band before the middle, and a very broad band behind the middle. The anterior margin of the latter nearly straight, but the posterior margin forming an arch on each elytron. Still another band at the apex with a narrow bare spot.

Length, 34 millimeters; width at shoulder, 11; antenna, 54.

MINDANAO, Surigao, Surigao (*M. Ramos*). Type in my collection.

The close relationship of this species to *N. rosenbergii* Rits.[4] from Toelabollo, North Celebes, according to the description of the latter is apparent, but the markings seem to differ.

Pachyteria ilocana sp. nov. Plate 1, fig. 1, ♂.

Head punctulate and rugulose, black, except the front, which is rufescent-ochraceous. Interantennary ridge strongly concave and divided by a well-pronounced medial groove, the latter reaching from front to vertex. Palpi and antennæ rufescent-ochraceous and finely setose. Prothorax closely punctured, constricted and transversely grooved anteriorly and posteriorly. Lateral margins acute tuberculate. A distinct groove circumscribes a somewhat tumid area, which is finely coriaceous and of a rufescent-ochraceous color. This area extends dorsolaterally from the anterior transverse groove to the tubercle, thence to the posterior groove, and is continued ventrally, passing anterior to the intercoxal process of the prosternum. Discal area of prothorax more or less covered with short black velvety pubescence, except two small oblong glossy depressions, at the middle, near the anterior, and near the posterior transverse groove. Scutellum black. Elytra densely punctured, covered with velvety pubescence, black, except the basal area, which is rufescent-ochraceous. Each elytron showing slight traces of three longitudinal costæ. Body beneath glossy, dark violet blue and irregularly punctured. Along the posterior margin of the first abdominal segment an oblong patch of silvery gray pubescence. Legs rufescent-ochraceous, irregularly punctured, rugose and finely setose. A fringe of setæ on the

[4] Ritsema, Notes Leyd. Mus. (1881) 148; Heller, Tijdschr. voor Entom. 62 (1919) 102.

underside of the tibiæ, more strongly pronounced in the posterior tibiæ; claws black.

Length, 37 millimeters; width, 11.

LUZON, Ilocos Norte, Bangui. Type in my collection.

Aphrodisium panayarum sp. nov. Plate 1, fig. 8, ♀.

Female.—Head, prothorax, and scutellum metallic purplish bronze, very glossy; elytra and legs, except tarsi, dark blue. Head with front strongly concave, densely punctured, a medial groove which terminates between the eyes on vertex, the latter as well as sides of head densely rugulose-punctate. Antennæ dark blue, first joint densely punctulate, the following joints faintly black pubescent. Prothorax constricted and transversely grooved anteriorly and posteriorly, with a strongly pronounced tubercle at the middle of each lateral margin. Discal area densely and coarsely rugulose-punctate, very faintly pubescent, somewhat raised, forming a rather sharp ridge posteriorly. Anterior and posterior grooves in the middle smooth. Lateral margins rugulose-punctate. Scutellum with a shallow indistinct medial groove, punctured toward the margins. Elytra with basal area sparsely and scatteredly punctured, glossy and with a violet sheen; toward the middle densely punctured and black pubescent, and gradually less so toward the apex. Medial area with a faint greenish, the apical area with a steel-blue, sheen. Abdominal segments scatteredly and sparsely punctured, very glossy greenish blue. Femora irregularly finely and coarsely punctured and faintly pubescent, tibiæ densely punctured, especially posterior tibiæ densely blackish pubescent with a fringe of setæ. Tarsi rufescent ochraceous, claws black.

Female, length, 35 millimeters; width, 9.

PANAY, Antique, Culasi (*R. C. McGregor*). Type in my collection.

Aphrodisium luzonicum sp. nov. Plate 1, fig. 4, ♀.

Head, prothorax, and scutellum glossy metallic greenish bronze, elytra metallic blue with a green reflection. Head with front concave, irregularly coarsely punctured, a medial groove which terminates between the eyes on vertex. The latter irregularly punctate, sides of head rugulose-punctate. Prothorax similar in form to *A. panayarum*, the sculpture more pronounced. At the disk a well-pronounced bifid patch of black pubescence. Elytra, basally, sparsely and scatteredly punctured, toward the middle densely punctured and sparsely black pubescent, less so toward the apex. Meso- and metathorax of female and in the male also the abdominal segments finely, somewhat iridescent, whitish pubescent. Abdominal segments of female glossy dark blue. Legs dark blue, except foretibiæ below, and tarsi, which are rufescent-ochraceous.

Male, length, 24.5 millimeters; width, 6.5. Female, length, 35 millimeters; width, 9.8.

LUZON, Ilocos Norte, Bangui (my collector). Types in my collection.

Aphrodisium semiignitum Chevr.[5] Plate 1, fig. 10, ♀.

As belonging to this species I identified several specimens that were caught with specimens of *Aphrodisium luzonicum* and *Pachyteria ilocana*, which are described in this paper. It is easily distinguished from *A. luzonicum* and *A. panayarum* by its strikingly different coloration: Head, prothorax, and elytra metallic reddish bronze, medial area toward lateral margins of elytra dark purple; antennæ and legs dark blue, except tarsi, which are rufescent-ochraceous. All the above-mentioned species were collected near Bangui, Ilocos Norte, Luzon, from certain flowers, on which they were feeding.

Bicon luzonensis sp. nov.

Head, antennæ, scutellum, elytra, and legs black; prothorax red. Head asperate, antennæ densely and irregularly punctured, third joint longest. Prothorax longer than broad, asperate, with a narrow blackish anterior marginal band. Elytra coarsely and densely punctured, especially toward the base, also somewhat granulated. Apex bispinose. Legs closely and strongly punctured and sparsely setose.

Male, length, 7.5 millimeters; width, 2. Female, length, 8.2 millimeters; width, 2.5.

LUZON, Bulacan, Angat (*M. Ramos*). Types in my collection.

Clytellus benguetanus sp. nov.

Black, very glossy. Head with front rugulose, with a well-pronounced medial carina and sparsely setose. Antennæ irregularly punctured, rugulose and sparsely setose, second joint half as long as third, third to sixth joints subequal in length, seventh to tenth joints shorter and broader than the former joints, eleventh joint longest. Prothorax impunctate, broadest anteriorly, strongly constricted at the posterior third, gaining

[5] Chevrolat, Rev. Zool. (1841) 227.

slightly in width again toward the posterior margin. Elytra strongly constricted before the middle, a few coarse punctures and a few white setæ at the constriction. At the apical triangle a small patch of silky white pubescence. Underside white pubescent. Legs sparsely whitish setose.

Length, 5.8 millimeters; width, 1.5.

LUZON, Benguet, Baguio (*W. Schultze*). Type in my collection.

Genus NEOCOLLYRODES novum

Head with the eyes very much produced; front concave, deeply notched between antennary bases, head slightly constricted behind the eyes. Antennæ filiform, reaching to basal fourth of elytra. First joint twice as long as broad; second joint one-third as long as first; third joint longest, twice as long as first and about equal in length to fourth and fifth together. Prothorax twice as long as broad, subcylindrical, slightly constricted posteriorly. Elytra subparallel in basal half, somewhat broader in apical half. Apex of each elytron with two acute angles. Legs slender, hind femora twice as long as front femora, the former reaching well beyond apex of elytra. Tibiæ with two spines at the apex. First tarsal joint of hind legs longer than the following joints together. This remarkable genus, resembling in aspect, and having a mimicry relationship to, the genus *Collyris* of the Cicindelidæ, I propose to place near *Collyrodes* Pascoe.[6]

Type, *Neocollyrodes macgregori* sp. nov.

Neocollyrodes macgregori sp. nov. Plate 1, fig. 5.

Glossy bluish black, femora dark red. Front with a strongly raised glossy medial ridge forming a triangle, laterally irregularly punctured; sides of head irregularly punctured, behind the eyes rugose. A bluish white tomentose spot on vertex. Antennæ with first and second joints glossy, third to fifth joints dorsally bluish white tomentose. Prothorax with an anterior and posterior submarginal groove, the surface strongly asperate and rugose, toward the base an irregular oblong smooth area. Apical third in female with a large black pubescent patch. At the middle laterally a small round bluish white tomentose spot and another at the base. Scutellum white tomentose. Elytra with a small round bluish white tomentose spot at the

[6] Pascoe, Trans. Ent. Soc. London II 5 (1859) 25.

basal fourth, a fascia interrupted at the suture and not reaching lateral margins, being located behind the middle. Two other roundish tomentose spots on each elytron in apical area. Basal area, up to the fascia, glossy, coarsely and confluently punctured and rugose toward the lateral margins, the sculpture similar to that found in species of the genus *Collyris*. Apical half finely and densely punctured and beset with black pubescence, which disappears toward apex. Underside irregularly punctured and finely setose. Episterna of metathorax with a white tomentose patch. First abdominal segment with a bluish white spot toward each lateral margin. Legs sparsely punctured and finely setose. Apical part, dorsally, of femora, tibiæ, and tarsi entirely, bluish white tomentose.

Male, length, 21 millimeters; width, 3. Female, length, 22 millimeters; width, 3.3.

PANAY, Antique, Culasi (*R. C. McGregor*). Type in my collection.

Three other specimens from Luzon, Paete, Laguna Province, and Bosoboso, Rizal Province, differ from the typical specimens of Panay in the following respect: The punctation on the basal half of the elytra is distinctly less pronounced and is sparser and less confluent.

Pharsalia mindanaoensis sp. nov. Plate 1, fig. 7.

Black, prothorax reddish brown, elytra with numerous pale reddish and very irregular narrow bands or spots. Head black, finely and sparsely silvery gray pubescent, front finely and densely punctured with a few scattered coarse punctures. A fine medial groove reaching to vertex. Antennæ black, finely pubescent, last five joints entirely white. Prothorax much broader than long, densely reddish brown pubescent. The spine at the lateral margins is located slightly behind the middle. An anterior and posterior submarginal groove. Discal area with some coarse scattered punctures, an indistinct ridge in the posterior half. Elytra black with numerous irregular combinations of pale reddish bands, which are more condensed toward the apex. Black areas with scattered coarse punctures. Underside pale reddish brown, middle of abdominal segments blackish. Last abdominal segment strongly emarginate. Legs black, finely and sparsely silvery gray pubescent.

Length, 25 millimeters; width, 7.5.

MINDANAO, Surigao, Surigao. Type in my collection.

Euclea panayana sp. nov. Plate 1, fig. 3.

Black. Head irregularly punctured. Front with a medial carina and two narrow tomentose stripes, forming the letter V; terminating on vertex. Prothorax irregularly punctured except a narrow oblong area discally impunctate. An oblique stripe extending from anterior margin, somewhat lateral, to lateral-posterior margin, gaining in width toward the latter margin. Elytra coarsely and densely punctured, less so in the apical half discally. A broad fascia of pale pinkish white extending from the suture posteriorly of scutellum obliquely to lateral margins, and beyond the middle from the margins oblique-posteriorly to the suture. Inside the fascia, at the suture and toward the base a small subtriangular bare spot. Apical third with a small triangular tomentose spot at lateral margin and another larger oblong subsutural spot at apical triangle. These spots as well as stripes on head and prothorax dark cream color, also pro-, meso-, and metasternum. Abdominal segments and femora finely whitish pubescent, in the former more pronounced along the posterior margins. Tibiæ and tarsi black pubescent.

Length, 17.5 millimeters; width, 5.5.

PANAY, Capiz Province, mountains near Jamindan. Type in my collection.

This species is nearly related to *E. mesoleuca* Pascoe.[7] Manila, the locality given for this species by Pascoe, seems very doubtful, since specimens which I identified by comparison with the type in the British Museum as *E. mesoleuca* Pasc. were collected by R. C. McGregor in Sibuyan Island. In Pascoe's species the bare spot at the suture of the elytra is located in the middle of the fascia and is large and roundish as compared to the very small bare sutural spot of *E. panayana* Schultze which is located close to the scutellum.

Euclea variolosa sp. nov. Plate 1, fig. 9.

Glossy black; head sparsely, irregularly, coarsely punctured. A well-pronounced medial carina from front to vertex. Front rufescent tomentose, at vertex this color intermixed with white. Small irregularly scattered bare spots are generally located around the punctures. Prothorax one-fifth broader than long, a small tubercle at lateral margins, irregularly scatteredly punc-

[7] Pascoe, Trans. Ent. Soc. London III 3 (1865) 150.

"*Euclea mesoleuca.*

"E. nigra, nitida, pube sparse niveo-irrorata; elytris punctatis, fascia latissima dense niveo-pubescente, adsuturam interrupta, ornatis.

"Hab.—Manila."

tured, rufescent and whitish tomentose with irregularly scattered bare spots. Elytra irregularly punctured, confluent pale rufescent and white tomentose.

Length, 27.5 millimeters; width, 8.7.

PANAY, Antique, Culasi (*R. C. McGregor*). Type in my collection.

This species is easily distinguished by its much stouter form and larger size from the other Philippine representatives of this genus.

Chlorisanis benguetanus sp. nov. Plate 1, fig. 2.

Dark metallic blue. Head sparsely and scatteredly punctured. Antennæ dark blue. Prothorax irregularly and scatteredly punctured. Discal area with two small roundish and an oblong callosity, the latter in the basal half. Elytra very densely and coarsely punctured, the punctures growing less toward apex. Lateral margins abruptly set off by a carina. Subsutural and apical areas finely pubescent, apical end of each elytron with two obtuse spines. Margins of apical fourth beset with rather long black setæ. Underside glossy green, finely whitish pubescent. Femora rufescent-ochraceous, glossy; tibiæ and tarsi black, pubescent, and setose, more pronounced on the posterior legs.

Length, 17 millimeters; width, 4.5.

LUZON, Benguet, Baguio (*F. Sanchez, S. J.*) Type in my collection.

From *C. viridis* Pascoe,[8] the type of the genus from Sarawak, the above species is easily distinguished by the rufescent-ochraceous femora.

Pachyrrhynchus erosus sp. nov.

Black, glossy; elytra with a series of fine longitudinal grooves, which form loops as in *Macrocyrtus erosus* Pasc. Head with rostrum in the basal half strongly depressed with a scale spot which is divided by a longitudinal groove extending to the front. Prothorax subglobular with a strongly pronounced anterior and a posterior submarginal groove. Elytra with nine or ten longitudinal grooves, respectively, one at the suture being common to both elytra, closely beset with creamy white scales, the grooves forming five loops. The shortest loop is located subsuturally, the others extend from near the base to the apical fourth. Near the apex and subsuturally another short oblong loop and at the apical triangle a triangular loop. Legs with a scale spot at the femora apically.

[8] Pascoe, Trans. Ent. Soc. London III 3 (1867) 413, pl. 16, fig. 7.

Male, length, 12 millimeters; width, 5. Female, length, 14 millimeters; width, 6.6.

LUZON, Benguet, mountain trail near Atoc (*W. Schultze*). Types in my collection.

The species is closely related to *P. annulatus* Chevr., *anellifer* Heller, and *schuetzei* Schultze. On a recent collecting trip to the Benguet mountains, during October to December, 1919, I was fortunate in finding a good series of this species, which varies very little, and in obtaining some data on its peculiar habits. This species was found near the trail at the steep mountain sides on tall, coarse grass growing between the rocks. All specimens were collected from about 4 o'clock in the afternoon until dark, in the act of crawling up. Several specimens found had recently emerged and were quite soft. A number were found in copula. Together with this species and from the same grass I collected a hitherto unidentified *Metapocyrtus* sp. in appearance very much resembling the former.

Pachyrrhynchus pinorum Pasc.

In a former paper [9] I omitted to mention from Baguio, Benguet, the species *P. chevrolati* Eyd. et Soul. and the commonest, *P. pinorum* Pasc. Many specimens of the last-mentioned species were collected at and around Baguio. These specimens have the broad grooves beset with very indistinct and little-pronounced rudimentary scales. On my recent trip I collected near Atoc, Benguet, a number of specimens of *P. pinorum* which have the grooves closely beset with small white scales. In structure, these specimens do not vary from those from Baguio.

Calidiopsis affinis sp. nov.

Closely related to *C. lineata* Schultze. Black, with longitudinal white stripes on the elytra. Antenna with the scape with scattered whitish scales and densely beset with fine black bristles, funicular joints whitish, the second joint being the longest. Prothorax very coarsely and irregularly punctured. A white medial line and another ill-defined line and a patch of scales at each lateral margin. Elytra with much coarser sculpture than in *C. lineata,* beset with black bristles which are slightly longer than in the above species. A white sutural stripe from the base to the apex, and three stripes on each elytron, and another stripe at the lateral margin surrounded by scattered scales. Underside and legs closely covered with greenish white scales.

[9] Philip. Journ. Sci. § D 12 (1917) 252.

Length, 10 millimeters; width, 4.2.

MINDANAO, Zamboanga, Malangas (my collector). Type in my collection.

DYNASTIDÆ

Xylotrupes mindanaoensis sp. nov. Plate 2, fig. 1, *a*, *b*, *c*.

Black, pronotum and elytra pale grayish brown, velvety iridescent pubescent, less pronounced in the female. Male: Head with a suberect, slightly curved horn, which is laterally slightly compressed and terminates in two diverging branches. Lateral basal angles of the horn forming a strongly pronounced toothlike projection. Pronotum, the anterior lateral angles very strongly projecting, at the disk a short, stout horn directed forward and bifid at the extremity. The pronotum irregularly and confluently punctured and densely beset with a short velvety pubescence, except the horn, which is bare toward the extremity above. Scutellum coarsely, irregularly punctured, with a posterior submarginal groove. Elytra irregularly punctured and very densely beset with velvety iridescent pubescence. Pygidium also densely pubescent. Metathorax beset with reddish hair. Abdominal segments irregularly punctured. Female: Head at the vertex with a very small obtuse tuberculate projection. Pronotum very coarsely and confluently punctured, toward the margins coriaceous, and sparsely pubescent. Elytra also velvety iridescent pubescent, but less pronounced than in the male.

Male, length, 34 millimeters; width at shoulder, 17.5. Female, length, 34 millimeters; width at shoulder, 16.5.

MINDANAO, Surigao, Surigao (*J. Ramos*), found in copula. Types in my collection.

This species is readily distinguished by the peculiar scalelike velvety iridescent pubescence, somewhat similar to that of species of cerambycids belonging to the genus *Aeolesthes*.

NOTES ON SOME PHILIPPINE DYNASTIDÆ

In my Catalogue of Philippine Coleoptera, page 173, I included *Dipelicus deiphobus* Sharp (det. C. Felsche). This species should be eliminated from the Philippine list since the species in question is *Dipelicus robustus* Heller.[10]

Furthermore, *Xylotrupes pubescens* Waterh.[11] is a valid species and not a synonym of *X. phorbanta* Oliv. The last mentioned is considered by Arrow [12] as a synonym of *X. gideon* Linn.

[10] Heller, Notes Leyden Mus. 19 (1897) 172.

[11] Waterhouse, Proc. Ent. Soc. London (1841) 17; Ann. & Mag. Nat. Hist. 7 (1841) 539.

[12] Arrow, Fauna Brit. India, Col. (1910) 262.

ILLUSTRATIONS

Plate 1

[Original drawings by W. Schultze.]

Fig. 1. *Pachyteria ilocana* sp. nov., male.
2. *Chlorisanis benguetanus* sp. nov.
3. *Euclea panayana* sp. nov.
4. *Aphrodisium luzonicum* sp. nov., female.
5. *Neocollyrodes macgregori* g. et sp. nov.
6. *Megopis* (*Baralipton*) *sanchezi* sp. nov., male.
7. *Pharsalia mindanaoensis* sp. nov.
8. *Aphxodisium panayarum* sp. nov., female.
9. *Euclea variolosa* sp. nov.
10. *Aphrodisium semiignitum* Chevr., female.

Plate 2

Fig. 1. *Xylotrupes mindanaoensis* sp. nov., *a*, male, dorsal view; *b*, male, dorsolateral view; *c*, female, dorsal view.
2. *Nemophas rosenbergii ramosi* subsp. nov.

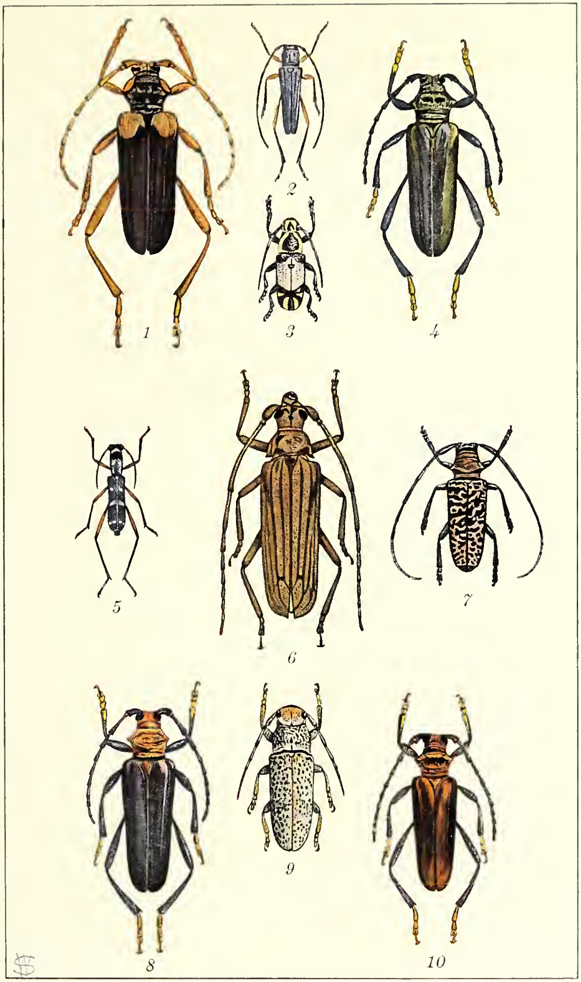

PLATE 1. PHILIPPINE COLEOPTERA.

Fig. 1. Xylotrupes mindanaoensis sp. nov.

Fig. 2. Nemophas rosenbergii ramosi subsp. nov.

PLATE 2. PHILIPPINE COLEOPTERA.

SUPPLEMENTARY NOTES ON PHILIPPINE BEES

By T. D. A. Cockerell
Of the University of Colorado

Xylocopa fallax mcgregori subsp. nov.

Abdomen in both sexes black, wholly without any green tint, and the first two segments without any distinct hair bands; antennæ black, reddened only at end of last joint; anterior wings of male, 22 millimeters long, rarely 23 (26 in typical *fallax*); of female, 21 to 24.5.

Luzon, Manila, July 24 and 25, 1919, type, at flowers of *Peltophorum inerme* (Roxb.) Naves, 22 females and 6 males; Manila, July 26, 1 male at *Antigonon leptopus* Hook. and Arn.: Bulacan Province, Obando, October, 1919, 1 female. All collected by R. C. McGregor. Two males, previously recorded as *X. fallax*, obtained by Baker at Baguio, differ from the above by the distinctly paler wings; the anterior wings measure 21.5 millimeters in one, 24.5 in the other. The Baguio form, when better known, may prove to be a separable race.

Xylocopa fallax was described by Maidl from two females and a male collected by "V. Schadberg" [doubtless von Schadenberg] in the Philippines, the particular island not stated. With the long series of fresh specimens before me, it is evident that the Manila form is not typical, though there appears to be no reason for regarding it as a distinct species. Presumably typical *fallax* is from some other island, and at present unknown to me.

The resemblance of *X. fallax mcgregori* to *X. pictipennis* Smith, from Java, is so close that I was inclined to consider it identical, until I noticed that *pictipennis* has the third antennal joint conspicuously longer, and the punctures on the clypeus larger and not so dense. I have a *pictipennis* from F. Smith's collection. *Xylocopa pictipennis* is larger than *mcgregori.*

Xylocopa nigrocærulea Smith.

Prof. C. F. Baker calls my attention to the fact that Gribodo records this from Mindoro, Palawan, and Mindanao. I have not seen it from the Philippine Islands; the wings are brown, not dark, with coppery iridescence; pubescence black; abdomen blue-black. It was described from Celebes, but according to

Bingham it also occurs in Ceylon. Bingham describes the abdomen as "deep obscure bottle-green."

Mesotrichia bombiformis (Smith).

Evidently common at Manila, where Mr. McGregor took it, July 23 to 26, at flowers of *Peltophorum inerme* and *Antigonon leptopus*. Also one from Obando, Bulacan Province, Luzon, October, 1919 (*McGregor*).

Mesotrichia philippinensis chlorina Cockerell.

LUZON, Manila, 9 females, collected as follows: March 2, 1919, at flowers of *Gliricidia sepium* (Jacq.) Steud.; June, and July 23, at flowers of *Peltophorum inerme;* July 26, at flowers of *Antigonon leptopus;* and September 21. All collected by McGregor. One specimen, taken in September, has the green wings of *chlorina*, but the yellow band on thorax posteriorly is narrowed to a line in the middle, so that the insect approaches true *philippinensis*. Another, taken July 23, has the wings mainly purplish, approaching *philippinensis* in this respect; but the thoracic band is as in *chlorina*. Two have a distinct patch of yellow hair beneath the wings, but this is usually wanting or reduced to a few inconspicuous hairs. In the type of *chlorina* it is present but small. The absence of this patch is a character of the form *bilineata* (Friese), but none of our bees is small enough for that.

With the females comes a male; Manila, July 26, at *Antigonon leptopus*. It is the insect which I provisionally regarded as the male of *M. bakeriana* Cockerell, but it now seems likely that it belongs to *chlorina*.

Megachile valdezi (Cockerell).

LUZON, Manila, February 12, 1919 (*McGregor*), 1 female.

Megachile mcgregori Cockerell.

LUZON, Bulacan Province, Obando, October, 1919 (*McGregor*), 1 male. In my table of Philippine *Megachile* this species is placed among those in which the tarsi have no long fringe behind. This is erroneous; all the tarsi have long creamy-white fringes, those of the hind tarsi in front. From *M. laticeps* Smith it is easily known by the white hair bands, broadly interrupted or reduced to a few hairs in middle, on abdominal segments 2 to 4.

Anthophora korotonensis var. **stantoni** (Cockerell).

LUZON, Manila, February 11, 12, and 14, 1919, 1 female and 8 males; October 9, 1918, a male at flowers of *Stachytarpheta* *jamaicensis* (Linn.) Vahl; November 25, 1918, 1 female. All collected by McGregor. The males vary, having the first, or first and second, band green; the rest blue.

Ceratina sexmaculata Smith.

LUZON, Manila, June, 1919 (*McGregor*), 1 male.

Ceratina dentipes Friese.

LUZON, Manila, June, 1919 (*McGregor*), 1 female. I have no specimens from Java, whence the species was described; but Friese determined the Philippine insect as *dentipes* for Baker years ago.

Ceratina philippinensis Ashmead.

LUZON, Manila, June, 1919 (*McGregor*), 2 females.

Ceratina bicuneata Cockerell.

This was described from females, but I find I have a male from Baguio, Benguet (*Baker*). It is about 6.5 millimeters long, similar in most respects to the female. The face has remarkably large and coarse punctures; lateral face marks entire, ending obliquely above and below, the shape not unlike that of the hull of a sailing ship; clypeal mark confined to lower half of clypeus, large and trilobate, not reaching lateral marks; supraclypeal mark transverse, bow-shaped. The middle and hind tibiæ are yellow, with a dark spot behind, the hind tibiæ also with a reddish spot in front near end. The labrum is entirely black. The apex of the abdomen has a well-defined median point.

Heriades sauteri philippinensis (Friese).

This was described from the female. Two males from Mount Maquiling, Luzon (*Baker*), are extremely like *H. sauteri* from Formosa, but the abdomen is more finely and densely punctured and therefore less shining.

Heriades mundulus sp. nov.

Male.—Length, about 4.5 millimeters; similar to *H. sauteri philippinensis*, but mesothorax much more finely punctured (about three punctures in 95 microns), while the ventral surface of the abdomen is clear ferruginous. The hair at the sides of the upper part of the face is pale reddish. Wings dusky hyaline, grayish.

PALAWAN, Puerto Princesa (*Baker*), 1 male. The mesothorax is much more finely punctured than in *H. fulvescens* Ckll., from Borneo.

REVIEWS

The Wassermann Test | by | Charles F. Craig, A. M. (Hon.), M. D. (Yale) | [six lines of titles] | Published with authority of the Surgeon General, | United States Army | illustrated with colored plates, half-tone | plates, and fifty-seven tables | St. Louis | C. V. Mosby Company | 1918 | Cloth, pp. 1–239, including index.

FROM THE PREFACE

The work has been largely prepared since the outbreak of the present war and, for this reason, is not as exhaustive as I had originally intended it to be, as owing to official duties it has been impossible to spend as much time in its preparation as would have been necessary to make it an exhaustive treatise, and it has also been impossible for me to consult much of the very extensive literature that has accumulated during recent years in regard to the test. However, it is believed that the work contains all of the essential and really valuable facts regarding the test which have been reported in the literature, and if there have been any omissions I would deem it a favor to have them called to my attention.

I have quoted quite liberally from some of the more recent investigators, as Noguchi, Nichols, Vedder, and Kolmer, and have also used much data previously published by myself in various medical journals, and it is a pleasure to tender my thanks to the editors of the *Journal of the American Medical Association,* the *Journal of Experimental Medicine,* the *Journal of Infectious Diseases,* and the *American Journal of Syphilis,* for permission to avail myself of the data previously published in these journals.

From personal experience, I believe that there is still a great deal of misunderstanding and confusion among the members of the medical profession regarding the exact value and limitations of the Wassermann test, both in the diagnosis of syphilis, and when used as a control of the treatment of the disease, and if this work will help in clearing up this confusion it will be a source of great gratification. Much of this misunderstanding rests upon the shoulders of laboratory workers, for it must be admitted that too often the performance of the Wassermann test has been delegated to poorly trained or careless assistants, and the results obtained with the test have thus been erroneous and unsatisfactory. I can not urge too strongly upon the profession the necessity for submitting material for this test to well-qualified serologists if reliable results are to be obtained. A standard technic for the test is much to be desired but all efforts in this direction have failed, owing largely to the difficulty of securing a standard antigen, so that at the present time several methods of performing the test are in use, all of which are reliable in the hands of experienced serologists. The method recommended in this work has stood the test of time and has been used by many different workers in thousands of syphilitic infections, and it is believed that it is as simple in technic and as accurate in results as any method of performing the Wassermann test that has been devised.

The | Medical Clinics | of | North America | July, 1919 | published bi-monthly by | W. B. Saunders Company | Philadelphia and London | Paper, pp. 1–277.

The Chicago Number, Volume III, No. 1, contains the following papers:

Prognosis of Disease in Infancy and Childhood, by Dr. Isaac A. Abt.
A case of Hanot's Cirrhosis in a Two-year-old Child, by Dr. Isaac A. Abt.
A Mediastinal tumor, by Dr. Frederick Tice.
Carcinoma of the stomach, by Dr. Frederick Tice.
Radiographic differential diagnosis of bone affections in infancy and childhood, by Dr. Julius H. Hess.
An unusual case of carcinomatous metastases in bones secondary to carcinoma of the stomach, by Dr. Milton M. Portis.
Acute pyelitis simulating intestinal obstruction, by Dr. Milton M. Portis.
Carcinoma of the esophagus treated with radium, by Dr. Milton M. Portis.
A case of cerebral lues to be differentiated from encephalitis lethargica, by Dr. Ralph C. Hamill.
Neurologic findings in a case of ethmoiditis, by Dr. Ralph C. Hamill.
A consideration of the causes of apprehension, by Dr. Ralph C. Hamill.
Pyelocystitis in infancy, by Dr. Clifford G. Grulee.
Pulmonary tuberculosis in association with other diseases in the general hospital.
  Case I. Pulmonary tuberculosis with gastro-intestinal symptoms.
  Case II. Pulmonary tuberculosis and hyperthyroidism.
  Case III. Diabetes and tuberculosis, by Dr. Solomon Strouse.
A case of belladonna poisoning, by Dr. Solomon Strouse.
Malignant endocarditis of the pulmonary valves (with autopsy), by Dr. Charles Spencer Williamson.
Gout, by Dr. Charles Spencer Williamson.
The Swift-Ellis treatment of paretic dementia, by Dr. Peter Bassoe.
The treatment of constipation, by Dr. W. D. Sansum.
An unusual case of typhoid fever, by Dr. George F. Dick.
Cardiac arhythmias, by Dr. James G. Carr.
A case of syphilitic periostitis of the humerus, by Dr. James G. Carr.
A pulmonary abscess following tonsillectomy, by Dr. James G. Carr.

Some aspects of Hodgkin's disease, by Dr. Arthur F. Byfield.

Eye findings as an aid to the diagnosis of general conditions; a suggestion for team-work, by Dr. Richard J. Tivnen.

Some interesting ear cases, by Dr. Robert Sonnenschein.

Irregular placement and fixation of the large bowel, by Dr. Walter W. Hamburger.

A consideration of the abnormal loss of fluid in contrast with Edema, by Dr. Frank Wright.

The Health | of the Teacher | by | William Estabrook Chancellor | Author of "Our Schools," etc. | Chicago | Forbes & Company | 1919. Cloth, pp. i–ix + 1–307, including index, $1.25.

FROM THE PREFACE

The purpose of this book is to guide teachers in the care of their own health while teaching. The need for it arises from several sources. First, the occupation has very high rates both of deaths and of diseases. Second, teachers read too many school physiologies, which have in view the public needs of children and youth and which do not teach the whole truth for adults. Third, such books as have appeared for adult teachers have not been written by men with medical training and experience but by teachers of hygiene who have considered the subject pedagogically rather than medically. Fourth, every book so far issued associates public sanitation with personal hygiene, thereby adding to the sense of responsibility felt by the already burdened teacher. The present discussion is meant to be essentially different in its motives and purposes.

The inner purpose of the book is to help teachers maintain health despite the necessity to accomodate themselves often to seriously unhealthy surroundings and regimen. It is, however, well for us all to remember that there are other occupations with yet greater difficulties to be met and overcome such as medicine, nursing, home management on a farm and some lines of factory, store and office employment. Let us, therefore, try to endure with healthy cheerfulness what for the present perhaps we cannot change.

And let us not imagine that from the point of view of hygiene or of any other art or science, even the best of modern schoolhouses or the latest of modern school courses and programs is a finality. Mankind is at the beginning, not the end of the discovery of truth. But even such truth as we now have is but narrowly distributed and but poorly utilized. In these pages, I have endeavored to present in untechnical, non-medical language as far as possible some of the most approved principles and practices of physicians and of hygienists for the maintenance and protection of the personal health of teachers.

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 16 MARCH, 1920 No. 3

PHILIPPINE AMPHIBIA

By EDWARD H. TAYLOR

Of the Bureau of Science, Manila

TEN PLATES AND NINE TEXT FIGURES

INTRODUCTION

The Philippines are rich in species of Amphibia, no less than sixty-six being treated in this work, which are, probably, not more than three-fourths of the species that exist in the Islands. Borneo has about 80 known species; New Guinea, 70; Sumatra, 42; Java, 47; Japan and Formosa together, about 50.

No extensive collection of Amphibia has been made in the Philippine Islands, and many of the larger islands have not a single record for specimens. Palawan and Mindanao appear to be better known than Luzon or the Visayan or Sulu groups. Very meager collections have been made in Samar, Leyte, and Mindoro, and apparently none have been made in Bohol, Cebu, or Panay.

LOCAL NAMES

Frogs and toads, with the exception of a rare cæcilian in Palawan, constitute the known Amphibia of the Philippines; they are known in the Islands under the Spanish names *rana* and *sapo,* and in the Philippine dialects, under a wide range of generic names. The best known are *palacá* (Tagalog), *talapang* and *cabacab* (Bicol), *panca* (Negros Visayan), and *baqui* (Leyte Visayan). Very few persons differentiate the various species; thus, in the Tagalog dialect three names are applied to the various species; these are *palacang-saguing* for *Polypedates leucomystax, palacang-bato* for *Kaloula picta,* and *palacá* applied

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indiscriminately to various other species. The Visayans of Negros recognize only two species; these are *Rana moodiei*, known under the name of *panca bubungan*, and *Rana erythraea*, known as *panca-manwit*. Among the Manobos of eastern Mindanao I found a greater number of specific names than elsewhere, no less than eight being in use. On the other hand, there appears to be no class or generic name for the group. The species designated are:

Species.	Manobo name.
Oxyglossus lævis	*Ompo.*
Rana leytensis and *Rana magna*	*Ambac.*
Rana grandocula	*Cóle catóc.*
Polypedates leucomystax	*Ali cá cá.*
Polypedates appendiculatus	*Piong.*
Cornufer laticeps	*Bag-boag.*
Staurois natator	*Antig.*
Kaloula conjuncta and *Kalophrynus stellatus*	*Coquat.*

I have made little use of local names in the discussions of species, owing to the fact that these names would be of little or no use in determining the species.

ECONOMIC VALUE

The economic value of this group is fairly large. Certain species are sold in the markets of the Islands, and large quantities that are caught and consumed by rural peoples are never taken to market. The catch represents a food value of probably more than half a million pesos annually. It seems highly probable that this sum might easily be doubled if frogs were cultivated for market and their skins utilized for leather. In Japan, France, and the United States quantities of skins of these animals are tanned and made into fine soft leather for use in the arts. It has been reported that:

> The skins of frogs and toads are used to a limited extent for leather purposes. Two or three factories in France pay much attention to tanning them, obtaining the raw skins from Northern Africa, Brazil and other tropical regions.
>
> The leather is thin and pliable. It possesses a delicate but not especially attractive grain and is used principally for card cases and other small fancy articles.[1]

In many places in the United States, France, and Japan there are large frog farms where frogs are raised for market. The farms are extremely profitable, the product bringing fancy prices in city markets. Usually only the hind legs are sold, and these

[1] Rep. U. S. Com. Fish and Fisheries (1902) 351.

sometimes sell for as high as 10 pesos [2] per dozen. The species ordinarily cultivated in the United States is the bullfrog *Rana catesbeiana,* which is the largest American species. There are two or three Philippine species which attain large size, one of which, *Rana magna,* approaches the size of the American bullfrog. There is no doubt that they could be cultivated readily in the swamps and marshes of the Philippines, or even in rice paddies, provided their enemies, snakes and large lizards, were partially eliminated.

Many toads of the families Bufonidæ and Engystomidæ have poisonous secretions in the skin, which protect them from being eaten by some animals. Snakes, however, will eat most of the species. Only species of the family Ranidæ should be regarded as of value as food for man.

Frogs and toads, particularly in the tadpole stage, destroy many mosquitoes, especially during the rainy season, which is the breeding season for the group. The adults eat quantities of ants, flies, beetles, and other insects.

REPRODUCTION

Frogs, toads, and salamanders reproduce by eggs. The eggs are fertilized extraneously, the male clasping the female and remaining on her back during the process of ovulation. As the eggs are being extruded the seminal fluid of the male, which contains the sperms, escapes and flows over and about the eggs, which are fertilized when the sperms enter them. None of the Amphibia, save the cæcilians, has an intromittent sexual organ.

After a given period the young escapes from the egg and passes through a larval stage. During this stage the animal lives for the most part in the water and appears more like a fish than an amphibian. In the salamanders and cæcilians true external gills are developed. In some rare cases the larval stage continues during the entire life of the animal, and it breeds and reproduces even though it has not developed beyond that stage.

In the genus *Ichthyophis,* a representative of the cæcilians, the females place their eggs in underground holes near water. These eggs are about 6 by 9 millimeters in diameter, being more or less oval in outline. In *I. glutinosus* the female coils about the eggs, evidently for the purpose of protecting them from their enemies. The eggs attain a much larger size before hatching; the mature embryo weighs four times as much as the newly

[2] One peso Philippine currency equals 50 cents United States currency.

laid eggs.[3] When the larvæ are hatched, the gills are lost and the young take to the water; but occasionally they come to the surface to breathe. This species attains almost adult size while still in the larval stage, but apparently it does not breed until the adult form is reached. Finally the gill slit closes and the fin on the tail disappears, the animal becoming a burrowing land creature; it is said to drown very quickly when placed in water.

There is no authentic record of the occurrence in the Philippines of the true salamanders. I obtained eggs attached to rocks in running water in a small stream on Mount Maquiling, Luzon, which had the appearance of salamander eggs; but, having no preserving fluid at hand, I was unable to make the study requisite to determine them before they had disintegrated.

Philippine frogs have various methods of laying their eggs. For the most part the eggs are laid directly in the water. Here the eggs hatch, and the young pass through a larval stage of varying duration, in which stage the large finlike tail develops, but there are no legs. At this time they are known as tadpoles. Later they emerge from the water with four developed legs, a miniature replica of the adult, the tail having disappeared. Certain species, notably *Polypedates leucomystax* (the banana frog, *palacang-saguing*), lay their eggs in a mass of froth or foam deposited along the edges of small pools of water, on reeds or plants growing in the water, or on an overhanging bough of a tree at some distance above water. After about three days the eggs hatch; and the young emerge from the mass, fall into the water, and become free-swimming larvæ. The fully transformed young animal is smaller than the larva, when the latter has attained its greatest size. *Polypedates pardalis* lays its eggs in water collected in holes in trees and very rarely, if ever, descends to the ground. *Polypedates appendiculatus* usually deposits its eggs in water collected in the axils of the leaves of wild abacá or caladium. In this species the larval stage is very probably of shorter duration.

On the small island of Little Govenen, near Basilan, I observed a species of *Cornufer*. This island, which contains only a few hundred square meters of land, has neither standing nor running water, even after a heavy rain; yet this species appears to be able to maintain itself. It is not improbable that the young emerge from the eggs fully transformed, as is known to occur in certain extra-Philippine species.

[3] Sarasin, P. and F., Zur Entwicklungsgeschichte der ceylonischen Blindwühle Ichthyophis glutinosa, Erg. Nat. Forsch. auf Ceylon (1887–1890).

FOOD

Frogs and toads are carnivorous, and their food for the most part consists of small insects. However, many species do not depend much on insects. I have examined the stomach contents of numerous species and have found the following: A large specimen of *Rana vittigera* that had just swallowed a full-grown *Kaloula picta;* the stomachs of other species contained tadpoles, earthworms, small pebbles, caterpillars, etc. In the Santo Tomás Museum, Manila, a large specimen of *Rana vittigera* is preserved which had swallowed a 6-centimeter fresh-water gastropod, the sharp apex of which pierced the stomach and body wall and now extends about 2.5 centimeters beyond the body wall in the region of the shoulder. Certain of the Engystomidæ feed almost wholly on ants of various species.

GEOGRAPHIC DISTRIBUTION

While our knowledge of the distribution of species is far from complete, it may be well to review the known distribution of the families, genera, and species of the Philippine Archipelago, with a view to determining the derivation of the faunas, their relationships, and what light they may throw on the geographic interrelationships of the various islands within the Archipelago and on the relation of the Philippine group to other island groups in the East Indies and about Australia. Table 1 shows the distribution of the orders of Amphibia in the Orient.

TABLE 1.—*Distribution of the orders of Amphibia in the Orient.*

Order.	Australia.	New Guinea.	Celebes.	Mindanao.	Luzon.	Palawan.	Borneo.	Java.	Sumatra.	Malay Peninsula.	Asia.	Japan.
Apoda	------	------	------	------	------	×	×	×	×	×	×	------
Caudata	------	------	------	------	(?)	------	------	------	------	------	×	×
Salientia	×	×	×	×	×	×	×	×	×	×	×	×

The order Apoda is composed of a single family, the Cæcilidæ, represented in the East Indian region by two genera, numbering four or five species. Of the eleven genera of this family recorded in Boulenger's Catalogue,[4] the distribution is as follows:

[4] Boulenger, Cat. Batr. Grad. s. Caud. Batr. Apod. Brit. Mus. ed 2 (1882).

Two genera are Malayan, one of which occurs in India and Ceylon, and the other in southern Asia and Africa; five genera are American; two are African; one is American and African; and one is confined to southern Asia.

There is no authentic record of the occurrence of a species of the order Caudata in the Philippine Islands or in the East Indian and Australian Archipelagoes. It is highly probable that a species may be discovered in Luzon.

The order Salientia is well represented in the Malay and East Indian regions, and among its families and genera we may expect to find evidences of faunal relationships and derivations.

From Table 2 it will be observed that, of the seven families represented in the Oriental Region, only four are Philippine; two of these may be wanting in Luzon, since there is no authentic record of any member of either the Bufonidæ or the Pelobatidæ having been found there. Borneo on the one side, and Celebes on the other, each has representatives of the same four families but of no others.

TABLE 2.—*Distribution of the families of Amphibia that occur in the Orient.*

Family.	Oceania.	New Zealand.	Australia.	New Guinea.	Celebes.	Mindanao.	Luzon.	Palawan.	Borneo.	Java.	Sumatra.	Malay Peninsula.	Southern Asia.	Central Asia.	Japan.	Europe.	Madagascar.	Southern Africa.	Northern Africa.	North America.	South America.
Ranidæ	×	---	[a] ×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	[a] ×
Engystomidæ	---	---	---	×	×	×	×	×	×	×	×	×	×	×	×	---	×	×	×	×	×
Cystignathidæ	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	[b] ×	×
Bufonidæ	---	---	×	---	×	×	---	×	×	×	×	×	×	×	×	×	---	×	×	×	×
Hylidæ	---	---	×	×	---	---	---	---	---	---	---	---	×	×	×	×	---	---	×	×	×
Pelobatidæ	---	---	---	×	×	×	---	×	×	×	×	×	×	---	---	---	---	---	---	×	---
Discoglossidæ	---	×	---	---	---	---	---	---	---	---	---	---	---	×	×	×	---	---	×	×	---

[a] In only the extreme northern part. [b] In Mexico and Florida.

New Guinea, on the other hand, has no known representative of the Bufonidæ, but has representatives of the Hylidæ,[5] and very probably also of the Cystignathidæ, which occurs in northern Australia.

Japan and Formosa have representatives of four families, but the Hylidæ, not the Pelobatidæ, forms the fourth.

Table 3 shows how poorly frogs and toads are represented

[5] Casto de Elera lists *Hyla chinensis* Günther from Luzon and Basilan. This is probably incorrect.

in the Philippine Islands by endemic genera. Only a single, recently described genus, *Hazelia*, appears to be confined to the Archipelago. Fifteen genera, all that are known from the Islands, are found in Mindanao; five of these have been discovered also in Luzon, and ten in Palawan. The five genera known from Luzon also occur in Celebes and Borneo, and two of them occur in Japan; the latter, however, are the widely spread genera *Rana* and *Polypedates*.

TABLE 3.—*Distribution of the genera of Amphibia that occur in the Philippine Islands.*

Genus.	Oceania.	New Zealand.	Australia.	New Guinea.	Celebes.	Mindanao and Sulu.	Luzon.	Palawan.	Borneo.	Java.	Sumatra.	Malay Peninsula.	Southern Asia.	Central Asia.	Japan.	Europe.	North Africa.	South Africa.	Madagascar.	North America.	South America.
Oxyglossus	—	—	—	—	×	×	×	×	×	×	×	×	×	×	—	—	—	—	—	—	—
Rana	×	—	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Staurois	—	—	—	—	—	×	—	×	×	—	—	×	—	—	—	—	—	—	—	—	—
Polypedates	—	—	—	—	×	×	×	×	×	×	×	×	×	×	×	—	—	—	—	—	—
Hazelia	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Philautus	—	—	—	—	—	×	—	×	×	×	—	×	—	—	—	—	—	—	—	—	—
Cornufer	×	—	×	×	×	×	×	—	×	—	—	—	×	—	—	—	—	—	—	—	—
Microhyla [a]	—	—	—	—	—	×	—	—	×	×	×	×	×	—	×	—	—	—	—	—	—
Kaloula	—	—	—	—	×	×	×	×	×	×	×	×	×	×	—	—	—	—	—	—	—
Kalophrynus	—	—	—	—	—	×	—	×	×	—	×	×	×	×	—	—	—	—	—	—	—
Chaperina	—	—	—	×	—	×	—	×	×	—	—	—	—	—	—	—	—	—	—	—	—
Phrynixalus	—	—	—	×	—	×	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—
Nectophryne	—	—	—	—	—	×	—	—	×	—	×	×	—	—	—	—	×	×	—	—	—
Bufo	—	—	—	—	×	×	—	×	×	×	×	×	×	×	×	×	×	×	—	×	×
Megalophrys	—	—	—	—	—	×	—	×	×	×	×	×	×	—	—	—	—	—	—	—	—

[a] Very doubtful in the Philippine Islands.

New Guinea has four genera in common with Mindanao, three of which are also common to Borneo. Celebes has six genera in common with Mindanao, of which only two are found in New Guinea, while all of them are found in Borneo.

Thus, of the fifteen genera, only three might be regarded as having been derived from New Guinea; these are *Phrynixalus*, *Chaperina*, and *Cornufer*. It is significant, however, that single representatives of the two genera last mentioned are known in Borneo. Eleven of the genera, which are for the most part southern Asiatic or Malayan in distribution, have undoubtedly entered our territory from Borneo through the Sulu and Palawan groups.

DOUBTFUL SPECIES AND SPECIES ERRONEOUSLY CREDITED TO THE PHILIPPINE ISLANDS

Due to incorrect labeling and incorrect identification some species have been erroneously credited to the Philippine Islands. The following records are open to question:

Oxyglossus lima Tschudi.

Reported by Casto de Elera, Cat. Fauna Filipinas 1 (1895) 445, from "Luzon, Abra, Cagayan," with specimen in Santo Tomás University collection. No specimen exists in that museum at the present time.

Rana chalconota Schlegel.

Reported by Casto de Elera (op. cit.) as *R. chalconata* Gthr. from "Paragua, Inagauan, Bulacan," with specimens in Santo Tomás Museum. No specimen exists in the museum at the present time. Barbour, Mem. Mus. Comp. Zool. Harvard Coll. 44 (1912) 67, also mentions this species as occurring in the Philippines. He does not state his authority, and I have overlooked the original reference.

Rana signata Günther.

Boulenger is of the opinion that *Rana similis* Günther is a synonym of this species. I have not followed him in this conclusion.

Rana corrugata Peters.

Reported by Casto de Elera (op. cit.) from "Mindoro, Naujan, Ilocos," with specimens in Santo Tomás Museum. No specimen exists in that collection to-day.

Rana kuhli Duméril and Bibron.

Reported by Casto de Elera from Paragua, Samar, and Borongan, with specimens in Santo Tomás Museum. No specimen of this species exists in that collection to-day.

Rana varians Boulenger.

This species is very probably a synonym of *R. sanguinea* Boettger.

Rana macrodon Tschudi.

This species has long been confused in the Philippine Islands with *R. magna* Stejneger. The presence of vocal sacs in the latter species clearly differentiates it from *R. macrodon.*

Rana gracilis Wiegmann.

This species is reported by Casto de Elera (op. cit.) from "Samar, Villareal," with specimens in Santo Tomás Museum. No specimen exists in that collection at the present time.

Rana guentheri Boulenger.

Reported by Casto de Elera (op. cit.) from "Paragua, P. Princesa, Mindoro, Naujan," with specimens in Santo Tomás Museum. No specimen of this species is there at present.

Rana macrodactyla Günther.

Reported by Casto de Elera (op. cit.) from Luzon, Laguna, Cagayan, Dinagat, Negros, Zamboanga, and Mindanao, with specimens in Santo Tomás Museum. No specimen of this species is in the museum at present.

Rana jerboa Günther.

Reported by Casto de Elera (op. cit.) from "Samar, Loquilocum," with specimens in Santo Tomás Museum. No specimen is there at present.

Rana luctuosa Peters.

Reported by Casto de Elera (op. cit.) from "Mindanao, Butuan," with specimens in the Santo Tomás Museum. No specimen of this species is there at the present time.

Rhacophorus rizali Boettger.

According to Boulenger, this species is synonymous with *Polypedates pardalis* Günther, an opinion in which I concur.

Ixalus pictus Peters.

Reported by Casto de Elera (op. cit.) from Paragua.

Nectophryne sundana Peters.

This problematic species of Peters has been included in the Fauna by Müller, III Nachtr. Cat. Herp. Samml. Basel. Mus. (1883) 7. The locality given is Mindanao. On the statement of Jean Roux, Proc. Zool. Soc. London 1 (1906) 64, the type is the only specimen extant. Evidently Müller's specimen has received another designation. The type of this species, as well as the specimen studied by Müller, should be reëxamined and the status of the name permanently fixed.

Nectophryne guentheri Boulenger.

Listed from Mindanao by Casto de Elera; no specimen is now in Santo Tomás Museum.

Bufo divergens Peters.

The species reported from Palawan under this name by Mocquard, Nouv. Arch. Mus. 2 (1890) 153, is regarded by Boulenger, Ann. & Mag. Nat. Hist. VI 14 (1894) 88, as synonymous with *Bufo philippinicus* Boulenger, an opinion in which I concur.

Bufo biporcatus Günther.

Reported by Casto de Elera from Luzon, Manila, Batangas, and San Pablo, with specimens in the Santo Tomás Museum.

Bufo panayensis Seaone.

This species and a snake, *Piesigaster boettgeri* Seaone, were reported as originating in Panay. As a matter of fact, they are both West Indian species; the toad is *Bufo lemur*, and the snake is *Epicrates inornatus* Reinhardt.

Hyla chinensis Günther.

This species is reported by Casto de Elera from Luzon and Basilan, with specimens in Santo Tomás Museum.

Hyledactylus pictus Bibron.

Reported by Casto de Elera from "Luzon, Bulacan." A synonym of *Kaloula picta?*

Molge sinensis Boulenger.

Reported by Casto de Elera from "Luzon, Cagayan, Pamplona."

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BARBOUR, THOMAS. A contribution to the zoögeography of the East Indian Islands. Mem. Mus. Comp. Zool. Harvard Coll. 44 (1912) 1–203; 8 plates.

In the distributive tables twenty-one frogs are attributed to the Philippines. *Rana signata* and *R. chalconota* are included in the list.

BOETTGER, OSKAR. Aufzählung der von den Philippinen bekannten Reptilien und Batrachier. Ber. Senck. Nat. Ges. (1886) 91–134.

A check list of crocodiles, turtles, lizards, snakes, and frogs. The list contains the names of twenty-seven frogs, based on records of other authors.

BOETTGER, OSKAR. Drei neue Wasserfrösche (Rana) von den Philippinen. Zool. Anz. 16 (1893) 363–367.

Rana moellendorffi, from Culion; *R. sanguinea*, from Culion; and *R. leytensis*, from Leyte, are described as new. The first two appear to have been collected by Moellendorff, the last by José Quadras.

BOETTGER, OSKAR. Neue Reptilien und Batrachier von den Philippinen. Zool. Anz. 20 (1897) 161–166.

Calophrynus acutirostris (=*Kalophrynus acutirostris*) is the new batrachian described. The type locality is "Culion oder Samar;" collected by Moellendorff.

BOULENGER, G. A. Catalogue of the Batrachia Gradientia Salientia and S. E. Caudata in the Collection of the British Museum, ed. 2 London (1882) i–xvi + 1–503; 30 plates and numerous text figures.

This splendid work has stood as a basis for much of the recent work on the Amphibia. Two new species are described from the Philippines; namely, *Rana everetti*, from Zamboanga, and *Cornufer guentheri*, from Dinagat. The types were collected by A. Everett. Drawings are given of these two species, as well as of *Cornufer meyeri*, *Rana glandulosa*, and *Polypedates appendiculatus*, which are also found in the Philippines. *Rana mindanensis* is regarded as an uncertain species. The following species are listed from the Philippines:

Oxyglossus laevis Günther.
Rana erythraea Schlegel.
Rana macrodon Tschudi (= probably *Rana vittigera* Wiegmann).
Rana natatrix Günther (= *Staurois natator* Günther).
Rana similis Günther.
Rhacophorus hecticus Peters (= *Polypedates hecticus* Peters).
Rhacophorus surdus Peters (= *Polypedates surdus* Peters).
Rhacophorus pardalis Günther (= *Polypedates pardalis* Günther).
Rhacophorus appendiculatus Günther (= *Polypedates appendiculatus* Günther).
Rhacophorus maculatus Gray and var. *quadrilineata* Wiegmann (= *Polypedates leucomystax* Gravenhorst).
Ixalus acutirostris Peters (=*Philautus acutirostris* Peters).
Cornufer corrugatus A. Duméril.
Cornufer jagori Peters.
Cornufer meyeri Günther.
Callula picta Bibron (= *Kaloula picta* Bibron).
Callula conjuncta Peters (= *Kaloula conjuncta* Peters).
Callula baleata Müller (= *Kaloula baleata* Müller).

Bufo brevipes Peters.
Bufo melanostictus.
Megalophrys montana Kuhl (= *Megalophrys* species?).

BOULENGER, G. A. On new batrachians from Malacca. Ann. & Mag. Nat. Hist. V 19 (1887) 345–348, pl. 10.

Describes *Bufo philippinicus* as new, from Puerto Princesa, Palawan; the type was collected by Everett.

BOULENGER, G. A. Descriptions of new reptiles and batrachians in the British Museum (Natural History)—Part III. Ann. & Mag. Nat. Hist. V 20 (1887) 50–53.

Bufo muelleri is described as new from Mindanao, P. I. The type specimen was sent to Boulenger by F. Müller, of the Basel Museum.

BOULENGER, G. A. On the herpetological fauna of Palawan and Balabac. Ann. & Mag. Nat. Hist. VI 14 (1894) 18–90.

This important contribution lists one turtle, seven lizards, sixteen snakes, and thirteen batrachians. *Rana palavanensis*, *Rana varians* (= *Rana sanguinea* Boettger), *Rhacophorus everetti* (= *Polypedates everetti*), and *Ixalus longicrus* (= *Philautus longicrus*) are described as new. *Rana glandulosa* Boulenger, *Rhacophorus macrotis* Boulenger (= *Polypedates macrotis* Boulenger), and *Leptobrachium hasselti* Tschudi (= *Megalophrys hasselti* Tschudi) are reported from the Philippines for the first time. Specimens and types were collected by Everett. *Rana macrodon* is included, but the species so identified by him was probably *Rana magna* Stejneger, with vocal sacs.

BOULENGER, G. A. Descriptions of new batrachians in the British Museum. Ann. & Mag. Nat. Hist. VI 17 (1896) 401–406, pl. 17.

Rana luzonensis is described as new from Lepanto, northern Luzon, P. I. The type was collected by John Whitehead.

BOULENGER, G. A. A catalogue of the reptiles and batrachians of Celebes, with special reference to the collections made by Drs. P. and F. Sarasin in 1893–1896. Proc. Zool. Soc. London (1897) 193–237, pls. 7–11.

Discusses several species found in the Philippines and treats of faunal relations.

CASTO DE ELERA. Catalogo systemático de toda la fauna de Filipinas conocida hasta el presente, y á la vez el de la colección zoológica del museo de PP. Dominicos del Colegio-Universidad de Sto. Tomás de Manila, escrito con motivo de la exposición regional filipina. Manila, Imprenta del Colegio de Santo Tomás (1895–1896) 3 vols.

Volume 1 treats of vertebrates; amphibians, pages 445 to 454. The following species listed are regarded as doubtful or incorrect:

Oxyglossus lima Günther.
Rana corrugata Peters.
Rana kuhlii Günther.
Rana macrodon Günther.
Rana tigrina Günther.
Rana gracilis Wiegmann.
Rana guentheri Boulenger.
Rana macrodactyla Günther.
Rana chalconata Günther.
Rana jerboa Günther.
Rana luctuosa (Peters).
Rana sp.
Ixalus pictus Peters.
Nectophryne guentheri (Boulenger).
Nectophryne = ? *sundana* Peters.
Bufo biporcatus Günther.
Bufo panayensis Seaone.
Hyla chinensis Günther.
Hyledactylus pictus Bibron.
Molge sinensis Boulenger.
Ichthyophis monochrous Peters.

FISCHER, J. G. A list of reptiles and batrachians of Mindanao. Jahrb. Wiss. Anst. Hamburg 2 (1885) 80 and 81.

Lists *Hylorana erythraea* Schlegel (= *Rana erythraea* Schlegel), *Rana everetti* Boulenger, *Megalophrys montana* Kuhl, and *Microhyla achatina* Boie. The last two records may be considered doubtful.

GIRARD, CHARLES. United States Exploring Expedition during the Years 1838, 1839, 1840, 1841, 1842, under the Command of Charles Wilkes, U. S. N. Herpetology 20 (1858) i–xvii + 1–496, with folio atlas of plates.

Two Philippine frogs are listed. *Hylorana mindanensis* (= *Rana mindanensis*) is described on page 52 as new, from Caldera, Zamboanga, Mindanao.

GÜNTHER, ALBERT. Catalogue of the Batrachia Salientia in the Collection of the British Museum. London (1858) i–xvi + 1–160, pls. 1–13.

In this early catalogue the following new species are described from the Philippines: *Oxyglossus lævis*, from "Philippine Islands;" *Ixalus natator* (= *Staurois natator*), from the "Philippines," *Rhacophorus pardalis* (= *Polypedates pardalis*), from "Philippines" and Borneo, and *Polypedates appendiculatus*. *Platymantis plicifera* is also described as new from the Philippines, but this species is the same as *Cornufer corrugata* A. Duméril. Excellent drawings of all these species, except *P. appendiculatus*, are given. The types were collected (very probably) by Hugh Cuming.

GÜNTHER, ALBERT. Notes on some reptiles and batrachians obtained by Dr. Adolph Bernhard Meyer in Celebes and the Philippine Islands. Proc. Zool. Soc. London (1873) 165–172, pls. 17 and 18.

Several snakes and lizards are described. Two frogs, *Polypedates similis* (= *Rana similis*) and *Platymantis meyeri* (= *Cornufer meyeri*), are described as new from "Laguna de Bay."

GÜNTHER, ALBERT. List of the mammals, reptiles, and batrachians sent by Mr. Everett from the Philippine Islands. Proc. Zool. Soc. London (1879) 74–79.

Seven species are listed from Dinagat or Surigao.

MÜLLER, F. III. Nachtrag Katalog der herpetologischen Sammlung des Basler Museums (1883).

A few Philippine species are mentioned, among which are *Nectophryne sundana* Peters and *Megalophrys montana* Kuhl. These are very probably incorrectly identified.

MOCQUARD, M. F. Recherches sur la faune herpétologique des iles de Bornéo et de Palawan. Nouv. Arch. du Mus. d'hist. Nat. 2 (1890) 115–165.

Four frogs are listed, and *Ixalus nubilus* is described as new. This is now regarded as identical with *Staurois natator* Günther. *Bufo divergens* Peters and *Megalophrys montana* Kuhl are listed, but these are probably identical with *B. philippinicus* Boulenger and *M. ligayæ* Taylor.

PETERS, W. Mittheilungen über neue Batrachier. Monatsb. Ak. Wiss. Berlin (1863) 445–470.

Among other batrachians from the Philippines the following frogs are described as new, three belonging to the Ranidæ and one to the Engystomidæ: *Hylædactylus* (*Holonectes*) *conjunctus* (= *Kaloula conjuncta*), from Luzon; *Halophila jagorii* (= *Cornufer jagori*), from Samar; *Polypedates hecticus*, from Loquilocum, Samar; and *Polypedates surdus*, from Luzon. The types of these species were collected by F. Jagor.

PETERS, W. Herpetologische Notizen. Monatsb. Ak. Wiss. Berlin (1867) 13–37.

Describes, among others, specimens from the collections made by Carl Semper in the Philippines. Nine lizards and two snakes are recorded or described as new from the Philippines. The following frogs are described as new: *Ixalus acutirostris* (= *Philautus acutirostris*), from eastern Mindanao; *Leptomantis bimaculata* (= *P. bimaculatus*), from upper Agusan Valley, Mindanao; and *Hylaplesia brevipes* (= *Bufo brevipes*), from Zamboanga, Mindanao. The new genus described, *Leptomantis*, the type of which is *Leptomantis bimaculata*, is no longer recognized as distinct from *Philautus*.

STEJNEGER, LEONHARD. Two new species of toads from the Philippines. Proc. U. S. Nat. Mus. 33 (1903) 573–576.

Phrynixalus anulatus, from Davao, Mindanao, and *Kalophrynus stellatus*, from Basilan, are described as new. The types were collected by E. A. Mearns.

STEJNEGER, LEONHARD. Three new frogs and one new gecko from the Philippine Islands. Proc. U. S. Nat. Mus. 28 (1905) 343–348.

The following species are described as new: *Rana mearnsi*, from east Mindanao; *Cornufer worcesteri* and *Philautus woodi*, from Mount Apo, Mindanao. The gecko described is *Lepidodactylus planicaudus*. The types were collected by E. A. Mearns.

CLASSIFICATION

Class AMPHIBIA Linnæus

Stejneger [6] has shown that the long-accepted name Batrachia, as usually applied to this class, is merely a synonym of the much older name Amphibia. It consists of three recognized orders as follows:

1. No legs; tail rudimentary; males with intromittent copulatory organ. Apoda.
2. Two or four legs; tail present; no intromittent organ........ Caudata.
3. Four legs; no tail; no intromittent organ........ Salientia.

[6] Bull. U. S. Nat. Mus. 58 (1907) 2.

Representatives of two of these orders, the Apoda and the Salientia, occur in the Philippines, while the Caudata are of very doubtful occurrence. Only a single species of the first order is known from the Philippines. It is a small wormlike animal and has been found only in Palawan. A species of the second order has been reported by Casto de Elera,[7] but I regard this as somewhat doubtful.

On two occasions I was told of the occurrence of a salamander-like amphibian in Cagayan Valley, and I obtained what appeared to be salamander eggs in a small stream on Mount Maquiling, Laguna Province, Luzon. The eggs were surrounded by a thick gelatinous mass. Because of lack of preservative the material deteriorated before study was possible.

It is significant that the Philippine locality given for Casto de Elera's specimen is "Luzon, Cagayan, (Pamplona)." There is no specimen in Santo Tomás Museum at present. If Casto de Elera had a Philippine specimen of a salamander, I doubt greatly that it was *Molge sinensis*. It is quite probable that a new species awaits discovery.

The third group, Salientia, includes all the frogs and toads. It is a large group, represented in the Philippines by four families; namely, Ranidæ, Engystomidæ, Bufonidæ, and Pelobatidæ, each with several representatives, although the first is by far the largest family.

Order APODA

"No limbs. Tail rudimentary or absent. Frontal bones distinct from parietals; palatines fused with maxillaries. Males with an intromittent copulatory organ." (*Boulenger.*)

This order consists of a single family.

CÆCILIIDÆ

The characters of the family are the same as those of the order. Many genera are known, but only *Ichthyophis* has been found in Philippine territory. These small batrachians were formerly regarded as snakes. They are small, legless, snake-like, burrowing creatures.

[7] Cat. Fauna Filipinas 1 (1895) 453. *Molge sinensis* Boulenger.

Genus ICHTHYOPHIS Fitzinger

Ichthyophis FITZINGER, Neue Class. Rept. (1826) 36; GRAY, Cat. Spec. Amph. Brit. Mus. II (1850) 60; PETERS, Mon. Berl. Ak. (1879) 931; BOULENGER, Cat. Batr. Grad. Brit. Mus. ed. 2 (1882) 89; Fauna Brit. India, Rept. (1890) 515.

Epicrum WAGLER, Isis (1828) 743; Nat. Syst. Amph. (1840) 198; TSCHUDI, Class. Batr. (1838) 90; DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 285 and 288.

Rhinatrema DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 288.

Squamosal bones in contact with parietals; two series of teeth in upper jaw; usually two series of teeth in lower jaw; tentacle cultriform, exsertile, between eye and nostril; cycloid scales embedded in skin.

Three species are known, only one of which is Philippine.

Ichthyophis weberi sp. nov.

Type.—No. B1, Bureau of Science collection; collected at Malatgan River, Palawan, P. I., January 28, 1909, by C. M. Weber.

Description of type.—Two rows of teeth in upper jaw, the series forming oval arches, parallel to each other, the inner row extending much farther back than the outer but not widening; lower jaw with a single row of teeth, with no evidence of a second row; head oval, eyes distinct, the distance between them very slightly less than width of head between eyes; distance between eyes a little greater than length of snout; tentacle withdrawn, the groove rather moon-shaped, situated anterior to eye near the edge of upper jaw; body surrounded by three hundred twenty-four circular folds meeting on belly in an angle, except those on posterior part of body, which run straight across without an angle; the first three or four folds on anterior part of body fail to meet; a more or less distinct groove from tip of lower jaw to some distance in front of anus along the median ventral line of body.

Color in alcohol.—Above yellowish brown, somewhat darker on median part of body; below lighter yellowish brown. Under a microscope the color appears as minute, rounded yellowish dots surrounded by a network of brown. A white spot on tip of lower jaw.

Measurements of Ichthyophis weberi sp. nov.

	mm.
Total length	25
Tail	2.5
Width of head at eyes	7.5
Length of snout	5
Eye to nostril	3.5
Eye to tentacle	1.5

Remarks.—This species differs from the two other known species in the absence of the secondary row of teeth in the lower jaw. I do not think that this fact warrants the making of a new genus, since we find that the second series of teeth appears to be degenerating, even in *Ichthyophis monochrous*. A single specimen was collected in Palawan by C. M. Weber. I take pleasure in naming this species for Mr. Weber, whose untiring efforts have greatly enriched the natural-history collections of the Bureau of Science.

RANIDÆ

Upper jaw toothed; diapophyses of sacral vertebræ not or but slightly dilated; sternal structure variable; precoracoids always present; vertebræ procœlian; coccyx attached to two condyles; no ribs; terminal phalanges assume a variety of shapes.

This family is represented in the Philippines by six long-recognized genera; namely, *Oxyglossus*, *Rana*, *Staurois*, *Polypedates*, *Philautus*, and *Cornufer*. A seventh generic name, *Hazelia*, is proposed in this paper for a species recently discovered in Mindanao and Basilan, characterized by a spiny skin, the skin on the head partially involved in the cranial ossification, and bony ridges in the interparietal region.

The largest genus is *Rana*, which includes twenty-three species, or about four-ninths of the Philippine Ranidæ. This colossal cosmopolitan genus will undoubtedly have to be divided into two or more genera. Boulenger [8] proposes to divide the group occurring in Papua and Melanesia into three subgeneric groups; namely, *Rana* s. str., *Discodeles* n. n., and *Hylorana* Tschudi, using the toe disks and the arrangement of the metatarsals as the basis for this division. Among the Philippine species there appear to be three natural divisions, characterized as follows:

1. Tips of toes not or but slightly dilated; no enlarged disks; no bony "teeth" in lower jaw. *Rana vittigera*, *R. moodiei*, and possibly, *R. parva*, belong to this group.
2. Tips of toes more or less dilated into pads; enlarged "teeth" in lower jaw. *Rana magna* and *R. leytensis* belong to this group.

[8] Ann. & Mag. Nat. Hist. IX 1 (1918) 236–242.

3. Tips of toes dilated into regular disks, with a distinct groove around edge of each disk. To this group would be assigned most of the other known Philippine species of *Rana*.

The external distinctions between *Staurois* and *Rana* or between *Polypedates* and *Philautus* are scarcely more "generic" in nature than the obvious distinctions pointed out between the various groups of *Rana*. Barbour states, speaking of *Philautus pallidipes* Barbour:

> The small size (body one inch long for nearly adult female), lack of cranial ossification, the absence of vomerine teeth place this form with the genus *Ixalus*. The fact, however, that two species of *Polypedates* have been discovered, viz. *P. edentulus* (F. Müller) and *P. anodon* (Van Kampen) which also lack vomerine teeth, shows how scant is the basis of separation for the two genera. Cranial ossification is unknown in *Ixalus* and, of course, is not general in *Polypedates* so that the adult size alone stands as the generic distinction. A very slim one surely.[9]

The Ranidæ are the so-called true frogs. They are not known to be poisonous and for the most part are edible. Many of the species are large enough to be of commercial value and are found frequently in Philippine markets. The larger species are bred on farms in various parts of the world and sell for high prices. The clear white flesh is considered a great delicacy. The manufacture of fine leather from frog skins is an industry of considerable importance in Japan.

The Philippine species which appear to attain the largest sizes are *Rana vittigera*, *R. magna*, and *R. moodiei*. Some specimens of these species in the collection have a body length of 13 centimeters and the hind legs measure 16.4 centimeters, making a total length of nearly 30 centimeters. Doubtless they grow to even larger sizes.

The largest species known in the world appears to be *Rana goliath* Boulenger, from Africa, which attains a body length of about 30 centimeters, with legs nearly 35 centimeters long, or a total of 65 centimeters (nearly 2 feet 2 inches).

Key to the Philippine genera of Ranidæ.

a^1. Tongue entire; fingers free, toes webbed; tympanum indistinct; very small or no disks on digits; no vomerine teeth........ Oxyglossus Tschudi.

a^2. Tongue more or less deeply nicked behind.

  b^1. Vomerine teeth present; fingers perfectly free; no intercalated bone between last two phalanges; toes more or less webbed; outer metatarsals separated by a web; with or without disks on tips of digits.................................... Rana Linnæus.

  b^2. Vomerine teeth present or absent; a small intercalated bone between last two phalanges of digits; terminal digits T-shaped; outer metatarsals separated by a web.

[9] Proc. Biol. Soc. Washington 21 (1908) 190.

c^1. No vomerine teeth; tympanum distinct; fingers free, toes webbed, disks large........ Staurois Cope.

c^2. Vomerine teeth usually present; fingers more or less webbed; toes webbed; disks present; skin of head sometimes involved in cranial ossification........ Polypedates Tschudi.

c^3. Vomerine teeth wanting; fingers free, toes webbed; disks present; head with bony ridges; skin of head involved in cranial ossification. Hazelia g. nov.

c^4. Vomerine teeth wanting; fingers free or webbed; toes webbed, disks present; skin on head not involved in cranial ossification. Philautus Gistel.

b^3. Vomerine teeth present; no intercalated bone between last two terminal phalanges; fingers free; toes usually free, sometimes slightly webbed; outer metatarsals united or separated by a groove; terminal phalanges T-shaped........ Cornufer Tschudi.

Genus OXYGLOSSUS Tschudi

Oxyglossus TSCHUDI, Class. Batr. (1838) 35; DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 332; GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 6; COPE, Nat. Hist. Rev. (1865) 117; BOETTGER, Ber. Senck. Nat. Ges. (1886) 121; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 5; Fauna Brit. India, Rept. (1890) 436.

Microdiscopus PETERS, Mon. Berl. Ak. (1877) 422.

"Pupil horizontal. Tongue narrow, entire, and free behind. Vomerine teeth none. Tympanum indistinct. Fingers free; toes webbed, the tips not dilated into regular disks. Outer metatarsals separated by a web. Omosternum with a bony style; sternum a cartilaginous plate. Terminal phalanges simple." (*Boulenger.*)

Three species of this genus are known, only one of which appears to enter our territory. A second is included in Casto de Elera's list, but the specimen reported to be in the Santo Tomás University collection is no longer extant.

Oxyglossus lævis Günther. Plate 1, fig. 1.

Oxyglossus lævis GÜNTHER, Cat. Batr. Sal. Brit. Mus. 7 (1858) pl. 1, fig. A; Rept. Brit. India (1864) 401; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 6; Fauna Brit. India, Rept. (1890) 437; Proc. Zool. Soc. London (1897) 228; STOLICZKA, Journ. As. Soc. Bengal (1870) 273; (1872) 101; BOETTGER, Ber. Senck. Nat. Ges. (1886) 121; BOULENGER, Ann. & Mag. Nat. Hist. VI 14 (1894) 85.

Microdiscopus sumatranus PETERS, Mon. Berl. Ak. (1877) 422, 682.

Description of species.—(From No. 1236, E. H. Taylor collection; collected at Hinigaran, Occidental Negros, P. I., March, 1915, by E. H. Taylor.) No vomerine teeth; choanæ small, round, not widely separated; tongue regularly oval, rounded behind; no canthus rostralis; head broader than long; loreal region sloping very obliquely to mouth; nostrils halfway between eye and end of snout, the distance between them greater than their distance from eye; interorbital region narrow, much less than a single eyelid; eye moderately small, its diameter less than length of snout; tympanum covered with skin, its outline dim, its diameter less than eye; skin above granular, striated, corrugated or with small tubercles; chin roughly granular, with a series of dim glandular tubercles forming two longitudinal parallel rows, which run from point of lower jaw to breast, where they meet a row of small glands, which cross the neck to near angle of mouth and go above arm to some distance on side; belly finely granular; anal region and underside of thighs granular; a straight supratemporal fold from eye to behind angle of mouth; parietal regions somewhat swollen; arms short, thick; fingers short with tips not as wide as fingers; palm with two prominent tubercles, that on first finger largest; first finger slightly longer than third or second; hind legs short and thick; toes with small disks, a little wider than toes; toes webbed to base of disks, very slightly incised between digits; subarticular tubercles small; a sharply defined inner metatarsal tubercle about one-third the length of first toe; no outer metatarsal tubercle; a skin fold on outer side of first and fifth toes, that on first toe continued on tarsus. Male with internal subgular vocal sac. The tibiotarsal articulation reaches snout.

Color in life.—Above black-brown, with a dull yellow stripe from snout to anus; sides lighter, mottled brown; belly, chin, and underside of legs dirty cream, more or less spotted or mottled with dark brown.

Measurements of Oxyglossus lævis Günther.

	mm.
Length, snout to vent	61
Length of head	19
Width of head	20.5
Length of snout	7.5
Diameter of tympanum (about)	5
Diameter of eye	6
Foreleg	27
Longest finger	11
Hind leg	93
Femur	23
Tibia	21.5
Longest toe	22

Variation.—The variation in color is marked; some specimens in my collection are dull reddish brown above and white below, with a few scattered markings on legs; one specimen examined is uniform gray, yellowish below; hind legs dark above, light below, mottled and spotted darker. A Mindanao specimen is grayish, with a hair line on back with two dark stripes on each side; arms and legs barred with darker; the small tubercles on hind legs tipped with yellowish. The rows of glands on neck are scarcely visible in preserved specimens, but are distinct in living frogs.

Remarks.—The frogs of this species are thoroughly aquatic in habit, and are invariably found in water. They sit in the edges of the pools, only the snout and part of the head emerging. On the slightest disturbance they disappear below the surface, where they remain for a considerable time. A search among leaves and mud at the bottom of small pools often revealed specimens whose presence was only suspected. These frogs appear to be found everywhere in the Philippines. Specimens were collected by H. Otley Beyer at Banaue, Mountain Province, at an elevation of 1,800 meters. They are known from Luzon, Samar, Leyte, Mindanao, Dinagat, Basilan, Sulu Archipelago, Negros, Panay, Mindoro, Palawan, and Busuanga; also from Celebes, Borneo, Sumatra, Malay Peninsula, and Burma. The two types in the British Museum are females, both from the Philippines; the exact type locality is no longer known.

Genus RANA Linnæus

Rana LINNÆUS, Syst. Nat. ed. 10 1 (1758) 210; WAGLER, Nat. Syst. Amph. (1830) 203; TSCHUDI, Class. Batr. (1838) 78; DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 335; GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 8; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 6; STEJNEGER, Bull. U. S. Nat. Mus. 58 (1907) 93.

Hylarana TSCHUDI, Class. Batr. (1838) 78.

Hylorana GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 71; Rept. Brit. India (1864) 423.

Limnodytes DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 510.

Polypedates TSCHUDI, Class. Batr. (1838) 78; GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 77.

"Pupil horizontal. Tongue free and deeply notched behind. Vomerine teeth. Tympanum distinct or hidden. Fingers free; toes webbed, with simple or dilated tips. Outer metatarsals separated by web. Omosternum and sternum with a strong bony style. Terminal phalanges acute, transversely dilated or T-shaped." (*Boulenger.*)

Widely distributed, except in the southern parts of South America and in New Zealand. Absent in Australia, except in the extreme northern part.

It has been necessary to eliminate from the Philippine list some species long regarded as occurring there, such as *Rana* *tigerina* Daudin and *R. macrodon* Kuhl. Stejneger [10] recognized that the large-toothed species of the Philippines is distinct from *R. macrodon* and named it *R. magna*. *Rana vittigera* and *R. moodiei* have long been confused with *R. tigerina*, but the characters which obtain in the first two groups show clearly that they are very distinct from *R. tigerina*.

It was with great hesitancy that I united the two species, *Rana varians* Boulenger and *R. sanguinea* Boettger. I have not examined the types, but a comparison of the type descriptions shows no differences warranting separation. My opinion was confirmed by a comparison of specimens from the Calamianes and Palawan.

Key to the Philippine species of Rana Linnæus.

a^1. No gland on upper arm.
- b^1. Fingers and toes not or but slightly dilated at tips; no bony teeth in lower jaw.
  - c^1. Eyelid much wider than interorbital distance; no distinct canthus rostralis (large frog).
    - d^1. A flap of skin on outer side of fifth toe and metatarsal. **R. moodiei sp. nov.**
    - d^2. No skin flap on fifth toe and metatarsal.... **R. vittigera Wiegmann.**
  - c^2. Eyelid about equal to interorbital space.
    - d^1. Toes almost completely webbed; skin granular (small frog). **R. mindanensis Girard.**
    - d^2. Toes about two-thirds webbed; a narrow dorsolateral fold. **R. palavanensis Boulenger.**
  - c^3. Eyelid much narrower than interorbital space; skin smooth; toes one-half webbed (small frog).................................. **R. parva sp. nov.**
- b^2. Fingers and toes distinctly dilated into small disks, without a groove around the edge; two well-developed bony teeth in the anterior part of lower jaw. Canthus rostralis distinct, angular.
  - c^1. Toes entirely webbed; tympanum large, distinct; dorsolateral fold sometimes present in young (large frog). **R. magna Stejneger.**
  - c^2. Toes about two-thirds webbed; tympanum large; dorsolateral fold usually present (rather small frog).............. **R. leytensis Boettger.**
- b^3. Fingers and toes dilated into regular disks with a transverse groove around disk; no bony mandibular teeth.
  - c^1. A broad glandular dorsolateral fold; tympanum equals four-fifths eye; canthus rostralis rounded; toes about four-fifths webbed. **R. erythræa (Schlegel).**
  - c^2. A narrow dorsolateral fold.
    - d^1. First finger shorter than second.
      - e^1. Snout truncate; finger disks large; tympanum three-fourths eye; canthus rostralis angular.............. **R. mearnsi Stejneger.**
      - e^2. Snout obtuse; tympanum about two-fifths eye; canthus rostralis angular .... **R. dubita sp. nov.**

[10] Smithson. Misc. Coll. 52 (1908–10) 437.

e^3. Snout acutely pointed; tympanum about three-fourths eye.
R. luzonensis Boulenger.

e^4. Snout rather pointed; tympanum about one-third diameter of eye; an inner and an outer metatarsal tubercle.
R. guerreroi sp. nov.

d^2. First finger equals second; toes three-fourths webbed; finger disks about one-half tympanum; snout rounded.
R. sanchezi sp. nov.

d^3. First finger much longer than second; snout obtusely pointed; tympanum more than three-fourths eye; toes four-fifths webbed.
R. sanguinea Boettger.

c^2. No dorsolateral glandular fold.

d^1. Eyes moderate.

e^1. First finger shorter than second; tympanum three-fourths eye.
R. everetti Boulenger.

e^2. First finger longer than second.

f^1. Diameter of tympanum three-fourths eye; first finger not opposed to others.. **R. suluensis** sp. nov.

f^2. Diameter of tympanum about three-fifths eye; first finger opposed to others................................ **R. philippinensis** sp. nov.

d^2. Eyes large.

e^1. Interorbital area one and one-half times upper eyelid; tympanum about one-half eye................. **R. moellendorffi** Boettger.

e^2. Interorbital area equals upper eyelid........ **R. similis** (Günther).

a^2. A gland present on upper arm; tips of toes swollen into small disks.

b^1. Diameter of eye longer than snout; upper eyelid one and one-third times interorbital distance; no dorsolateral white lines.
R. grandocula sp. nov.

b^2. Diameter of eye equals length of snout; interorbital space equals upper eyelid; eyes red.. **R. glandulosa** Boulenger.

b^3. Diameter of eye reaches nostril; interorbital space equals upper eyelid.
R. melanomenta sp. nov.

Rana moodiei sp. nov. Plate 1, fig. 5.

Type.—No. 1240, E. H. Taylor collection; collected at Manila, P. I., November, 1914, by E. H. Taylor.

Description of type.—Vomerine teeth in two strong oblique series, beginning on anterior inner edge of choanæ but extending a considerable distance behind them, separated from each other by a very slight distance; choanæ moderate, separated from each other by a distance a little larger than that between nostrils; no apophyses or "teeth" on anterior part of lower jaw; distance between Eustachian tubes about one-fifth longer than their distance from choanæ; length of head from angle of jaw only slightly greater than width of head at tympanum; eyes moderate, not extending to edge of outline of head when viewed from above, their diameter equal to their distance from snout; nostrils very distinctly nearer tip of snout than eye; tympanum large, distinct, about three-fourths diameter of eye; upper eyelid about one and one-half times interorbital distance; tympanum separated from eye by a distance equal to three-fourths its diameter; loreal region sloping broadly, not concave; canthus rostralis rounded or very indistinct; skin above extremely rugose with tubercles and folds of irregular length; a skin fold across occiput behind upper eyelids continuous with the angular folds from eye to arm above tympanum; a fold on posterior part of upper lip turning down at angle of jaw; a series of dorsolateral longitudinal folds not continuous, other shorter folds on sides and back; upper part of limbs with small tubercles; belly and throat smooth; underside of limbs and posterior part of thighs smooth, except in anal region; first finger longer than second and fourth; subarticular tubercles distinct; palmar tubercles, except that on base of first finger, very indistinct; tips slightly swollen; toes not more than three-fourths webbed, the web reaching near tip of fifth and outer side of third, a distinct flap of skin on outer side of fifth; a very strong, compressed, inner metatarsal tubercle, no outer; an indistinct tarsal fold from inner tubercle; tibiotarsal articulation reaches anterior corner of eye. Males with vocal sacs.

Color in life.—Above brownish olive, with very indistinct darker markings; sides rather lighter, yellowish, with dense, darker reticulations; belly yellowish; large dark spots on upper labials.

Measurements of Rana moodiei sp. nov.

	mm.
Length, snout to vent	73
Length of head	30
Width of head	29
Diameter of eye	9.5
Diameter of tympanum	5.5
Length of snout	12
Eye to nostril	7.5
Interorbital distance	4
Upper eyelid	5.8
Foreleg	40
Longest finger	15
Hind leg	120
Femur	32.5
Tibia	34
Foot and heel	55
Longest toe	37

Variation.—Certain variations exist in this species. Mindanao specimens are greenish brown to brownish with darker spots, and the distance between the point of skin flap on the fifth toe to the inner metatarsal tubercle is greater than in Manila specimens. In certain specimens the skin is pulled tight across the occiput, and the transverse fold is scarcely noticeable. In none of the specimens (there are no less than forty in my collection and that of the Bureau of Science) is there a trace of the median dorsal stripe, a stripe on the tibia, or a diagonal lateral yellowish stripe; the skin flap is universally present. Males usually have large black spots on each side of the throat, the skin of which is sometimes in folds.

Remarks.—This species differs from *Rana vittigera* Wiegmann in much the same manner that *R. tigerina* Daudin differs from *R. limnocharis;* that is, in the presence of the flap of skin on the fifth toe. From *R. vittigera* it also differs in having a fold of skin across the head; the head broader in proportion to length; the eyes smaller and less prominent; the nostrils nearer tip of snout; and in the absence of stripes on the body. It differs from *R. tigerina* in the absence of "teeth" in the lower jaw, the more forward position of the nostrils, and the much less extent of webbing on toes.

The species is common in Mindanao, Luzon, and Negros, and probably occurs on many other islands. It is probable that certain records of *Rana tigerina* from the Philippines are referable to this species.

The breeding season for the species in Manila begins about July 10; it breeds in the same pools as does *Rana vittigera.* I am as yet unable to differentiate the tadpoles of the two species.

The species is named for my friend and former teacher, Dr. Roy Lee Moodie, associate in anatomy, University of Illinois, Chicago, noted for his extensive researches on extinct Amphibia of North America.

Rana vittigera Wiegmann. Plate 2, fig. 3.

Rana vittigera WIEGMANN, Nova Acta Ac. Leop.-Carol. (1836) 225, pl. 21, fig. 1.

Rana tigrina and *Rana tigerina* of various authors in the references of this species to the Philippines.[11]

[11] It is highly probable that many of the references of *Rana tigerina* Daudin to the Philippines should be placed under this species, at least in part, since it is probable that specimens of *R. moodiei* have also been confused with it. I am confident that the Philippine specimen of *R. vittigera* Wiegmann (which was one of the types) belonged to the species here considered; the Macao specimen may be referable to *R. limnocharis.* In consequence I have resurrected Wiegmann's name. (Note distinctive characters under remarks.) My opinions regarding the treatment of this species are concurred in by Prof. S. F. Light, of the University of the Philippines, who for a number of years has used this species as well as *R. moodiei* for dissection and demonstration in his biological classes.

Description of species.—(From No. 1234, E. H. Taylor collection; collected at Manila, P. I., November, 1914, by E. H. Taylor.) Vomerine teeth in two oblique series beginning on anterior inner edge of choanæ and extending behind their posterior edge; tongue large, deeply notched, extensively free; (male with vocal sacs) ; distance between choanæ equals distance from eye to nostril; head longer than wide; snout rather pointed, tip rounded in lateral profile, slightly projecting; nostrils equidistant or slightly nearer tip of snout than eye; no canthus rostralis, the lores very slightly concave, sloping broadly to mouth; diameter of eye a little more than distance of eye to nostril; tympanum from one-half to two-thirds eye; distance from eye to tympanum equals about three-fifths the diameter of the latter; interorbital distance about half the width of an eyelid; skin above on back strongly rugose, with longer and shorter longitudinal folds, the spaces between distinctly granular; a strong angular fold from eye above tympanum to above foreleg; a short glandular fold from corner of mouth to above foreleg; sides granular, with short longitudinal folds on upper part; chin and throat smooth; belly smooth, except posterior part, which is slightly wrinkled and granular; anal region granular; fingers not, or but very slightly, swollen at tip, rather blunt; subarticular tubercles prominent; carpal tubercles indistinct; first finger extends considerably beyond second and fourth, no trace of skin fold on sides of inner fingers; toes from one-half to three-fourths webbed, the membranes failing to reach the tips, and deeply excised between digits; no free skin fringe on outer toe, but a mere indication of a skin fold; inner metatarsal tubercle small, compressed, its length about one-third that of first toe; no indication of an outer tubercle; tibiotarsal articulation reaches anterior corner of eye or slightly farther; interorbital region equals about one-half the distance between nostrils.

Color in life.—Above dark olive gray, with numerous, scattered, larger and smaller blackish spots on back, sides, and limbs; a prominent bar across head over posterior part of eyelids, and a prominent, broad W-shaped mark between shoulders; sides olive to yellowish brown with a dim, lighter, yellow-brown diagonal stripe from eye to near groin; axilla, underside of arm, groin, underpart of hind limbs, and upper side of foot, bright lemon to canary; belly whitish; throat dusky; lips above and below with dark spots; a loreal stripe present; underside of hand and foot rather purplish; posterior aspect of thigh black, reticulated with yellow lines.

Measurements of Rana vittigera Wiegmann.

	mm.
Length, snout to vent	95
Length of head, to angle of jaw	35
Width of head	30
Length of snout	15.5
Diameter of eye	10
Diameter of tympanum	6.5
Eye to nostril	7.2
Interorbital distance	4
Upper eyelid, width	7
Foreleg	45
Longest finger	17
Hind leg	154
Femur	43
Tibia	46
Foot	66
Longest toe	45

Variation.—There is slight variation in the amount of webbing between the toes, and the toes are never fully webbed. In young specimens the toes are more pointed at the tip, while in older specimens they are blunter and sometimes swollen. The size of the tympanum varies, but is always more than one-half the diameter of the eye. Occasional specimens have the nostrils exactly halfway between tip of snout and eye. The number and arrangement of the longitudinal folds vary with each specimen. The arrangement of the vomerine teeth is quite constant; these teeth are usually larger and stronger in older specimens.

The color varies remarkably; about two-thirds of the two hundred specimens examined had a median, dorsal, greenish yellow or white stripe, from tip of snout to anus, varying in width from a stripe of 5 millimeters to a hair line. The diagonal line on the sides is invariably evident, often bright green or yellow, frequently dull and rather obscure. The ground color varies from grayish yellow to dark blackish brown; frequently in lighter specimens the dark spots are green; other specimens show the entire back a bright green. Many specimens have a narrow yellow line from knee to heel.[12]

Remarks.—This species differs from *Rana tigerina,* with which it has frequently been confused, in the absence of the membranaceous fringe on the fifth toe; the absence of bony teeth or prominences in the lower jaw; and the lesser amount of webbing

[12] I am indebted to Prof. S. F. Light for several living specimens of this species, with numerous tadpoles; and for the privilege of examining a large quantity of living and preserved material at the University of the Philippines.

between the toes. Other less important differences are evident on a comparison of the two species. From *Rana limnocharis* it differs in its larger size, the more anterior arrangement of the vomerine teeth, and the absence of an outer metatarsal tubercle. They agree with each other in the absence of the fringe and the proportionally longer legs. From *Rana macrodon* and *R. modesta* Boulenger, it differs in the absence of large bony teeth, the absence of distinct disks on toes, and the lesser extent of the webbing. *Rana moodiei,* with which it is most frequently confused in the Philippines, has a membranaceous fringe on the fifth toe, but neither a dorsal nor a diagonal lateral stripe is ever present; the limbs are shorter in *R. moodiei,* the nostrils farther forward, and a fold is usually present between the posterior corners of the eyes across the head, at least in adult specimens. *Rana vittigera* is common in Luzon, and I have taken specimens in Mindoro and Negros. In the Bureau of Science collection there is a specimen from Polillo. It is found in the same localities and habitats as *R. magna* and *R. moodiei.* The breeding season at Manila begins about the first of July. The eggs are usually deposited in pools of water, left by rains.

Tadpoles.—Specimens of tadpoles of this species obtained July 17 measured as follows: Total length, 52 millimeters; snout to vent, 20; depth of tail fin, 10; hind legs, 11. Spiracle sinistral; distance between nostrils less than their distance from eye; nostrils nearer eye than tip of snout; mouth with short suckerlike distension; maxillary beak a heavy, regularly curved, black plate; plate in lower jaw rather angular medially; upper lip with a series of minute black teeth on its extreme outer edge, two shorter curved series, widely separated somewhat below it; lower lip rather lobulated on edge with three series of teeth on inner surface, the upper series longest, the lower shortest and widest.

Color.—Above greenish, with darker markings; usually a few specimens show a median lighter line on back and lateral, diagonal, yellowish green lines on sides; occasionally there is a blackish bar across interorbital region and eyelids; golden and green on sides and variegated golden on belly.

Rana mindanensis (Girard).

Hylarana mindanensis GIRARD, Proc. Acad. Nat. Sci. Philadelphia 6 (1853) 423; U. S. Expl. Exp., Herpetology (1858) 52; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 6.

Rana mindanensis BOETTGER, Ber. Senck. Nat. Ges. (1886) 121; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 445.

Description of species.—(From Girard.) "This appears to be the smallest species of its genus, the greatest length of the body and head together measuring but one inch, the head forming about the third of it, and is as long as broad. The upper surface of the head is almost flat, and, when viewed from above, ovoid in its outline. The snout is elevated, rounded, narrow, and quite prominent. The nostrils are conspicuous, and nearer the extremity of the snout than the anterior rim of the orbit. The space between the nostrils and eyes is subconcave, whilst the margin of the jaw constitutes a convex ridge. The eyes are proportionally large and prominent, subcircular in shape, their diameter being equal to the distance between their anterior rim and the extremity of the snout. The interocular space is equal to the greatest width of the upper lid, which, itself, is smooth like the surface of the head. The tympanum is situated very close to the eye, and is less in diameter than the latter. The tongue is large, fleshy, subelliptical; its posterior bifurcation being narrow and diverging. The inner nostrils are subcircular, of medium size, and situated near to the jaw-bone. The vomerine teeth are not very conspicuous, disposed upon two narrow, widely separated, elliptical groups or series, directed obliquely inwards and backwards from the posterior margin of the inner nostrils.

"The body is elongated, subcylindrical; the anterior limbs slender, shorter than the trunk; the posterior ones, comparatively well developed, longer than the body and head together, by the whole length of the foot. The fingers are subdepressed; the first is but very little longer than the second and fourth; the latter two being nearly equal. The palm of the hand exhibits ridges running in the direction of the fingers. The articulations of the latter are provided beneath with conspicuous though small knobs or tubercles, in every point similar to the swellings on the inferior surface of their extremities. The toes are webbed, very nearly to their tips, but the membrane is very deeply concave between all of them. The swellings at their extremities are larger than the tubercles under their articulations. There is but one metatarsal tubercle, situated at the base of the inner toe, from which a horny ridge extends along the inner edge of the tarsus. The exterior ridge of the fifth toe is bordered by a membranous ridge, which, however, does not reach quite to its extremity. The skin above is minutely pustulous, and smooth beneath."

Color.—"The ground color is greenish-brown, uniform and lighter beneath. There are obsolete darker spots on the body as well as on the limbs. The margin of the upper jaw and sides of the head exhibit similar traces of maculæ."

Remarks.—Two specimens were captured "in the Caldera, on Mindanao" near Zamboanga. Boulenger regards this as a doubtful species. It has not been rediscovered.

Rana parva sp. nov. Plate 3, fig. 4.

Type.—No. F409, E. H. Taylor collection; collected at Bunawan, Agusan, Mindanao, P. I., August, 1912, by E. H. Taylor.

Description of type.—Vomerine teeth in two elongate, oblique, converging series, beginning on inner side of choanæ and extending much beyond hinder level of choanæ, narrowly separated medially; choanæ small, rather hidden under edge of jaw; tongue oval, very slightly notched behind, the "horns" only slight rounded knobs, widely separated at their base; head and body flat above, head about as wide as long; eye distinctly less than length of snout; tympanum distinct, its diameter about two-thirds that of eye; nostril much nearer end of snout than eye; tympanum separated from eye by a distance equal to one-half its diameter; interorbital width one and one-half times upper eyelid; canthus rostralis distinct, rounded; loreal region with slight oblique slope; a slight depression behind nostrils, distance between nostrils much greater than their distance from eyes; skin on back smooth; on snout, sides, and upper side of limbs skin with numerous minute rounded depressions; chin, throat, and belly smooth; a very slight supratemporal fold above tympanum to near arm; no dorsolateral fold; fingers very slender, widened at tips into very small disks, slightly wider than the digits themselves; first finger distinctly longer than second, slightly longer than fourth; no skin fold on outer finger or on arm; toes one-third to one-half webbed, third toe barely longer than fifth; disks of toes slightly larger than those on fingers; subarticular tubercles moderate; an elongate, oval, inner metatarsal tubercle, more than a third the length of first toe; no outer tubercle visible; no tarsal fold; tibiotarsal articulation reaches nostril.

Color in life.—Above uniform reddish brown on back, snout, and head, with very indistinct darker areas interorbitally and between shoulders; sides of head and body darker brown than back, becoming almost black along the straight dorsolateral limit of the ground color of back, forming a distinct contrast; the ventrolateral area much lighter, with small yellowish spots; belly cream, chin densely powdered with cinnamon brown; arms and limbs brown, lightly barred with darker brown.

Measurements of Rana parva sp. nov.

	Type. mm.	Cotype. mm.
Length of head	10.5	10
Width of head	10.1	10.2
Diameter of eye	3	3
Diameter of tympanum	1.8	2.1
Depth of snout, in front of eye	3.3	3.3
Length of snout	4.2	4.2
Foreleg	15.5	15.5
Longest finger	6	5.9
Hind leg	47	46
Femur	14	14
Tibia	16	16.5
Longest toe	13.5	13

Variation.—A third specimen in my collection agrees fairly well in proportions with the other two, but is smaller. In this specimen the following differences in markings are evident: The ground color of the back is much lighter along the dorsolateral line; the sides are lighter with only a narrow dark line along the upper part; the chin and underside of limbs are somewhat more densely powdered with brown.

Remarks.—Three specimens are in my collection. They were taken in low mountains near Bunawan, Agusan, Mindanao. They may be related to Girard's species *Rana mindanensis*, of Mindanao, but they differ from it in a few essential points. In *R. mindanensis* the eyelid equals the interorbital region, and the toes are entirely webbed; the coloration also is different. Other differences are evident on a comparison of the two descriptions.

Rana palavanensis Boulenger.

Rana palavanensis BOULENGER, Ann. & Mag. Nat. Hist. VI 14 (1894) 85; Proc. Zool. Soc. London (1897) 230.

Description of species.—(From Boulenger.) "Vomerine teeth in two short oblique series commencing on a line with the hinder edge of the choanæ. Head moderate, as long as broad; snout short, rounded, as long as the diameter of the orbit; canthus rostralis angular; loreal region slightly concave; nostril equidistant from the orbit and the end of the snout; interorbital space as broad as or a little narrower than the upper eyelid; tympanum distinct, three-fifths the diameter of the eye. Fingers moderate, the tips swollen or dilated into very small disks; first finger extending slightly beyond second; toes moderate, two-thirds webbed, the tips dilated into small but very distinct disks; subarticular tubercles moderate; inner metatarsal tubercle elliptical, flat, measuring two-fifths or one-half the length of the inner toe;

no outer metatarsal tubercle; no tarsal fold. Tibio-tarsal articulation reaching the tip of the snout or beyond; tibia as long as or a little shorter than the fore limb. Skin nearly smooth; posterior half of upper eyelids warty; a fold from the eye to the shoulder; a narrow glandular dorso-lateral fold, beginning behind the upper eyelid, above the supratemporal fold."

Color.—"Brown or greyish brown above; sides of snout below the canthi blackish or dark grey, with some more or less distinct dark vertical bars on the lip; supratemporal and dorso-lateral folds edged with dark brown or black on the outer side; a dark crossbar between the eyes and a dark /\-shaped interscapular marking usually present; limbs with regular dark cross-bands; lower parts whitish, uniform, or throat and breast spotted with brown. Male with internal vocal sacs.

"From snout to vent 43 millim."

Remarks.—The types are from Palawan where they were collected by A. Everett. Later the species was discovered by the same collector on Mount Kinabalu, Borneo, and in Celebes. The types are females and consequently have no vocal sacs. Specimens of males taken in Celebes had vocal sacs. In Celebes the species has been taken at an elevation of 4,000 feet. The species appears to be closely related to *Rana leytensis* Boettger, but that species lacks the dorsolateral fold present in *R. palavanensis*. According to Boulenger, it is related also to *R. modesta* Boulenger, *R. doriæ* Boulenger, *R. limborgii* Sclater, and *R. hascheana* Stoliczka.

Rana magna Stejneger. Plate 2, fig. 2.

Rana magna STEJNEGER, Smithson. Misc. Coll. 52 (1908–10) 437.

Description of species.—(From No. 28, Bureau of Science collection; collected on Polillo Island, P. I., October, 1909, by C. Canonizado.) Vomerine teeth in two large, oblique, strongly denticulated series, arising from the anterior inner edge of the choanæ, but their greater length lies behind the posterior edge; separated from each other by a distance less than one-half the length of a single series; two strongly raised, transverse, bony ridges behind choanæ, separated from each other by a distance equal to two-thirds that between choanæ; vomerine teeth barely extend to their anterior level; this latter distance equal to distance of nostril to eye; tongue very large, cordiform; Eustachian tubes as far from each other as from choanæ; two large mandibular teeth on the anterior part of lower jaw, fitting into the depressions in upper jaw; head very slightly longer than broad, occipital region rather rugose; snout smooth and flat, except in front of nostrils, which slope very slightly to tip; end of snout high, vertical; canthus very strongly defined, angular to tip; upper part of loreal region vertical, lower part sloping broadly, making the region behind nostril distinctly concave; eye moderate, its diameter reaching a little beyond nostril; nostril about one-fourth nearer tip of snout than eye; tympanum small, its outer edge moderately distinct, about one-half the diameter of eye, separated from eye by a distance one and one-fourth times its diameter; interorbital distance a little greater than width of upper eyelid; skin above rough, tuberculated; a very strong fold from eye to above arm, above tympanum; a short, distinct, glandular fold behind angle of mouth, an elongate fold behind eye curving inward; two strong tubercles on occipital region; two large tubercles on shoulders, behind which are three large tubercles on each side of back; skin of posterior part of body finely granulate, interspersed with numerous larger tubercles; posterior part of eyelid strongly tubercular; indications of a fold between posterior parts of interorbital region; sides strongly tubercular; loreal region tubercular; skin below smooth or finely granulate, wrinkled in posterior part of belly, smooth on posterior part of limbs; first finger longer than second but slightly shorter than fourth, second and third fingers with distinct skin folds on inner side and dim ones on outer side; subarticular tubercles large, round, blunt; tips of fingers swollen into small rounded pads; a prominent tubercle at base of first finger; toes webbed fully, the membrane reaching tip of pad on outer side of first, second, and third toes, and to base of terminal pads elsewhere; pads on toes a little larger than those on fingers; a cutaneous flap on outer part of first toe extending to inner metatarsal tubercle, another on fifth toe interrupted near the middle; inner metatarsal tubercle strong, oval, about half the length of first toe; no outer tubercle; no dorsolateral fold; tibiotarsal articulation reaches nostril or a little beyond; a rather indistinct tarsal fold; distance between nostrils a little less than their distance from eye, greater than their distance from mouth, and slightly less than width of upper eyelid.

Color in alcohol.—Above brown of varying darker and lighter shades; snout somewhat lighter, with an indistinct darker band between eyes; region below and behind eye lighter than loreal region; lower lip spotted and mottled with black; limbs with darker markings, not forming bars; posterior part of limbs dark, reticulated with yellowish brown; below dusky, variously mottled and reticulated with darker; heels and soles of feet dark brown.

Measurements of Rana magna Stejneger.

	mm.
Length, snout to vent	130
Length of head, from angle of jaw	58
Width of head, at tympanum	53
Length of snout	22
Diameter of eye	14
Eye to nostril	13
Distance between nostrils	10
Tympanum	7
Eye to tympanum	9.1
Upper eyelid	11
Interorbital distance	13
Foreleg	67.5
Longest finger, from base of palm	33
Hind leg	164
Femur	70
Tibia	60
Foot	89
Longest toe	64

Variation.—The collection of the Bureau of Science contains specimens of this species; my own collection also contains specimens from various localities. The young, like the young of *Rana macrodon,* differ rather markedly from the adult. In *R. magna* the upper eyelid is broader than the interorbital distance; the tympanum is distinct and not as far from the eye; the tubercles and folds on body are less numerous; there is a rather distinct broken dorsolateral fold from eye to above groin (rarely continuous), and there are other shorter longitudinal folds on the sides; the webs on the feet are somewhat excised between the toes; the disks on the fingers are slightly more distinct; the tibiotarsal articulation reaches variously from eye to tip of snout; the dorsolateral fold is separated from the supratympanic fold. The body above is dark brown of varying shades, sometimes with darker spots; groin strongly marked with black; the youngest specimens usually have a strong, dark brown temporal spot; labials with large brown spots which are continuous on both upper and lower jaws; posterior part of limbs dark, mottled with yellow and white; usually a loreal stripe present.

In the adult specimens the length of the first and fourth fingers varies somewhat. Occasionally the first is longer than the fourth, frequently shorter; the toes are frequently fully webbed, the membrane reaching more than halfway on the toe disks or pads; the large teeth of the females are low, and not prominent as in the males; males invariably have small vocal sacs, the openings being rather small, back and near the angle of the mouth; the arrangement of the vomerine teeth varies considerably, beginning sometimes on the anterior inner edge of the choanæ, sometimes at some distance from them, sometimes in advance of the anterior level, sometimes nearer the hinder level, or they may extend to or behind the transverse palatine ridges.

Remarks.—I have no doubt that the specimens are correctly referred to this species. All have small vocal sacs, a character which is not mentioned by Stejneger in his specimens. Boulenger states that *R. modesta* is a smaller species than *R. macrodon.* It is possible that he had not examined the largest specimens. Stejneger compares his specimens with *R. macrodon* only and makes no mention of its relation to *R. modesta* Boulenger.

Rana magna is the largest of the Philippine frogs. Specimens are found in the immediate vicinity of water, usually along the banks of small mountain streams or about pools. When disturbed they at once take refuge in the water. Their eggs are deposited in water. Eggs taken from the ovary of a female in the Bureau of Science collection measured 2.5 millimeters in length.

Rana leytensis Boettger. Plate 2, fig. 1.

Rana leytensis BOETTGER, Zool. Anz. 16 (1893) 365; BOULENGER, Proc. Zool. Soc. London (1897) 229.

Description of species.—(From No. 1040, E. H. Taylor collection; collected at Bunawan, Agusan, Mindanao, P. I., 1912.) Vomerine teeth in two oblique series, arising from the inner edges of the choanæ, but lying for the most part behind them, separated from each other by a distance about half the length of a single group; two distinct, enlarged, sharp teeth in anterior part of lower jaw; choanæ not large, distance between them equal to distance of nostril from eye; head longer than wide, the canthus rounded angularly; snout rather rounded; upper part of loreal region nearly vertical, lower part obliquely sloping, leaving the lores concave; nostril one and a half times farther from eye than end of snout; distance between nostrils equals their distance from eye; eye large, more than four-fifths the length of snout; tympanum large, distinct, about one-half the size of eye, separated from eye by a distance about one-half its diameter; interorbital region equal to width of a single eyelid; skin on anterior part of body above smooth, with longitudinal folds of unequal length; an inverted V-shaped fold in middle of back; the most prominent folds are dorsolateral, beginning behind eye, and not continuous with the very distinct supratympanic fold which continues to near insertion of arm; posterior part of body with tubercles, some large, some very small; tibia and foot also minutely tubercular; sides rough, with short longitudinal folds and tubercles; belly, throat, and underside of limbs entirely smooth; posterior aspect of thigh rather granular; a few small glandular folds above arm and at angle of jaw; fingers elongate, rather slender, with distinct, though small, disks without transverse grooves; first and second fingers equal, reaching first subarticular of third; fourth longer than first two; subarticular tubercles prominent; a prominent tubercle at base of first finger, two indistinct ones on palm; inner side of second and third fingers with distinct skin fold; toes elongate, slender, with disks, about two-thirds webbed; membrane reaches base of disk on second and third toes on outer side, but not on inner, and to base of disk on inner side of fifth; on fourth toe the web reaches first outer subarticular tubercle, and continues to disk as two narrow margins; fifth toe reaches second outer tubercle, and third toe reaches first subarticular tubercle of fourth; a distinct, elongate, oval, inner metatarsal tubercle more than one-third the length of first toe; no outer tubercle; a skin flap on outer side of fifth toe; a very slight skin fold continues behind inner metatarsal tubercle; tibiotarsal articulation reaches to near nostril. Males with internal vocal sacs, the slitlike opening conspicuous on either side and somewhat behind tongue.

Color in life.—Above dark olive brown with a blackish stripe across head over eyelids; folds and tubercles usually slightly darker in color; sides brownish, with a black tympanic spot and a few scattered darker spots on sides; loreal region dark; limbs indistinctly barred with darker; posterior part of limbs dark, mottled with yellowish; belly cream, with dusky markings on throat and under thighs; palms and soles slate color.

Measurements of Rana leytensis Boettger.

	mm.
Length, snout to vent	48
Width of head	17
Length of head	18.5
Length of snout	8
Diameter of eye	6.8
Diameter of tympanum	3.5
Foreleg	29.5
Longest finger	12.5
Hind leg, from vent	74.5
Femur	21
Tibia	21.5
Foot	34.5
Longest toe	22.5
Toe disk	1.2

Variation.—In the collections studied there are four groups of specimens: from Polillo; from southern Sulu Archipelago; from Zamboanga, Mindanao; and from Bunawan, Agusan. These may be separated easily, as they all differ from each other more or less.

The Polillo specimens (in alcohol) are lighter brown above, showing two yellowish brown stripes from eye to end of body. The stripes on the legs are distinct, but the temporal spot is sometimes dim or wanting; behind the V-shaped mark the large granules, or tubercles, are arranged roughly in two parallel rows, which continue backward to end of body. The skin folds on inner fingers are distinct; the enlarged teeth are prominent in males and females; eggs in the belly of females measure 2 millimeters in length. The large teeth in the lower jaw are dim or wanting in individuals of the size of Boettger's type specimens, 28 millimeters.[13]

The Mindanao specimens resemble the Polillo forms; many of them, however, have the anterior part of the head yellowish brown in front of the transverse blackish line, and many have the belly spotted brown. The webbing of the feet and the proportionate length of the digits are exactly the same as in the Polillo specimens.

The specimens from the islands about the southern end of Tawitawi are very dark, almost slatish black above, the band scarcely distinguishable from the body color; the anterior part of head is lighter; the web between toes reaches to second tubercle of fourth toe, leaving three joints free; the membranes fail to reach disks, save as very narrow skin folds; the skin fold on fifth toe is slightly narrower; the first finger is longer than second by half the length of disk, and the skin fold on inner fingers is less distinct; the inverted V-shaped fold is present, but the double row of pustules behind is wanting.

Remarks.—The type was collected by José Quadras and the locality given is "Island of Leyte." The species is known also from Polillo, Mindanao, Tawitawi, Bongao, and Papahag, in the Philippines. Boulenger reports the species from several localities in Celebes, and from Sandakan, North Borneo.

Specimens are found invariably in the immediate neighborhood of water, usually along streams. I have not been able to recognize their tadpoles.

[13] Boettger does not mention this character in his description, nor does Boulenger in his notes.

Rana erythræa (Schlegel). Plate 1, fig. 2.

Hyla erythræa SCHLEGEL, Abbild. Amphib. (1837) 27, pl. 4, fig. 3.
Limnodytes erythræus DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 511; CANTOR, Cat. Mal. Rept. (1847) 141; Journ. As. Soc. Bengal 16 (1847) 1062.
Hylarana erythræa TSCHUDI, Class. Batr. (1838) 78.
Hylorana erythræa GÜNTHER, Rept. Brit. India (1864) 425; STOLICZKA, Proc. As. Soc. Bengal (1872) 104; ANDERSON, Zool. Yunnan 846; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 65; FISCHER, Jahrb. Wiss. Anst. Hamburg 2 (1885) 80.
Hylorana subcærulea COPE, Proc. Acad. Nat. Sci. Philadelphia (1868).
Rana erythræa BOULENGER, Proc. Zool. Soc. London (1897) 231; BARBOUR, Mem. Mus. Comp. Zool. Harvard Coll. 44 (1912) 67.

Description of species.—(From No. 858, E. H. Taylor collection; collected at Hinigaran, Negros, P. I., October, 1915, by E. H. Taylor.) Vomerine teeth in two transverse, oblique, converging series, arising near the anterior inner edge of choanæ, and extending somewhat behind their hinder level, separated from each other by a distance equal to the length of a single

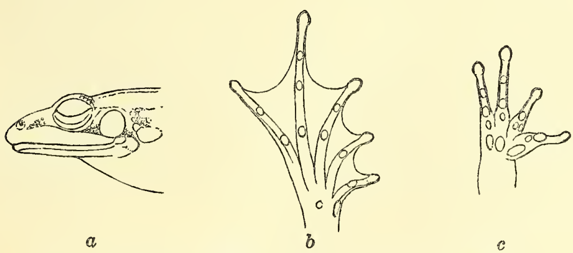

FIG. 1. *Rana erythræa* (Schlegel). *a*, side of head; *b*, foot; *c*, hand. × 1.

group; choanæ small, partly hidden under edge of jaw; tongue notched deeply behind, forming two rather long horns; head elongate, nearly one-fourth longer than wide; snout rather pointed, one and one-half times diameter of eye; nostril nearer end of snout than eye; tympanum large, distinct, rounded, its diameter about four-fifths that of eye, separated from eye by a distance slightly more than half its diameter; interorbital region equal to the width of an upper eyelid; distance between nostrils equals their distance from eyes; skin above on back granular, on head smooth, no granules on upper eyelids; snout high, projecting over lower jaw; canthus rostralis rounded; loreal region nearly vertical, a deep groove behind nostril on lores; a broad dorsolateral glandular fold from eye to end of body; upper lip thickened, appearing like a glandular fold, continuing somewhat beyond angle of mouth; another elongate glandular fold above arm, continuing brokenly along side; sides strongly granular; chin, throat, and belly perfectly smooth; posterior aspect of thighs strongly granular; tibia with very narrow, dim, longitudinal folds above; first finger extending farther than second and slightly shorter than fourth; fingers provided with small, longitudinally oval pads, much larger than subarticular tubercles, which are distinct; disks with grooves around edges; no skin fold on forearm or outer finger; toes about three-fourths to four-fifths webbed, the web reaching disks on outer sides of toes except fourth and touching disk also on inner side of fifth; web reaches last subarticular tubercle on fourth toe; no skin fold on outer side of fifth toe or on tarsus; a small inner metatarsal tubercle, no outer tubercle; disks on toes slightly smaller than on fingers; tibiotarsal articulation reaches to between eye and nostril.

Color in life.—Above bright olive to yellow-green, with two golden to cream yellow stripes covering the dorsolateral glandular folds; a slight, dark brown line borders the yellow stripe on its inner side, and a wider, more distinct blackish stripe below it from eye to end of body; a dark loreal streak and a dark area in front of tympanum; latter golden brown; upper lip creamy yellow, the stripe continuing to the ground color; below cream, with a wash of canary, posterior aspect of thighs brownish, mottled and spotted with darker; no bars on limbs; dark color arranged in longitudinal lines on femur and tibia; web between toes yellowish, dusky spotted.

Measurements of Rana erythræa (Schlegel), Nos. 858 and 860.

	mm.	mm.
Length, snout to vent	62	64
Length of head	24	25
Width of head	19.8	20.8
Diameter of eye	6.2	7.5
Length of snout	10.2	10.8
Diameter of tympanum	5.3	6
Depth of snout, in front of eyes	6.8	7
Foreleg	40	42.5
Longest finger	18	21
Hind leg	107	122
Femur	31	35
Tibia	33	38
Longest toe	31	39

Variation.—No great amount of variation is observable. In certain specimens the eyelid is slightly wider than the interorbital region; in other specimens the belly and the underside of the limbs are distinctly marked with dusky spots. The longitudinal arrangement of the brown color on the legs is apparently invariable.

Remarks.—This frog, which I failed to find in Mindanao, was incredibly numerous in central Negros. In the rice fields, where they spawn, the young appear in countless numbers during the latter part of the rainy season. When the dry season begins they collect around pools. My collector brought in more than a hundred specimens taken from a shallow disused well near Hinigaran, Occidental Negros. Only a few of these were preserved.

The species is known in the Philippines from Negros and, according to Fischer, from southern Mindanao. It is widely distributed and is known from Celebes and Borneo, through Sumatra and Java, to the mainland of southeastern Asia. The distribution in the Philippines would appear to be localized. It has not been discovered in Palawan, and careful search has failed to reveal it in Sulu.

Rana mearnsi Stejneger. Plate 4, fig. 4.

Rana mearnsi STEJNEGER, Proc. U. S. Nat. Mus. 28 (1905) 343.

Description of species.—(From No. 855, E. H. Taylor collection; collected on Canlaon Volcano, Negros, P. I., at an ele-

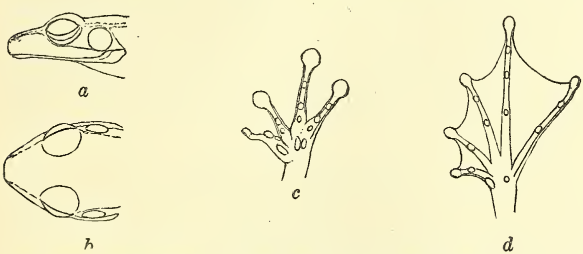

FIG. 2 *Rana mearnsi* Stejneger. *a*, side of head; *b*, top of head; *c*, hand; *d*, foot. × 1.

vation of about 900 meters, December 24, 1915, by E. H. Taylor.) Vomerine teeth in two short, somewhat oblique, well-defined series, beginning anterior to posterior level of choanæ, and separated from each other by less than one-third the length of a single group, and from the choanæ by a distance equal to nearly the length of a single group; choanæ large; tongue elongate, deeply notched behind; head low, flat, practically same depth at tympanum as at nostril; canthus rostralis distinct, angular; upper part of lores vertical, lower part sloping obliquely; a slight depression behind nostril; eye large, its diameter reaching slightly beyond nostril; distance of nostril from end of snout contained in distance from eye to nostril about four times; eyes prominent, the interorbital distance equal to the width of an upper eyelid; tympanum large, nearly three-fourths diameter of eye, separated from eye by a distance equal to half its diameter; head much longer than wide; skin of body smooth above, on limbs and sides; below, chin and anterior part of belly smooth; posterior part and under thighs strongly granular; a distinct dorsolateral fold from eye, rather narrow; a very slight fold behind tympanum, continuous with the dorsolateral fold; upper eyelids without granules; limbs slender; fingers slender, with greatly widened disks, the disks with grooves around edges, disk of first finger not larger than subarticular tubercles; first finger shorter than second, the disk reaching a little beyond base of disk of second, latter shorter than fourth, which reaches some distance beyond outer subarticular tubercle of third; toes slender, almost fully webbed, the membranes reaching base of disks, except on fourth toe; here the membrane reaches first subarticular tubercle and then continues as a very narrow margin to disk; subarticular tubercles well developed; disks of toes larger than disk of first finger, that of fifth toe smallest, prominent; inner metatarsal tubercle present, a very small outer tubercle; a very slight fold along fifth toe and along tarsus; no free flap on outer edge of fifth toe; tibiotarsal articulation reaches a considerable distance beyond tip of snout.

Color in life.—Above uniform reddish to lavender brown; sides, loreal region, and about tympanum, lavender; a whitish streak from tip of snout to groin; throat dusky; belly yellowish cream; a few lavender spots under thigh; limbs very dimly barred with darker; small white spots on digits at base of disks.

Measurements of Rana mearnsi Stejneger.

	mm.
Total length, snout to vent	58
Length of head	22
Width of head	18.4
Length of snout	9
Eye to nostril	6.5
Diameter of eye	7.7
Diameter of tympanum	4.3
Depth of snout, in front of eye	6
Foreleg	40
Longest finger	20.2
Finger disk	4
Hind leg	111
Tibia	34
Femur	30
Longest toe	31.5
Toe disk	2.5
Foot and heel	45

The description here given differs from the type description as follows: Vomerine teeth only partially behind choanæ; interorbital distance equal to upper eyelid; tympanum more than one-half, but less than three-fifths, diameter of eye; distance of eye from nostrils a little less than diameter of eye; disks on fingers not pointed anteriorly; no pustules on eyelids or above tympanum; color obviously different.

Three specimens in my collection from Bunawan also differ from the type in a few characters: Tympanum about five-sixths the diameter of eye; interorbital distance greater than upper eyelid; disks of fingers appearing pointed and somewhat smaller than in the Negros form. The last character may be due to the preserving fluid, as the specimens are somewhat hardened. They differ markedly from the type in coloration; two are dark brown above, whitish below, and the third is brownish gray; only one specimen shows two white areas below the anus; the V-shaped mark is evident in two specimens, the dorsolateral streak is wanting in all. The snout in all the specimens is not so truncate as in the Negros form. A specimen in my collection from Baguio, in a rather poor state of preservation, apparently belongs to this species; the snout is even more truncate than in the Negros specimen; the body is grayish above, and the posterior part of the legs is uniform brownish; the vomerine teeth are in two very small, almost transverse, groups, lying largely in front of the posterior border of the choanæ.

In the proportions of the legs, the webbing of the toes, and the general contour these specimens are almost identical. I believe we have to do with only a variable form and not with different species; the Bunawan specimens are from a place less than 80 kilometers from the type locality.

Remarks.—The specimens were all found along small mountain streams, usually under small plants growing on the rocks. They are not uncommon at Bunawan, but are difficult to capture. Many other specimens taken were lost before they could be studied. The type was collected on Baganga River, Davao, Mindanao, by E. A. Mearns.

Rana luzonensis Boulenger.

Rana luzonensis BOULENGER, Ann. & Mag. Nat. Hist. VI 17 (1896), 401.

Description of species.—(From Boulenger.) "Vomerine teeth in two oblique groups between, and extending beyond, the posterior borders of the choanæ. Snout much depressed, acutely pointed, projecting, longer than the diameter of the orbit; canthus rostralis strong; loreal region feebly oblique, grooved; nostril nearer the end of the snout than the eye; interorbital space as broad as the upper eyelid; tympanum very distinct, two-thirds to three-fourths the diameter of the eye. Fingers long and slender, first a little shorter than second, dilated into large disks. Toes webbed to the disks of the third and fifth, to the penultimate phalanx of the fourth; disks smaller than those of the fingers; subarticular tubercles strong; a small oval inner metatarsal tubercle. The tibio-tarsal articulation reaches far beyond the tip of the snout. Skin smooth; a feeble narrow dorso-lateral glandular fold."

Color.—"Greyish or olive above, with or without a light vertebral line; a blackish canthal streak and temporal spot; tympanum reddish brown; upper lip with a light, dark edged streak; limbs with dark cross-bands; whitish beneath, throat and breast sometimes brown.

"From snout to vent 58 millim."

Remarks.—This little-known species was discovered in the highlands of Lepanto, Luzon, by John Whitehead. Four specimens were taken, female and half grown. It has not been rediscovered.

Rana guerreroi sp. nov.

Type.—No. 881, E. H. Taylor collection; collected at Baguio, Mountain Province, Luzon, P. I., June 1, 1915, by E. H. Taylor.

Description of type.—(Young.) Vomerine teeth in two small, rounded, transverse groups between posterior parts of choanæ, separated from choanæ by a distance twice as great as their distance from each other; distance between choanæ about equal to distance between nostrils; head much longer than broad; snout sloping from eye to tip in lateral profile, rather pointed anteriorly; nostril very much nearer tip of snout than eye; eye large, its diameter equal to nearly four-fifths the length of snout; lores slightly concave, nearly vertical; tympanum small, fairly distinct, about one-third of eye, not as large as finger disks, separated from eye by a distance equal to two-thirds its diameter; distance between nostrils greater than interorbital space; interorbital space one and one-half times upper eyelid; skin on body and limbs above and below smooth; anal region and posterior part of thigh partly granular; a very indistinct trace of dorsolateral skin fold, and another very dim fold above tympanum, not conjoined; fingers slender, the three outer with large, well-developed disks, first finger shorter than second, with a very narrow disk, fourth much longer than second, reaching base of disk on third; disks truncate or slightly rounded anteriorly, with distinct grooves around their edges; subarticular tubercles well developed, carpal tubercles dim; toes almost fully webbed, the membrane reaching outer base of disks on first, second, and third, and inner edge of fifth, and to near outer subarticular tubercle of fourth; third and fifth toes equal, reaching outer subarticular tubercle on fourth; rather large inner metatarsal tubercle and a small outer tubercle; hind leg brought forward, the tibiotarsal articulation reaches much beyond tip of snout.

Color in life.—Dark blackish brown above, lighter on sides, with indications of a dim dorsolateral lighter stripe; arms and legs light yellowish drab, barred with numerous darker stripes; belly yellowish white, flecked with dusky; posterior part of thighs and groin yellowish cream.

The species is named for Dr. L. M. Guerrero, of the Bureau of Science, Manila.

Measurements of Rana guerreroi sp. nov.

	mm.
Length, snout to vent	27
Length of head	11
Width of head	9
Diameter of eye	4
Diameter of tympanum	1.4
Length of snout	5
Foreleg	17.8
Longest finger	8.2
Hind leg	46.5
Femur	73
Tibia	16
Foot	20
Longest toe	12
Finger disk	1.5
Toe disk	1

Variation.—The nineteen specimens in my collection are all young, most of them having just completed their transformation; several still have tail buds, and one specimen, poorly preserved, is a tadpole. They vary from dark to light above, some showing rather distinct dorsolateral glandular folds and a fold above the tympanum; the limbs are lighter than the rest of body and are barred more or less distinctly.

Remarks.—I have endeavored to refer this group of specimens to some known species, but have failed to do so to my satisfaction. The characters recorded will serve to identify the adult.

The species differs from *Rana luzonensis* Boulenger in having a very much smaller tympanum, and in the presence of an outer metatarsal tubercle and a supratympanic fold, the latter separate from the dorsolateral glandular fold.

The specimens were taken along small streams near Baguio, usually under rocks or bits of wood, though frequently at some distance from water.

Rana sanchezi sp. nov.

Type.—No. F38, Bureau of Science collection; collected in the extreme northern part of Palawan, P. I., April, 1918, by E. H. Taylor.

Description of type—Vomerine teeth in two slender oblique series, arising between the choanæ at a distance from their inner edge equal to about one-third the length of one group; they fail to reach farther forward than the middle of the choanæ, and their greater part lies behind the posterior border; separated from each other by a distance a little less than the length of one series; distance between Eustachian tubes equals their distance from choanæ; distance between choanæ much greater than distance between nostrils and equal to distance between eye and nostril; head much longer than wide; diameter of eye equal to its distance from nostril; nostril one-third nearer end of snout than eye; tympanum large, its diameter more than two-thirds eye; distance from eye equal to a little more than one-third its diameter; interorbital distance about equal to width of eyelid; snout slightly depressed between nostrils; canthus rostralis distinct, angular; snout rather rounded in front, sloping downward in front of nostrils; loreal region concave, the upper part nearly vertical; skin above finely granular, the granules less distinct on upper part of limbs and eyelids and wanting on snout; a strong, well-defined dorsolateral glandular skin fold from eye to end of body; fold behind tympanum wanting or very obscure; a distinct white glandular fold behind angle of mouth to above arm, broken medially; sides finely granular; throat, chin, and belly entirely smooth; posterior part of thigh granular; also granular about anal region; first and second fingers equal, both distinctly shorter than fourth; fingers with well-defined disks, the largest disk not more than one-half tympanum; disks on first and second fingers equal, smaller than those on third and fourth; subarticular tubercles large, rounded; an elongate tubercle at base of first finger; very slight skin folds on inner sides of second and third fingers; toes about three-fourths webbed, the membrane reaching to base of disk on outer side of second and third, inner side of fifth, and midway between first and second subarticular tubercles of fourth; third toe extends as far as fifth, both reaching halfway between first and second tubercles of fourth; disks on toes a little smaller than those on fingers and slightly more pointed; a very small inner metatarsal tubercle, not more than one-sixth the length of first toe; a small, dim outer tubercle; tibiotarsal articulation reaches tip of snout; no skin, but a very indistinct skin fold along fifth toe and metatarsal; disks of toes and fingers with strong grooves around edges. Males with vocal sacs.

Color in life.—Above bronzy to olive brown with very small, indistinct darker flecks and marblings; canthus rostralis and dorsolateral fold silver-gray, a dark loreal stripe continuing to behind tympanum; tympanum lighter brown; lip rather glandular, with a greenish to yellowish white, narrow, regular stripe continuing to insertion of arm; upper part of sides similar to back; belly silvery white; lower lip rather dark, with a dim spot at base of arm; limbs same as back, with very indistinct barring; black spots on disks of outer fingers; posterior part of thigh reticulated with yellowish.

Measurements of Rana sanchezi sp. nov.

	mm.
Length, snout to vent	49
Length of head	19
Width of head	14
Length of snout	9.2
Eye to nostril	5.5
Diameter of eye	6.5
Diameter of tympanum	4.4
Interorbital distance	4.1
Foreleg	32
Longest finger	14.2
Finger disk, largest	2
Hind leg	82
Femur	21
Tibia	26
Foot	36.5
Longest toe, with metatarsal	24
Toe disk, largest	1.9

Variation.—A specimen was taken on Lubang Island, north of Mindoro; one on Busuanga, Calamianes; and several in northern Palawan. The Lubang specimen is a young female. In color markings, both above and below, the specimen is practically the same as the type save for the following variations: The Lubang specimen has a slightly lighter line following the dorsolateral glandular fold which continues on canthus rostralis; disks on first and second fingers about equal, very much smaller (nearly half) than those on third and fourth fingers; membranes between fingers more deeply excised, reaching disks by a rather narrow margin; the broken white glandular fold from mouth to above arm prominent; no traces of bars on legs. The Busuanga specimen (31 millimeters) is slightly larger than the Lubang specimen; its sides are darker than in the type and its back is a little lighter and marbled indistinctly with darker; the fifth toe extends very slightly farther than third; no trace of bars on hind or front legs. In one of the Palawan specimens the first toe extends very nearly as far as the second; two specimens are lavender, with darker markings, and the bars on the legs are extremely dim or wanting.

Remarks.—Specimens were taken along streams in low mountains. For the most part they were found perched on leaves of vines or plants, or on the bark of trees near the water, in which they immediately took refuge. *Rana sanguinea* was found in similar places.

The species is closely related to *Rana sanguinea*, and young specimens are very much alike in habitus. They are clearly differentiated by color and markings, the strongly defined, definitely limited temporal spot being very charecteristic of *R. sanguinea* Boettger, as is also the long first finger, which extends considerably beyond the second and fourth fingers. In like manner this species also differs from *R. varians* Boulenger, which I regard as identical with *R. sanguinea.* The toe and finger pads of this new species are more truncate than in *R. sanguinea,* and numerous other differences are evident on a comparison of specimens or of descriptions.

From *Rana everetti, R. sanchezi* differs in having smaller disks on digits (disks on toes and fingers are nearly same size) their diameter less than one-half of tympanum; the toes are not fully webbed, and there is present a distinct dorsolateral glandular fold, but no separate temporal fold above tympanum. From *R. luzonensis* it differs in having shorter limbs, the skin granular above, and in the presence of an outer metatarsal tubercle. It appears to be related to *R. labialis* Boulenger, although that species is said to be allied to *R. chalconota.* From *Rana labialis* it differs in having the first and second fingers equal, and the disks of the toes practically of the same diameter as those of the fingers; the lateral glandular folds are distinct to the end of the body. Unfortunately, I have no specimens of *R. labialis* for comparison.

The species is named for Father F. Sanchez, S. J., of Ateneo de Manila.

Rana sanguinea Boettger. Plate 5, fig. 2.

Rana sanguinea BOETTGER, Zool. Anz. 16 (1893) 364.
Rana varians BOULENGER, Ann. & Mag. Nat. Hist. 14 (1894) 86; Proc. Zool. Soc. London (1897) 231; BARBOUR, Mem. Mus. Comp. Zool. Harvard Coll. 44 (1912) pl. 5, fig. 12.

Description of species.—(From No. F60, Bureau of Science collection; collected in the extreme northern end of Palawan, P. I., May 10, 1918, by E. H. Taylor.) Vomerine teeth in two oblique transverse series, somewhat separated from choanæ and extending behind the posterior edge, separated from each other by a distance less than half the length of a single series; tongue rather pear-shaped, with two rounded horns behind; head rather depressed, slightly concave on forehead, nearly one-third longer than broad; canthus rostralis angular, distinct, the snout rather obtusely pointed; loreal region nearly vertical, only slightly concave; distance from nostril to tip of snout contained slightly more than twice in distance from nostril to eye; interorbital region slightly concave, about as wide as an eyelid; tympanum large, very distinct, separated from eye by a distance less than one-half the diameter of tympanum; latter little more than three-fourths the diameter of eye; a slight, distinct dorsolateral skin fold from eye along sides to end of body; another very dim fold from eye to insertion of forearm above tympanum continuous anteriorly with the lateral folds; fingers unwebbed, with small, longitudinally oval disks, about the size of, or a little larger than, the subarticular tubercles; three large, distinct tubercles on palm; first finger much longer than second, which is shorter than fourth; toes about four-fifths webbed, webs not reaching base of disks, save on outer side of first three toes; on fourth toe web reaches a little above last subarticular tubercle; toes with well-developed disks, larger than disks on fingers; well-developed inner and outer metatarsal tubercles, inner oval, outer rounded; no skin flap on outer toe; no fold on tarsus or heel; tibiotarsal articulation reaches beyond tip of snout by a distance equal to that from eye to end of snout; skin almost smooth above, with no granulations apparent; skin on chin, sides, and belly smooth; a granular area on ventral aspect of thighs and on eyelids; skin on upper part of tibia granular.

Color in life.—Above pinkish brown, with dim darker reticulations; loreal region from point of snout to eye dark blackish brown; a large, dark black-brown spot behind eye, limited by the dim skin fold from eye to arm, entirely covering tympanum but not reaching mouth; a small longitudinal spot on anterior base of arm; posterior side of arm with dark spots and markings; a few scattered small spots on sides; transverse bars on anterior part of foreleg; hind leg with dusky transverse bars, anterior aspect of limb spotted and mottled with dark brown; posterior aspect of thighs yellow, reticulated with brownish; a brown stripe on anterior side of tibia; below creamy, yellow on posterior part of belly; chin rather dusky, lower jaw darker, with cream spots; breast with two rather large distinct spots; entire interdigital membrane dark; heel and under part of foot dark.

Measurements of Rana sanguinea Boettger.

	Female. mm.	Male. mm.
Length, snout to vent	62	40
Length of head	24	16
Width of head	18	12
Diameter of eye	6.5	5
Diameter of tympanum	5.4	3.8
Length of snout	10.5	7.5
Height of head, in front of eye	7	4
Foreleg	38	27
Hind leg	119	82
Tibia	39	28

Variation.—Two small specimens taken in the same locality agree very well with the one described. One of them is reddish brown above, the other grayish brown; the latter lacks the two spots on the breast, and the lip above is rather whitish. Two specimens taken at Concepcion, Busuanga, agree with the latter specimen in having a stripe on the upper part of the lores and the lip rather lighter. In these specimens the fold from the eye to the arm is very dim or wanting.

Remarks.—Boettger described his *Rana sanguinea* in 1893, and Boulenger his *R. varians* in 1894. Both species are recorded as being related to *R. temporalis* Günther. A comparison of descriptions reveals no essential differences. I am convinced that the two species are identical, and that the type of *R. sanguinea* Boettger is an immature specimen of *R. varians* Boulenger. I have no specimens of *R. sanguinea* from the type locality, which is Culion, but have a specimen from a nearby locality, Busuanga, at a point on the island nearest Culion. Boettger [14] describes a *R. moluccana* from Halmaheira and Ternate, while in a later work [15] he regarded this species as identical with *R. varians* Boulenger. Barbour [16] fails to agree with the later conclusion, but retains the species as distinct from *R. varians* Boulenger. Boettger evidently recognizes Boulenger's species as distinct and makes no mention of *R. moluccana* as being related to *R. sanguinea.*

Let us note the differences between the recorded description of the type and the description of the other two species. In *Rana varians* the tympanum is as large or nearly as large as the eye; in *R. sanguinea* it is more than three-fourths of the eye. In *R. varians* the interorbital distance is as broad as the upper eyelid or a little narrower; in *R. sanguinea* it is broader than a single eyelid. *Rana varians* has the toes nearly entirely webbed, the last two phalanges of the fourth toe free; *R. sanguinea* has the toes three-fourths webbed, the last two phalanges of the fourth toe free. In *R. varians* the tibiotarsal articulation reaches the snout or beyond; in *R. sanguinea* it is one and one-half times as long. In *R. varians* the tibia is as long as the foreleg or a little shorter; in *R. sanguinea* it is slightly longer. None of the characteristics are contradictory; the only significant ones are the difference in the length of the hind leg and

[14] Zool. Anz. 18 (1895) 132.
[15] Abh. Senck. Nat. Ges. 25 (1900) 366.
[16] Mem. Mus. Comp. Zool. Harvard Coll. (1912).

in the reach of the tibiotarsal articulation. Boettger mentions a small glandular fold below the tympanum behind the mouth in *Rana sanguinea* which Boulenger does not mention in his species.

Undoubtedly, the species which I have described is *Rana sanguinea*, but certain variations occur which should be considered. In the largest specimen the small fold behind the mouth is not evident; in nearly all the specimens there appears to be a slight supratemporal fold; the spots on the breasts are wanting in two specimens. There is some variation in the reach of the tibiotarsal articulation. In the younger specimens the dorsolateral folds are dim or wanting.[17]

Rana everetti Boulenger. Plate 6, figs. 1, 1*a*, and 1*b*.

Rana everetti BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 72, pl. 6; Proc. Zool. Soc. London (1897) 232.

Description of species.—(From type description, Boulenger.) "Vomerine teeth in two small oblique series, commencing on a level with the hinder edge of the choanæ. Head depressed; snout rounded, with distinct canthus rostralis and concave loreal region; interorbital space as broad as the upper eyelid; tympanum three-fourths the width of the eye. Fingers slender, first not extending as far as second; toes moderate, entirely

[17] I append the original description of *R. varians* Boulenger, Ann. & Mag. Nat. Hist. VI 14 (1894) 86.

"4. *Rana varians* sp. n.

"Closely allied to *R. temporalis*, Gthr. Vomerine teeth in two oblique series extending beyond the level of the hinder edge of the choanæ. Head depressed, longer than broad; snout obtusely or acutely pointed, prominent, longer than the diameter of the orbit; canthus rostralis angular; loreal region nearly vertical, strongly concave; nostril nearer the tip of the snout than the eye; interorbital space as broad as the upper eyelid or a little narrower; tympanum very distinct, as large as the eye or a little smaller. Fingers moderate, first extending beyond second; toes nearly entirely webbed; tips of fingers and toes dilated into well-developed disks; subarticular tubercles well developed; inner metatarsal tubercle oval, blunt; a small round outer metatarsal tubercle; no tarsal fold. Tibio-tarsal articulation reaching beyond the tip of the snout; tibia as long as the fore limb. Skin finely granulate, with or without scattered small warts; a narrow glandular dorso-lateral fold. Brown, pink, or dark grey above; a black streak below the canthus rostralis and a black temporal blotch; limbs with dark cross bands; hinder side of thighs marbled with brown; some specimens with a pale line along the vertebral line and another along the upper surface of the tibia. Male with internal vocal sacs and without humeral gland.

"From snout to vent, ♂ 43 millim., ♀ 70."

webbed; tips of fingers and toes dilated into disks, those of the former large, measuring about two-thirds the width of the tympanum, those of the latter smaller; subarticular tubercles well developed; a small oval inner, and an indistinct outer metatarsal tubercle. The hind limb being carried forwards along body, reaches the tip of the snout. Skin smooth; a rather indistinct glandular fold above the tympanum; angles of the mouth glandular."

Color.—"Light greyish brown above, with round dark spots; limbs indistinctly cross-barred; under surface of hind limbs speckled with greyish brown."

Remarks.—Boulenger has given no measurements for this species, but it is presumed that his superb figure reproduced here is life size. It measures 88 millimeters from snout to vent.

The type, a female specimen, is from Zamboanga, and was collected by Everett. The species has since been found by the same collector in Borneo and Celebes. *Rana everetti* may be distinguished from *R. varians* (= *R. sanguinea* Boettger) by the following characters: The first finger is shorter than the second; the finger disks are larger, equal to from one-half to two-thirds the tympanum; the tibiotarsal articulation reaches tip of snout or a little beyond; the males have internal vocal sacs and no humeral gland; a white streak usually borders the upper lip. *Rana everetti* is said to lay its eggs in a frothy mass out of the water.

Description of tadpoles.—(From Boulenger.)[18] "Length of body once and a half to once and two-thirds its width, about half as long as the tail. Nostrils nearly equally distant from the eyes and the tip of the snout. Eyes on the upper surface, equally distant from the tip of the snout and the spiraculum, the distance between them a little greater than the distance between the nostrils. Spiraculum on the left side, directed upwards and backwards, nearer the posterior extremity of the body than the end of the snout. Anal opening on the right side close to the lower edge of the caudal crest. Tail about thrice and a half as long as deep, acutely pointed; crests lower than the muscular portion, the dorsal not extending on the body. Mouth as broad as the interocular space; series of labial teeth $\frac{4}{3}$, the outer upper and the three lower continuous, the others restricted to the sides; lower lip bordered by a double series of papillæ; beak broadly edged with black. Dark brown or blackish above, greyish below; upper caudal crest dark brown, lower greyish.

[18] Proc. Zool. Soc. London (1897) 232.

"Total length 45 millim.; body 14; tail 31; depth of tail 8.
"This tadpole is essentially that of a typical *Rana*."

Rana suluensis sp. nov.

Type.—No. 1638, Bureau of Science collection; collected near the southern end of Tawitawi Island, P. I., October, 1918, by E. H. Taylor.

Description of type.—(Female.) Vomerine teeth in two short, obliquely placed series between choanæ, separated from the latter by a distance half their length, and from each other by a distance nearly equal to their length; choanæ large, distinct, distance between them greater than distance from eye to nostril; distance between Eustachian tubes equals their distance from nostril; head rather flat, longer than broad, very slightly depressed on middle part of snout; canthus rostralis angular; loreal region nearly vertical, somewhat concave; snout rounded when viewed from above, rather pointed when viewed laterally, projecting; nostril much nearer end of snout than eye; distance between nostrils equals their distance from eye, as well as the interorbital distance and width of upper eyelid; diameter of eye reaches beyond nostril; diameter of tympanum from two-thirds to three-fourths that of eye; tympanum very distinct; skin above smooth or minutely granular; no dorsolateral glandular folds; no supratympanic folds; no fold or a very indistinct one above insertion of forearm; skin on sides with occasional, rather large tubercles; limbs smooth above and below; belly, chin, and throat entirely smooth; anal region strongly granular; limbs slender; first finger very slightly longer than second, both a little shorter than fourth; fingers with small disks, rather pointed in front; subarticular tubercles distinct; three distinct carpal tubercles, the largest at base of first finger; toes slender, long, the disks larger than the finger disks, tips somewhat pointed; toes scarcely more than half webbed; the membrane reaches second subarticular tubercle on fourth toe; fifth longer than third, reaching midway between first and second subarticular tubercles; a small inner metatarsal tubercle equal to about one-fourth the length of first toe, and a distinct outer metatarsal tubercle; subarticular tubercles of toes well developed; a very slight fold from tip of fifth toe to tibia; males with well-developed internal vocal sacs; tibiotarsal articulation reaches nostril.

Color in life.—Above grayish brown to reddish brown, variegated dimly with purplish, darker brown, and with numerous small, rounded blackish spots with grayish centers; tip of snout whitish, a dorsolateral silver-gray line from tip of snout to end of body; sides of head and temporal region dark blackish brown, somewhat lighter on sides of body; sides with darker grayish-centered spots; a white line from tip of snout to above arm; arm with dark purple stripe on posterior side, and a dark stripe on underside near insertion; hind limb lighter brown than back, strongly barred with blackish to purplish brown; underside of foot purplish, the outer tubercle white; belly silvery white; chin slightly dusky; hind legs dusky white, below yellowish white; posterior part of thigh dark, marbled and reticulated with yellowish.

Measurements of Rana suluensis sp. nov.

	mm.
Length, snout to vent	47.5
Length of head	19.5
Width of head	13.5
Diameter of eye	6.1
Diameter of tympanum	4.8
Tympanum, from eye	1.25
Eye to nostril	51
Length of snout	7.3
Distance between nostrils	4.6
Foreleg	30
Longest finger	13.5
Hind leg	81
Femur	23.2
Tibia	26
Longest toe	24
Largest toe disk	1.1

Variation.—The chief variation noted is the presence of a narrow, glandular, dorsolateral fold on several younger specimens, which is dim or wanting on older specimens.

One specimen from the same island was uniformly light brown above, with a distinct dorsolateral fold, the back strongly granular, the granules of different sizes; upper part of legs strongly granular and with longitudinal folds; younger specimens are darker on throat and belly, usually lighter on back, the dark spots not round.

Remarks.—This species is related to *Rana sanchezi,* from Palawan, and *R. labialis,* from Borneo, Java, and Malay Peninsula. It differs from these in the lesser extent of webbing between toes, in color and markings, and in the smaller finger disks, which are smaller than those on toes. The species was taken only on

Tawitawi and a small island at the extreme southern end, only a few meters from the seacoast, at some distance from fresh water. They were found hopping about the base of a large *balete* tree, on the sides, and about roots. They would take refuge under leaves and root masses. They appeared common in these two localities, but were not observed elsewhere. Fourteen specimens were preserved.

Rana philippinensis sp. nov.

Type.—No. 662, E. H. Taylor collection; collected in Mindanao, P. I., August 12, 1913, by E. H. Taylor.

Description of type.—Vomerine teeth in two oblique rounded groups, separated from choanæ and from each other by an equal distance; tongue large, without papillæ; distance between Eustachian tubes much less than their distance from choanæ; distance between choanæ equal to distance between nostrils; head obtusely pointed in upper and lateral profile, projecting somewhat; loreal region nearly vertical, somewhat concave; interorbital region one and one-fourth times upper eyelid; eye large, diameter of orbit equal to the distance to tip of snout; nostril very much nearer tip of snout than eye; tympanum distinct, a little more than three-fifths eye, separated from eye by a distance equal to less than one-third its diameter; skin on entire body smooth; no granules on posterior part of thigh in anal region; no fold above tympanum; no dorsolateral fold; fingers long, large, with pointed disks, larger than subarticular tubercles, which are distinct and well developed; first finger opposed to rest of hand, longer than second, only minutely shorter than fourth, and reaching last joint on third; disks with a small groove around edge; carpal tubercles elongate, comparatively small; no gland on upper arm; toes with pointed disks, larger than those on fingers, and larger than subarticular tubercles on foot; toes nearly two-thirds webbed, webs not reaching disks; an elongate inner metatarsal tubercle and a small outer tubercle present; tibiotarsal articulation reaching beyond eye.

Color in life.—Above on back and head yellow to olive brown, with indistinct darker mottling; a broad distinct dark brown dorsolateral stripe from eye to end of body; sides olive yellow, with darker mottling; eyelids dark; tympanum golden yellowish, tympanic region dark brown; limbs yellowish olive brown, with irregular spots and marblings not forming bars; throat dusky brown, belly lighter.

Measurements of Rana philippinensis sp. nov.

	mm.
Length, snout to vent	50
Length of head	20.5
Width of head	16
Diameter of eye	8
Length of snout	8.1
Tympanum	4.9
Interorbital area	6.5
Foreleg	35
Longest finger	14.5
Hind leg	86
Femur	22
Tibia	28
Longest toe, with metatarsal	26
Diameter of toe disk	1.4

Remarks.—Only a single specimen, an adult female with eggs, has been collected. The character of the opposed first finger seems to differentiate it clearly from other Philippine species of *Rana*. The markings and the color are characteristic.

Rana dubita sp. nov.

Type.—No. 1460, E. H. Taylor collection; collected at Bunawan, Agusan, Mindanao, June, 1913, by E. H. Taylor.

Description of type.—Vomerine teeth in two slight series between the choanæ, their hinder edge on a level with the choanæ, separated rather widely by a distance of at least half their length; snout rather obtuse, not sloping strongly in front; canthus rostralis evident, rather angular; loreal region nearly vertical, strongly concave; head about one and one-third times as long as broad; snout moderately long; diameter of eye equal to distance from eye to a little beyond nostril; nostril nearer tip of snout than eye; distance of nostril to point of snout contained in distance from nostril to eye a little more than twice; tympanum round, large, its diameter from two-thirds to three-fourths eye; separated from eye by a distance less than half its diameter; interorbital distance much wider than one upper eyelid; skin smooth on back, sides, and belly; no granulation on limbs; probably a very slight lateral fold; no supratemporal fold apparent; fingers slender with large disks; first finger with very small disk, not wider than digit, less than half the width of second finger disk; second finger much shorter than fourth; latter reaching to near base of disk of third finger; largest disks one-half to two-thirds tympanum, disks with a distinct groove around edges; toes broadly webbed, the membrane reaching disk on outer side of first, second, and third toes, and on inner side of fifth; it reaches last subarticular tubercle on fourth toe; disks not as large as those on fingers, those on second and third toes largest; tibiotarsal articulation reaching about halfway between eye and nostril.

Color in life.—Dark, rather blackish brown above, darker on head; a white line along upper lip, widening below tympanum and continuing back above front limb; arms lighter brown, barred with darker; subarticular tubercles of fingers whitish, a white spot on fingers above at base of disk; hind legs brown, spotted or mottled indistinctly with darker brown; a few yellowish white markings on posterior aspect of thigh and tibia; below dusky yellowish white with darker spots and marbling; underside of thighs yellowish with a few dark spots; interdigital membrane of toes dusky.

Measurements of Rana dubita sp. nov.

	mm.
Total length, snout to vent	34.5
Length of head	15
Width of head	11.2
Length of snout	6
Diameter of orbit	4.2
Diameter of tympanum	3.9
Length of longest finger	10
Length of longest toe	14.5
Tibia	19.5
Foreleg	22
Hind leg	56

Remarks.—A single specimen was collected at Bunawan, Agusan. It was found in deep forest about 100 meters from water.

Rana melanomenta sp. nov.

Type.—No. 1661, Bureau of Science collection; collected at Papahag, Sulu, P. I., October 5, 1917, by E. H. Taylor.

Description of type.—Vomerine teeth in two slender oblique series lying between, but extending a little behind, posterior part of choanæ; separated from choanæ by a distance about as great as a single series, from each other by a distance little more than half the length of one series; distance between Eustachian tubes greater than their distance from choanæ; distance between choanæ equals distance between nostrils; tongue without papilla; males with vocal sacs, the openings large; canthus rostralis distinct, slightly rounded; nostrils nearer end of snout than eye; diameter of eye less than snout, barely reaching beyond nostril; tympanum distinct, about three-fifths eye, separated from eye by a distance equal to one-half its diameter; interorbital distance equal to, or slightly less than, the width of an upper eyelid; loreal region sloping, concave; snout rounded in upper and lateral profile, projecting somewhat; skin on back, sides, and belly smooth; granular on lower and posterior aspect of thighs; skin on chin over vocal sacs somewhat distended and wrinkled; no fold above tympanum; no dorsolateral fold; a distinct glandular tubercle above insertion of arm; no gland on upper part of arm; fingers with small digital disks no longer than subarticular tubercles, which are distinct; first finger longer than second and but slightly shorter than fourth; first finger with nuptial excrescences; three carpal tubercles, large, well defined; each disk with simple groove around edge; toes from one-half to two-thirds webbed, the webs failing to reach disks except as a very narrow margin; disks on toes about as large as those on fingers, and apparently larger than subarticular tubercles of toes; an oval inner, and a rounded outer, metatarsal tubercle.

Color in life.—Above lavender-brown, with a wash of gray; a few very small black spots scattered over upper surface; laterally lavender-brown, with darker markings above arm; sides of head and tympanum black; throat black, belly dusky with white marblings; limbs closely barred with blackish; posterior aspect of thigh with small white dots; a white spot at final joint of digits.

Measurements of Rana melanomenta sp. nov.

	mm.
Total length, snout to vent	35
Length of head	19
Width of head	13
Diameter of eye	4.6
Length of snout	6.3
Foreleg	26
Longest finger	10
Hind leg	66
Tibia	19
Femur	18
Longest toe, including metatarsal	1.8

Variation.—Four specimens were taken, all agreeing with the type in essential characters; one specimen has the throat black, with numerous white spots. The third and fifth toes of all except the type are practically the same length; in the type, however, the third toe of the right foot is much longer than the fifth.

Remarks.—These specimens were all obtained near small pools of stagnant water in the forest on Papahag, near Tawitawi. The species was observed on other islands, but no specimen was taken. In the character of the digits it appears to be closely related to the group to which *Rana similis*, *R. grandocula*, and *R. glandulosa* belong. It differs in having smaller eyes and a shorter snout and in the absence of a papilla on the tongue and of the arm gland.

Rana moellendorffi Boettger. Plate 1, fig. 4.

Rana moellendorffi BOETTGER, Zool. Anz. 16 (1893) 363.

Description of species.—(From No. 1482, Bureau of Science collection; collected in northern Palawan, P. I., May 10, 1918, by E. H. Taylor.) Vomerine teeth in two small, rounded, oblique series, very much nearer to each other than to the choanæ, extending behind posterior level of choanæ; tongue rather oval, small, with the two "horns" at the posterior corners, which are rather widely separated at their bases; no papilla; males with vocal sacs, the internal openings small; head somewhat longer than broad, not concave; snout obtusely pointed; eyes not especially prominent; interorbital area nearly one and a half times upper eyelid; diameter of eye only slightly less than length of snout; canthus rostralis rather rounded; lores nearly vertical, with a distinct longitudinal groove behind nostril; distance from nostril to end of snout less than its distance from eye; tympanum very distinct, little more than half diameter of eye, separated from eye by a distance less than one-third its diameter; skin smooth or finely shagreened above, indistinctly granulate on posterior part of eyelids and on sides; skin smooth below save on ventral surface of thigh; no dorsolateral fold; no fold or only a very indistinct one from eye above tympanum; a distinct gland on upper part of arm; fingers slender, with very slight longitudinal oval pads, scarcely wider than fingers; first finger slightly longer than second, fourth longer than first or second, reaching base of disk of third; toes three-fourths webbed, the webs nowhere reaching base of toe disks, which are as large as finger disks; subarticular tubercles well developed; inner metatarsal tubercle elongate, oval, outer smaller, rounded; hind leg brought forward, tibiotarsal articulation reaches somewhat beyond eye.

Color in life.—Above yellowish to bronze green; the entire back, head, and sides covered with large, usually elongate black spots, which frequently join each other, forming islandlike designs; a black loreal streak, below which is a yellow-green line; below this a short dark stripe on edge of lip; tympanum dark brown; dark spots on breast at insertion of arms; arm spotted with black above and a broken dark line on posterior side;

limbs strongly barred with black; posterior part of hind limb black, with a few yellowish white spots on femur; groin similar; below dirty white, with lighter yellowish spots; membrane between toes dark.

Measurements of Rana moellendorffi Boettger.

	mm.
Total length, snout to vent	40
Length of head	15
Width of head	13.5
Diameter of eye	5.2
Diameter of tympanum	4
Length of snout	6.1
Tibia	20
Femur	19
Foreleg	27
Hind leg	61

Variation.—Three other specimens, all of which are males, taken in the same locality, agree remarkably well with the described specimen, especially in color; two have the entire head outlined above with greenish yellow and the lower labials spotted with yellow; some of the specimens show the presence of a slight glandular area below, and slightly behind, tympanum.

These agree with the type description in essential details, save that the tibiotarsal articulation of the type reaches the point of the snout, while in the specimens at hand it reaches only a short distance beyond the eye; in these also the head is distinctly longer than wide, while in the type the head is as long as wide. The fact that the types are considerably larger, and probably females, may account for the discrepancy. Either the gland on the upper arm was overlooked by Boettger, or it is absent in the type.

Remarks.—The specimens were collected on the extreme northern end of Palawan Island. They were found perched on vines growing on trees at the edge of small streams. No other specimen was seen. The type locality is Culion, which is near Palawan.

Rana similis (Günther). Plate 4, fig. 5.

Polypedates similis GÜNTHER, Proc. Zool. Soc. London (1873) 171.
Rana similis BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 72.

Description of species.—(From No. F326, E. H. Taylor collection; collected on Mount Maquiling, near Los Baños, Luzon, P. I., April 5, 1916, by E. H. Taylor.) Vomerine teeth in two small, distinct, oblique groups lying between, and for the most part posterior to, the hinder level of choanæ; latter moderately large, distant from vomerine teeth by more than length of a single group; tongue rather small, with a moderate notch behind; a distinct, rounded, low papilla on tongue; males with vocal sacs, the openings small, rounding; snout short, equal, or nearly equal, in length to diameter of eye, rather rounded anteriorly; head longer than wide; canthus rostralis angular, loreal region concave, nearly vertical; tympanum large, distinct, about two-thirds eye, separated from eye by a distance about half its diameter; distance of nostrils from each other equals their distance from eye; interorbital distance equal to upper eyelid; nostril more than twice as far from eye as from tip of snout; skin above smooth on head and body, minutely pitted; sides smooth; chin and belly smooth; ventral and posterior parts of thighs granular; no dorsolateral skin fold; no supratympanic fold; a small glandular fold at corner of mouth and two smaller ones above insertion of arms; fingers slender, with small, distinct disks, those of third and fourth fingers of equal size, larger than those on first and second; first finger extending slightly farther than second, both shorter than fourth; an enlarged nuptial excrescence on inner side of first finger; an enlarged gland on upper arm; subarticular tubercles distinct, well developed; carpal tubercles large, distinct; toes about two-thirds webbed, membranes not reaching disks except as very narrow fringe on outer side of digits; toes with small disks slightly pointed, nearly as large as largest finger disks; an elongate inner metatarsal tubercle, and a small round outer tubercle; no skin fold on fifth toe; no tarsal fold; hind leg brought forward, tibiotarsal articulation reaches a little beyond eye; when viewed from above, eyes project beyond outline of jaws.

Color in life.—Above olive slate, slightly mottled with lighter olive on head; an olive yellow line from tip of snout along canthus rostralis, across edge of upper eyelid, to end of body along the dorsolateral edge; from tip of snout to eye a purplish slate loreal area; behind eye on sides dark purplish slate; tympanum brown; a narrow labial line, beginning in front of eye, continues to angle of mouth, ending in a white spot on the dim granular fold; lower side mottled with greenish yellow; throat dusky; belly dirty white; limbs olive above, with numerous, broad, slate bars, five or six on the tibia, and continuing on the foot; heel and underside of foot dark; underside of hind legs dusky.

Measurements of Rana similis (Günther). Nos. F326 and F325.

	mm.	mm.
Length, snout to vent	46	46
Length of head	17	16
Length of snout	6.5	6.6
Width of head	14	14.2
Diameter of eye	6.5	6.2
Diameter of tympanum	4.6	4.2
Depth of head, in front of eye	6	6
Foreleg	31.5	28.2
Longest finger	11	11.6
Hind leg	77	69.5
Femur	19.5	18.5
Tibia	24	19.5
Foot	33	31
Longest toe	21.5	19
Toe disk	1.2	1.5

Variation.—Eight specimens in my collection from Los Baños exhibit but very little variation in color and markings. All appear to be males; at least all have the internal openings to the vocal sacs. Comparison of the measurements in the preceding table with the following measurements of several specimens will show that there is a slight variation in the length of the hind leg.

Body length.	Hind leg.
mm.	mm.
43.5	70
46	77.5
46.5	69.5
41	67.5
44.5	69
44	69
45.2	71.5

In these specimens the tibiotarsal articulation reaches to the eye and, possibly, slightly beyond.

Remarks.—The smooth skin, the shorter legs, the presence of a swelling, or papilla, on the anterior part of the tongue, and the gland on the upper arm seem to distinguish this species from *Rana signata* Günther. *Rana moellendorffi* Boettger, from Palawan and the Calamianes, is very closely related also; the markings, however, of *R. moellendorffi* are strikingly different, the interorbital distance is wider, usually one and a half times the eyelid, and the papilla is absent from the tongue. Other differences are in evidence on a comparison of the specimens.

Specimens in the collections are from Bataan and Laguna Provinces, Luzon; the type is from "Laguna de Bay," Luzon, and was collected by A. B. Meyer. Boulenger is of the opinion that *Rana similis* and *R. signata* are the same species.

Rana grandocula sp. nov. Plate 7, figs. 2 and 2*a*.

Type.—No. F334, E. H. Taylor collection; collected near Bunawan, Agusan, Mindanao, P. I., August, 1912, by E. H. Taylor.

Description of type.—Vomerine teeth in two small, slightly diagonal, rounded series between choanæ, posteriorly separated from choanæ by a distance much greater than the length of a single series, and from each other by a distance less than half of a single series; distance between openings of Eustachian tubes less than their distance from choanæ; distance between choanæ equals distance between nostrils; head longer than wide, snout protruding slightly; eyes very large and protruding; diameter about one-fourth or one-fifth longer than snout; nostril nearer tip of snout than eye; tympanum quite distinct, its diameter about half of eye, separated from eye by a distance equal to one-third of its diameter; canthus rostralis distinct, roundly angular, the loreal region nearly vertical, the lores concave; width of upper eyelid little more than one and one-third times interorbital distance; skin of body above and below entirely smooth; a few granules on posterior aspect of thigh and about anal region; no dorsolateral fold; no fold above tympanum; digits slender, tips of fingers and toes dilated into small disks with grooves around their edges; first finger extending as far as, or very slightly farther than, second, both but slightly shorter than fourth, which just fails to reach base of disk on third; subarticular tubercles well developed, as are the carpal tubercles; first finger with nuptial swellings; toes about two-thirds webbed, the membrane failing to reach disks but approaching nearest on second toe; third and fifth toes of nearly equal length; subarticular tubercles strong; an elongate, inner metatarsal tubercle more than one-third the length of first toe; a rounded, fairly prominent, outer metatarsal tubercle; disks rather pointed at tips; tibiotarsal articulation reaches anterior edge of eye or slightly farther; a distinct oval gland on inner side of upper arm; males with internal vocal sacs, the openings rather far back on either side of tongue.

Color in life.—Above olive to chestnut brown, with numerous indistinct darker flecks and spots; sides slightly darker and rather thickly spotted; limbs with spots or bars; dusky brown on throat and chin, lighter on belly; underside of feet and hands rather purplish, the tubercles lighter; a distinct light spot above last joint of digits.

Measurements of Rana grandocula sp. nov. Nos. F334 and F337.

	mm.	mm.
Length, snout to vent	40	44
Length of snout	6.2	6.1
Diameter of eye	7.3	7.1
Diameter of tympanum	3.8	4.2
Interorbital distance	3.4	3.6
Upper eyelid	5.1	5
Length of head	16.5	17
Width of head	13	14.5
Foreleg	25	27
Longest finger, from wrist	11	11
Hind leg	65	68.2
Femur	18.2	20
Tibia	19.8	21.2
Foot	27.5	29
Longest toe	17	19.5
Finger disks	1.2	1.2
Toe disks	1.1	1.3

Variation.—Several specimens in the collection show but little variation. The ground color varies from darker to lighter than the type. Some of the specimens have a distinct white line on the upper lip. The gland on the arm seems to be present in both sexes.

Remarks.—There are several specimens of this species in my collection, all from Agusan River Valley, near Bunawan. It appears to be closely related to *Rana similis* (Günther) but differs from it strikingly in the much larger and more prominent eye, the shorter snout, the smaller tympanum, the absence of a fold at angle of mouth, and the very different markings and coloration. Specimens were taken along Bunawan River in large pools in worn rocks; numerous in this locality.

Rana glandulosa Boulenger. Plate 5, figs. 1, 1*a*, and 1*b*.

Rana glandulosa BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 73, pl. 7; Ann. & Mag. Nat. Hist. VI 14 (1894) 87; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 448; FLOWER, Proc. Zool. Soc. London (1896) 905; (1899) 897; LAIDLAW, Proc. Zool. Soc. London (1900) 887.

Description of species.—(From Boulenger.) "Vomerine teeth in two short oblique series, between the choanæ. Head rather large; snout rounded, as long as the orbit, with obtuse canthus rostralis and concave loreal region; nostril nearer snout than eye; interorbital space nearly same as upper eyelid; tympanum distinct three-fifths to three-fourths the diameter of the eye; fingers rather elongate, first extending much beyond the second; toes moderate one-half to two-thirds webbed; tips of fingers and toes merely swollen or dilated in small discs; subarticular tubercles prominent; a small oval inner metatarsal tubercle and a small round one at the base of the fourth toe; tibiotarsal articulation reaches the eye or between the eye and the tip of the snout; back more or less distinctly granulate, with large flat granules at least on the sides."

Color.—"Olive or reddish brown, spotted and speckled with blackish; lips dark with large whitish spots or bars; limbs with dark crossbars; lower parts whitish or buff, uniform or spotted with brown. Eye fiery red. Male with vocal sacs on each side forming folds and a large oval gland on the inner surface of the arm. Snout to vent, 95 mm. Found in caves in total darkness."

Remarks.—The types were obtained in Sarawak by A. Everett, who later discovered the species in Palawan; I failed to find it in Palawan. Boulenger reports it from Malay Peninsula.

Genus STAUROIS Cope

Ixalus GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 15, part.
Staurois COPE, Nat. Hist. Rev. (1865) 117.
Rana BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 71, part.
Micrixalus BOULENGER, Proc. Zool. Soc. London (1888) 205; Fauna Brit. India, Rept. (1890) 464.

No vomerine teeth; tympanum distinct; fingers free, with disks; toes webbed; otherwise agrees very well with *Rana*.[19]

One species is found in Palawan, Minadanao, and nearby islands. Very probably it does not enter Luzon, the western Visayan Islands, or Mindoro.

[19] Boulenger, Ann. & Mag. Nat. Hist. IX 1 (1918) 374, has redefined this genus, listing five species: *Staurois larutensis* Boulenger, Borneo and Malay Peninsula; *S. guttatus* Günther, Borneo; *S. natator* Günther, Philippines; *S. nubilus* Mocquard, Palawan; and *S. tuberilinguis* Boulenger, Borneo. He mentions the following generic characters:

Tympanum small; with or without vomerine teeth; disks on fingers large, broader than long, larger than those of toes, with a half disk within the disk on the lower surface; toes fully webbed, the webs involving base of disks; outer metatarsal separated to base.

The recognition of Mocquard's species *Ixalus nubilus* = *Staurois nubilus* by Boulenger in this paper presents an opinion in which I do not concur. My own collection has more than one hundred specimens of *S. natator* from Mindanao, and I have recently been able to examine specimens of what is probably Mocquard's *Ixalus nubilis* from various parts of Palawan and Busuanga. Occasional specimens from both lots show a papilla on the tongue; there appears to be no difference in average measurements; the granules on the Palawan specimens appear a little coarser than on most of the Mindanao specimens.

Staurois natator (Günther). Plate 4, figs. 2 and 2*a*.

Ixalus natator GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 15, pl. 4, fig. C; Proc. Zool. Soc. London (1879) 79.
Staurois natator COPE, Nat. Hist. Rev. (1865) 117.
Rana natatrix BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 71; BOETTGER, Ber. Senck. Nat. Ges. (1886) 121.
Staurois natator BOULENGER, Ann. & Mag. Nat. Hist. VI 14 (1894) 87.
Ixalus nubilus MOCQUARD, Nouv. Arch. Mus. 2^3 (1890) 153, pl. 11, fig. 3.

Description of species.—(From No. 1601, E. H. Taylor collection; collected at Bunawan, Agusan, Mindanao, P. I., August 12, 1912, by E. H. Taylor.) Vomerine teeth wanting; tongue elongate, oval, deeply notched behind; choanæ large; canthus rostralis angular, curving in between eye and nostril; loreal region vertical for some distance, then sloping out, with the lip nearly vertical; snout narrower behind nostrils than directly in front; tip of snout vertical, rounding in outline; eye very large, equal or nearly equal to length of snout; tympanum small, circular, its diameter from one-third to two-fifths eye; separated from eye by a distance less than half its diameter; interorbital region narrow, a little less than width of upper eyelid; distance of nostrils from each other less than their distance from eye; nostril half as far from eye as from end of snout; skin strongly granular above on loreal region, above eyelids, and back of body; upper surface of limbs smooth; chin and breast smooth; belly and sides with larger granules; anal region and part of underside of thighs granular; no distinct supratemporal fold; no tarsal fold; fingers large, with wide, roughly triangular disks, diameter of disk larger than tympanum; first finger shorter than second, second shorter than fourth, fourth not reaching base of disk of third; fingers unwebbed; toes completely webbed, the membranes reaching base of disks; disks on toes more rounding and a little smaller than disks on third and fourth fingers; disks with distinct grooves on edges and with a transverse depression above; fifth toe extending slightly farther than third, fourth longest; a small inner metatarsal tubercle and a still smaller outer tubercle; subarticular tubercles small, not very clearly defined; the tibiotarsal articulation reaches much beyond snout. Male with internal vocal sacs.

Color in life.—Above olive to bronzy green, mottled with darker; legs lighter, barred with the ground color of back; lips, chin, belly, and sides light blue-green, which color penetrates body; tongue, inside of mouth, body cavity, and intestines light blue-green; interdigital membrane of toes dusky.

Measurements of Staurois natator (Günther).

	mm.
Length, snout to vent	58
Length of head	18
Width of head	14
Length of snout	7.6
Diameter of eye	7.2
Diameter of tympanum	2.2
Foreleg	33
Longest finger	14.4
Hind leg	85
Femur	25
Tibia	28.5
Longest toe	21.5

Variation.—The variations in this species are chiefly in coloration, that given being most nearly typical. Sometimes the color of the back is bronze with yellowish spots or reticulations; sometimes the blue-green skin on sides and belly has a slight wash of yellow; certain specimens are dark greenish brown with cream yellow spots on sides and back; a small specimen in the Bureau of Science collection preserved in alcohol (No. 1669) has all the legs barred with brown and cream, a darker line from tip of snout through eye above tympanum, and the back brown, with cream reticulations.

Remarks.—This species is common in Leyte, Mindanao, Palawan, and Busuanga. It is also known to occur in Culion, Dinagat, and Basilan, in the Philippines, and is reported from Celebes.[20] The species is always found in the immediate vicinity of water, usually perched on rocks, in midstream. The frogs are extremely agile, and can make phenomenal jumps. They are captured with no little difficulty.

The types were collected in the Philippines, probably by Hugh Cuming; the exact type locality appears to be no longer known. The types, three in number, are in the British Museum.

Genus POLYPEDATES Tschudi

Polypedates TSCHUDI, Class. Batr. (1838) 34; DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 515; GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 77; COPE, Nat. Hist. Rev. (1865) 116; STEJNEGER, Bull. U. S. Nat. Mus. 58 (1907) 143.[21]

[20] Boulenger, Proc. Zool. Soc. London (1897) 193–237, does not include the species in the Celebes fauna. He states that Meyer's record, Abh. Mus. Dresden 2 (1887) 16, of *Rana natatrix* Gthr. from Gorontalo is probably wrong.

[21] Stejneger (loc. cit.) has shown the necessity of the use of *Polypedates* instead of *Rhacophorus* for this genus of frogs.

Theloderma TSCHUDI, Class. Batr. (1838) 32.
Buergeria TSCHUDI, Class. Batr. (1838) 34.
Rhacophorus TSCHUDI, Class. Batr. (1838) 34; DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 530; GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 116; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 73 and 74; Fauna Brit. India, Rept. (1890) 470.
Trachyhyas FITZINGER, Syst. Rept. (1843) 31.
Dendricus GISTEL, Naturg. Thierr. (1848) 8.

Pupil horizontal; tongue free and deeply notched behind; vomerine teeth rarely absent; tympanum either distinct or hidden, rarely the latter; fingers more or less webbed or free; toes more or less webbed, terminating in disks; a small bone inserted between last two phalanges; terminal phalanges T-shaped. Outer metatarsals separated by a web; omosternum and sternum with a bony style.

This large genus of frogs is widely distributed from India and Madagascar to China, southern Asia, and the East Indian Archipelago. More than fifty species are known. There are seven well-differentiated forms represented in the Philippine fauna.

Key to the Philippine species of Polypedates Tschudi.

a^1. Tympanum distinct; skin of head not involved in cranial ossification.
  b^1. Fingers about one-third webbed; toes more than three-fourths webbed; cutaneous prominences below anus and on outer edge of arm and foot; heel reaches almost to tip of snout.
    P. appendiculatus (Günther).
  b^2. Fingers about two-thirds webbed, membrane reaching disks of third and fourth fingers; toes webbed to base of disks; cutaneous flap over anus .... P. pardalis (Günther).
  b^3. Slight web at base of fingers; toes nearly entirely webbed; dorsolateral glandular folds present........ P. hecticus Peters.
  b^4. Slight rudiment of web at base of fingers; toes three-fourths webbed; no dorsolateral glandular fold; small tubercles below vent, at heel, and on outer edge of forearm and tarsus.... P. everetti (Boulenger).
a^2. Tympanum distinct, large; skin of head involved in cranial ossification.
  b^1. Slight rudiment of web at base of fingers; toes nearly entirely webbed; disks of fingers half the diameter of eye.... P. macrotis (Boulenger).
  b^2. Differs from *P. macrotis* in having smaller choanæ and a narrower interorbital space; spotted above, or with four or six longitudinal stripes .... P. leucomystax (Gravenhorst).
a^3. Tympanum nearly hidden under skin, about half size of eye; fingers with rudiment of web; toes a little more than one-half webbed.
    P. surdus Peters.

Polypedates appendiculatus (Günther). Plate 8, figs. 2, 2*a*, and 2*b*.

> *Rhacophorus appendiculatus* GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 79; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 86, pl. 8, fig. 4; BOETTGER, Ber. Senck. Nat. Ges. (1886) 122; Abh. Ber. Mus. Dresden 7 (1894–95) 2.

Description of species.—(From No. 184, E. H. Taylor collection; collected at Bunawan, Agusan, Mindanao, P. I., September, 1912, by E. H. Taylor.) Vomerine teeth in two converging series, beginning on anterior inner edge of choanæ, not especially distinct; choanæ not large; head distinctly longer than wide; eye prominent, its diameter slightly longer than distance from eye to nostril; canthus rostralis rounded, the area about nostrils forming two small rounded prominences, with a slight depression between them; forehead not concave; lores concave, sloping obliquely; snout somewhat triangular, constricted in front of nostrils, forming a distinct "nose;" diameter of tympanum equal to, or a little more than, half diameter of eye, very close to orbit, the distance separating them about one-fifth to one-sixth diameter of tympanum; distance of nostril to end of snout contained one and one-half times in its distance from eye; a very distinct skin fold from eye to arm above tympanum; skin rough, tubercular, or warty, especially on head, snout, and shoulders, and on sides of head about tympanum; skin on posterior part of back as well as on the limbs rather smooth; chin and chest smooth; belly and under aspect of thighs strongly granular; hand slightly less than one-third webbed; digits with broad disks, equal to, or slightly smaller than, tympanum; first finger shorter than second, fourth longer than second, reaching terminal disk of third; subdigital tubercles prominent; a very slight skin fold from base of third finger along inner arm; toes more than three-fourths webbed, the webs reaching to near base of disks on outer sides of toes; disks smaller than those on fingers; third and fifth toes of equal length; inner metatarsal tubercle well developed, outer indistinct or wanting; a decided, undulous skin fold along outer side of fifth toe and tarsus, and on outer part of forearm; two small cutaneous prominences below anus; hind limb brought forward, tibiotarsal articulation reaches to near tip of snout.

Color in life.—Above, light brownish lavender on head, back, and sides, and above limbs; two broad, rather irregular stripes of light pale lavender to whitish from eye to groin; below creamy white.

Measurements of Polypedates appendiculatus (Günther).

	mm.
Length, snout to vent	41
Length of head	15
Width of head	13.6
Length of snout	7.5
Diameter of eye	5.1
Diameter of tympanum	3.5
Diameter of finger disk	3.5
Foreleg	24.5
Hind leg	64
Tibia	22

Variation.—The chief variations noted in a series of about twenty specimens from Bunawan, Agusan, are as follows: The larger percentage of the specimens has the skin on the anterior part of the body smooth; in younger specimens the "nose" is not so distinctly evident; older specimens usually have a minute, but distinct, dermal fold on underside of head, outlining the mandible. The color varies markedly; half-grown and young specimens are usually uniform lavender above, and whitish below. Older specimens vary from purplish brown to gray, with indistinct spots and mottlings; the light lateral stripes are only rarely present; in certain specimens the hind legs are distinctly barred.

Remarks.—This species was especially common at Bunawan. The specimens for the most part were collected from the axils of the large caladiums that are found in profusion in the cut-over forests and along the rivers. Their eggs are deposited in the water that collects in the axils of caladiums and wild plantains.

The type locality is "Philippines," with no definite locality given. Known from Dinagat, Mindanao, and the Calamian Islands, in the Philippines. Reported also from Borneo.

Polypedates pardalis (Günther). Plate 4, fig. 1; Plate 6, figs. 2 and 2*a*.

Rhacophorus pardalis GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 83, pl. 6, fig. D; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 91; BOETTGER, Ber. Senck. Nat. Ges. (1886) 123; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 449.

Rhacophorus reinwartii EYDOUX and SOULEYET, in Voy. Bonite, pl. 10, fig. 1.

Rhacophorus rizali BOETTGER, Abh. Ber. Mus. Dresden 7 (1898–99) 1.

Description of species.—(From No. 1410, E. H. Taylor collection; collected in swamp between Gibong and Simulao Rivers, Agusan, Mindanao, P. I., April, 1913, by E. H. Taylor.) Vomerine teeth in two straight, or slightly converging, series, arising from anterior inner edge of the large, oval choanæ, and separated from each other by a distance greater than the length of one group; Eustachian tubes with large visible openings; tongue broad, very deeply notched, with rather long horns behind (male with internal vocal sac, the openings near inner angle of mouth); head distinctly broader than long; eyes rather prominent, interorbital width about one and one-half times the width of upper eyelid; canthus rostralis indistinct, rounded, rather concave between eye and nostril, making snout rather narrower behind nostrils than farther forward; nostrils on tip of snout; distance from nostril to end of snout contained in distance of nostril to eye about four times; lores sloping slightly, not or scarcely concave; snout high; a slight but distinct depression between nostrils and a slightly concave area in forehead; diameter of eye equal to its distance from nostril; tympanum large, distinct, separated from orbit by a distance less than one-half its diameter, and equal to a little more than half diameter of eye; a very slight supratympanic fold; skin above smooth, skin on head not involved in the cranial ossification; skin on belly and on lower aspect of thighs strongly granular; anal region covered with a broad flap of skin, which is free to tip of coccyx; very broad disks on ends of broad flat fingers, diameter of disks of two outer fingers larger than tympanum and more than two-thirds eye; fingers broadly webbed; web between first two digits extends from subarticular tubercle of first to slightly above that of second; web between other fingers extends to base of disks; a large, very hard tubercle at base of first finger, about one-third the length of digit; a distinct skin fold from base of third finger along inner side of arm to its insertion; a very slight fold on outer edge of fourth finger, continued on outer side of forearm; no trace of webs on hind leg; toes webbed to base of disks, which are smaller than those of fingers; fifth toe longer than third; a slight fold along outer side of fifth toe continued to heel; heel with a slight dermal fold; fingers and toes with decided kinks at upper base of disks, and a slight triangular depression on upper part of each disk; tibiotarsal articulation fails slightly to reach nostril.

Color in life.—Above, head and body and sides light reddish to orange brown with slightly darker brown markings; a darker brown band between eyes; entire upper surface speckled and mottled with brilliant orange-yellow spots and blotches, more numerous on shoulders; limbs yellow, with darker distinct broad bands of brown, and on the broader yellow interspaces single narrow brown lines with numerous small brown dots; digits and fingers dusky; a rather distinct brown line from anus to knee on hinder part of thigh; anal flap dusky with numerous small dark brown dots; below anus a large white spot, below which are scattered brown dots; membrane between toes yellowish with dusky markings, most noticeable between outer toes and fingers, usually an orange spot in the middle of the dark area; a dark brown line along the skin fold on outer side of hand and foot; chin, belly, and underside of limbs canary to lemon yellow; chin with a few brown spots outlining edge of mandible; a few dusky spots on sides near groin.

Measurements of Polypedates pardalis (Günther).

	mm.
Length, snout to vent	65
Length of head	23.5
Width of head	25.6
Depth of head, in front of eye	7.2
Diameter of tympanum	5
Diameter of eye	7.3
Length of snout	11
Foreleg	41
Hind leg	106
Width of toe disk	5.5
Tibia	36

Variation.—A male taken at the same time is much smaller, and strikingly different in color. Length, snout to vent, 55 millimeters. The ground color is bright orange yellow with a very narrow, irregular line across the eyes and another, slightly wider and more irregular, across snout in front of eyes; a dim irregular light brown blotch between shoulders and another small group of dark dots on middle of back; entire upper surface with scattered, small, round, brown dots; limbs dotted or with short irregular lines; barring on limbs not or scarcely evident. The webs between toes slightly shorter; that is, the web does not reach the disks, except on outer side of second and third toes. The webs between fingers are also shorter, not reaching the disks on any of the fingers.

A specimen from Luzon shows some slight differences. I append a rather complete description (No. 10, Bureau of Science collection). Vomerine teeth in two short series arising from anterior inner edge of choanæ, not curving, converging but slightly, and widely separated from each other; Eustachian tubes with large visible openings near inner angle of mouth; tongue broad, deeply notched behind; head as broad as long; eyes prominent; deep interorbital region, its width a little greater than the width of one eyelid; canthus indistinct, rounded, not or but very slightly concave between eye and nostril; snout not squarish, but sloping from nostrils to a low slight point; distance of nostril from end of snout contained about twice in distance of nostril to eye; lores sloping greatly, not or but slightly concave; diameter of eye reaches to half the distance between nostril and end of snout; tympanum distinct, scarcely more than half the diameter of eye, partly covered by the distinct skin fold which continues from eye to arm; distance of tympanum from eye equals about one-third its diameter; skin smooth above, skin of head not attached to head bones; sides of neck very slightly granulate; strongly granulate on belly and on underside of thigh; a flap of skin over anus free about halfway to end of coccyx; digits of hand with broad disks; webs between first two fingers up to subarticular tubercle; web of second finger on outer side extends to base of disk, but fails to reach base of disk of third finger; web between third and fourth fingers also fails somewhat to reach disks; first finger shorter than second, which in turn is shorter than fourth; large tubercle on thumb nearly equal to half length of the digit; a slight web from base of third finger along inner side of arm; disks of toes smaller; toes webbed, the web failing to reach disks on inner side of second and on either side of third; dermal fold on fifth toe and on foot very slight; cutaneous appendage on heel prominent; tibiotarsal articulation fails to reach nostril.

Color in alcohol.—Dusky, with a large, dim, irregular brown spot on occiput partly involving the supra- and interocular areas, and another large brownish blotch on posterior part of back; large yellowish white spots on shoulders, and an occasional whitish spot on back, more numerous on sides and in sacral region; limbs dimly barred with dusky, with an occasional whitish spot; white spot below anus; web between last fingers and toes with dusky marks; below without markings.

Measurements of Polypedates pardalis (Günther).

	mm.
Total length, snout to vent	60
Width of head	21
Length of head	22
Diameter of eye	7.2
Diameter of tympanum	3.5
Depth of head, in front of eye	4.8
Foreleg	42.5
Hind leg	95
Diameter of toe disk	4.8
Snout, length	9.8

Remarks.—This specimen differs from the Mindanao specimen by the following characters which appear very slight: Nostril not so near end of snout; snout not so high, lores sloping more; end of snout not so truncate; tympanum nearer eye; eye-to-arm fold more distinct; distance of eye and nostril from mouth less; tympanum somewhat smaller; the webbing of feet and toes agrees with that in the male described from Mindanao save that on one or two fingers the web reaches the disk on one side.

That *Rhacophorus rizali* Boettger is a synonym of this species is scarcely to be doubted.[22] A photograph of the type specimen in Germany is in my collection. It agrees very well with my Mindanao specimens.

The two Mindanao specimens, a male and a female, were copulating when taken. They were found on the side of a tree about 3 meters from the ground, just above a small cavity filled with water. No eggs were found. The two forms were so strikingly different in coloration and size that it seemed two species were at hand. It is certainly a rare species in Agusan Valley. Although remarkably familiar with the fauna and flora of the forests, the natives to whom these specimens were shown had never seen the species.

Polypedates macrotis (Boulenger).

Rhacophorus macrotis BOULENGER, Ann. & Mag. Nat. Hist. VI 7 (1891) 282; VI 14 (1894) 87.

Description of species.—(From Boulenger.) "Vomerine teeth in two oblique groups on a level with the front of the choanæ, which are very large. Head nearly as long as broad; skin adherent to the frontoparietals, which are rugose, studded with granules; snout triangular, a little longer than the diameter of the orbit; canthus rostralis angular; loreal region concave; nostril near the tip of the snout; interorbital space (in the middle) not wider than the upper eyelid, the frontoparietal bones narrowing posteriorly; tympanum very distinct, as large as the eye. Fingers long, with a distinct rudiment of a web; toes nearly entirely webbed; disks of fingers about half the diameter of the eye, of toes smaller; subarticular tubercles moderate; a very small inner metatarsal tubercle. Tibio-tarsal articulation reaching the tip of the snout; tibia half as long as head and body. Skin smooth, granular on belly and under thighs."

Color.—"Grey-brown above, with a few small dark brown spots; loreal region greyish white; a dark brown band from the end of the snout through the nostril, the eye, and the tympanum to

[22] See Zool. Record, Rept. (1897) 30.

the side of the body; on the tympanum this band expands into a large temporal blotch; limbs with ill-defined dark cross bands; hinder side of thighs brown, dotted with white; lower parts whitish speckled with brown.

"From snout to vent 78 millim."

Remarks.—This species was described from a female specimen from Baram, Borneo. It belongs to the group of *Polypedates maculatus*. "It differs from all the species of that group in the larger tympanum, from *R. maculatus* and *R. cruciger* in the absence of a parieto-squamosal arch, and in the larger choanæ, from *R. leucomystax* in the narrower interorbital space and the larger choanæ, and from *R. Colletti* in the shorter hind limbs." (*Boulenger.*)

From the Philippines this species is known only from Palawan, where it was obtained by A. Everett.

Polypedates hecticus Peters.

Polypedates hecticus Peters, Mon. Berl. Ak. (1863) 457.
Rhacophorus hecticus Boulenger, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 78; Boettger, Ber. Senck. Nat. Ges. (1886) 122; Casto de Elera, Cat. Fauna Filipinas 1 (1896) 448; Flower, Proc. Zool. Soc. London (1899) 898 (uncertain).

Description of species.—(From the type description.) Vomerine teeth in two oblique converging series between the choanæ; tongue cordiform; openings of the Eustachian tubes larger than choanæ; head almost one-fifth longer than broad, flat, with protruding eyes; diameter of eyes nearly as great as length of snout; snout projecting, rounded in front of nostrils; frenal region concave; nostril nearer tip of snout than eye; canthus rostralis distinct; tympanum very distinct and large, distinctly longer than high, about two-thirds the diameter of eye; skin on back granulated; a well-defined dorsolateral fold present from eye to end of body; a fold from corner of mouth, below tympanum, to axilla; forearm reaching end of body with longest finger; disks of fingers very large, broadly cordiform in shape, rather pointed anteriorly; a slight web present at base of fingers; first finger shorter than second, with smaller disk; subarticular tubercles well developed; a skin fold on inner side of arm; fifth toe longer than third; toes almost entirely webbed, the membrane not including last two joints of fourth toe; disks similar to those on fingers, but smaller; two metatarsal tubercles; a fold of skin on outer toe; tibiotarsal articulation reaches beyond end of snout; skin granular or tubercular above. Male without vocal sac.

Color.—Above grayish blue, the fold on back white, bordered by black; a white line from tip of snout along upper lip, widening below and in front of tympanum and continuing to insertion of arm; dark spots on temporal region, one in front, one behind tympanum, which sharply defines the light line; pale blue low on sides, with small blackish flecks; limbs brownish with more or less distinct flecks, especially on posterior aspect of thigh; below on body, white.

Measurements of Polypedates hecticus Peters.

	mm.
Total length	51
Length of head	17
Width of head	14
Foreleg	35
Hand, with third finger	17
Hind leg	84
Foot, with fourth toe	37

Remarks.—The type, which appears to be the only specimen recorded from the Philippines, is a full-grown male specimen collected at Loquilocum, Samar, by F. Jagor.

Flower has reported a frog which appears to be a specimen of this species, from Malay Peninsula, but expresses a doubt as to whether it is correctly classified.

Polypedates everetti (Boulenger).

Racophorus everetti BOULENGER, Ann. & Mag. Nat. Hist. VI 14 (1894) 87.

Description of species.—(From Boulenger.) "Vomerine teeth in two oblique groups between the moderately large choanæ. Head slightly broader than long, without dermal ossification. Snout rounded, shorter than the diameter of the orbit; canthus rostralis obtuse, curved; loreal region concave, very oblique; nostrils near the end of the snout; interorbital space as broad as the upper eyelid; tympanum distinct, two fifths the diameter of the eye. Fingers with a slight rudiment of web; disks moderate, nearly as large as the tympanum; toes three-fourths webbed; inner metatarsal tubercle very small; no tarsal fold. Tibio-tarsal articulation reaching a little beyond the tip of the snout. Skin finely granulate above, coarsely beneath; small conical tubercles below the vent, at the heel, and along the outer edge of the forearm and tarsus. Pale yellowish or reddish brown above, with dark brown markings; the most conspicuous of these are a cross band between the eyes and a symmetrical marking on the præsacral part of the back, roughly representing a frog with the four limbs stretched out; limbs with dark cross bands; lower parts uniform white.

"From snout to vent 32 millim."

Remarks.—This rare species is known from two specimens collected by A. Everett in Palawan.

Polypedates leucomystax (Gravenhorst). Plate 2, fig. 4.

Hyla leucomystax GRAVENHORST, Delic. Mus. Vratislav. (1829) 26.
Hyla sexvirgata GRAVENHORST, Delic. Mus. Vratislav. (1829) 28.
Hyla quadrilineata WIEGMANN, Nova Acta Acad. Leop.-Carol. 17 (1835) 260, pl. 22, fig. 1.
Polypedates leucomystax TSCHUDI, Class. Batr. (1838) 75; DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 520; KELAART, Prodr. Faun. Zeyl. (1852), 193; STEJNEGER, Bull. U. S. Nat. Mus. 58 (1907) 157.
Polypedates rugosus DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 520.
Polypedates quadrilineatus GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 79.
Polypedates megacephalus HALLOWELL, Proc. Acad. Nat. Sci. Philadelphia (1860) 507.
Rhacophorus maculatus BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 83; var. *quadrilineata*, 84; Proc. Zool. Soc. London (1889) 30.
Polypedates maculatus GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 78; Rept. Brit. India (1864) 428; BLANFORD, Journ. As. Soc. Bengal (1870) 376; ANDERSON, Proc. Zool. Soc. London (1871) 307; STOLICZKA, Proc. As. Soc. Bengal (1872) 106.
Polypedates biscutiger PETERS, Mon. Berl. Ak. (1871) 644.
Hylorana longipes FISCHER, Archiv. Naturg. 51 (1885) 47.
Rhacophorus leucomystax var. *sexvirgata* BOULENGER, Proc. Zool. Soc. London (1889) 30.

Description of species.—(From No. 686, E. H. Taylor collection; collected at Bunawan, Agusan, Mindanao, P. I., June 24, 1913, by E. H. Taylor.) Vomerine teeth in two slender diagonal series, beginning at some distance from anterior inner edge of choanæ, and separated from each other by a distance equal to their distance from choanæ; distance between Eustachian tubes equals their distance from nostrils; distance between choanæ much greater than distance between nostrils, equaling distance from eye to nostril; head a little longer than broad; interorbital area and a large area on snout depressed; canthus rostralis roundly angular, nostrils lateral, below level of choanæ; diameter of eye equal to its distance from nostril; nostril two and one-half times as far from eye as from tip of snout; tympanum large, its greatest diameter slightly less than diameter of eye, separated from the latter by a distance less than one-third its diameter; interorbital distance one and one-half times upper eyelid; latter equal to distance between nostrils; skin of body above minutely granular and apparently smooth in patches; skin of head, save a small area in frontal region, involved in cranial ossification; sides wrinkled and granular; throat and breast nearly smooth; belly very strongly granular, part of femur less so; a strong glandular fold from eye, curving above tympanum, then running backward and slightly downward some distance on side; this does not reach below the middle level of tympanum; fingers broad, all except first with large disks, that on first finger small; each digit with a deep groove around edge and a slight groove across face of disk; a very strong kink at base of disk; a rudiment of web at base of fingers very distinct; a distinct skin fold from base of third finger, continued above along inner arm; subarticular tubercles of hand very strong; first finger a little shorter than second; fourth finger reaching more than halfway on disk of third; a slight fold on outer side of fourth finger and outer side of forearm; toes from one-half to two-thirds webbed, membrane not reaching base of disks; disks smaller than finger disks; subarticular tubercles rather distinct; a blunt inner metatarsal tubercle and a very obscure outer; a very dim fold on outer side of fifth toe and tarsus; tibiotarsal articulation reaching slightly beyond tip of snout.

Color in life.—Above olive brown, with four darker brown, broken, irregularly widened stripes, two beginning on tip of snout and two on the eyelids; loreal region dark brown, lighter on lip; a broad dark stripe beginning behind tympanum and continuing some distance on side; legs barred with darker brown; posterior aspect of thigh brown, dotted with yellow; below yellow-cream; throat with dusky brown flecks; posterior part with canary yellow wash; sides brown, reticulated with yellow-cream; palms and soles purplish.

Measurements of Polypedates leucomystax (Gravenhorst).

	mm.
Length, snout to vent	81
Length of snout	13
Length of head	32
Width of head	29
Diameter of eye	8.5
Diameter of tympanum	7.5
Eye to nostril	9
Interorbital distance	10.5
Foreleg	51
Longest finger	23
Hind leg	148
Femur	41
Tibia	43.5
Foot	51.5
Longest toe	36
Finger disk	4.7
Toe disk	3.5

Variation.—The large synonymy is evidence of a great amount of variation in this species. In Philippine specimens the color and markings vary greatly; but relative measurements and proportions are rather constant, save in the case of the tympanum, which varies from one-half to nearly full size of the eye.

The markings are usually in four to six longitudinal lines, as described above (*Polypedates quadrilineatus*), or broken into numerous spots which do not conform to the outline of this design (*P. maculatus*) ; spots may be numerous or few, sometimes almost wanting. The ground color varies from very light yellow or whitish to dark purplish brown; sometimes (in life) almost black, with no markings visible. One of my specimens, taken in Mindanao, was bright lemon yellow over the entire body when first captured, with no markings. After being kept some time the yellow became grayish, and dim longitudinal stripes appeared.

Wiegman had a Manila specimen collected by Meyer for the type of his *Hyla quadrilineata.* One of the types of *Polypedates rugosus* Duméril and Bibron was from Manila.

It is significant that the *Polypedates maculatus* form is rarely, if ever, found in Mindanao; in a collection of more than fifty specimens from Bunawan not one occurs. On the other hand, Manila specimens are largely of that type.

Tadpoles.—Mandibles broadly edged with black, the upper forming a strongly arched, curved series, the lower a strongly V-shaped series; lower edge of lip with numerous papillæ; upper labial extension with four series of mandibular teeth, the first uninterrupted, the second barely interrupted medially, the other two series very short, separated by mouth; lower labial extension with three uninterrupted series.

Color.—Yellowish brown to olive brown above, with black spot on nose and nostrils; a bright yellow spot on point of snout, purplish on throat, lighter on belly; tail olive, the crests colorless.

It will be noted that these specimens differ from Flower's description, in that in the form described above there are only four instead of five series of small teeth on upper lip, and that the three series on lower lip are uninterrupted. Flower [23] also mentions a variation in a Singapore specimen. It may be possible to differentiate the various races or subspecies of *Polypedates leucomystax* by the characters of the tadpoles.

Remarks.—The species occurs over the entire Archipelago; it has been reported from many localities in Luzon, and from

[23] Proc. Zool. Soc. London (1899) 899.

Mindoro, Samar, Leyte, Negros, the Calamianes, Mindanao, and Palawan. I failed to get specimens in the Sulu Archipelago; but it very probably occurs there as I found specimens in Zamboanga, and in Borneo on the coast nearest the southern end of the Sulu Archipelago.

There appears to be no definite breeding season for the species. In Baguio, northern Luzon, I found floating masses of fertile eggs in December and May. In Manila I have found them in June and July. In Mindanao a number of egg masses were collected from branches above pools of water in September. One mass taken contained seven hundred eighty-six eggs.

Polypedates surdus Peters.

Polypedates surdus PETERS, Mon. Berl. Ak. (1863) 459.
Rhacophorus surdus BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 79; BOETTGER, Ber. Senck. Nat. Ges. (1886) 122; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 449.

Description of species.—Vomerine teeth in two short oblique series, beginning on inner edge of choanæ and lying between and behind them; tongue cordiform, very deeply notched behind; choanæ smaller by almost one-half than openings of Eustachian tubes. Head as broad as long; distance between anterior corners of eyes equal to their distance from point of snout; canthus rostralis distinct; distance between nostrils equal to their distance from eye; nostrils nearer end of snout than eye; loreal region concave; tympanum entirely covered, but its outline more or less visible, the diameter equaling about half the eye; diameter of eye shorter than snout; foreleg reaches almost to back end of body; fingers with rudiments of a web; finger disks large, rounded, that on first finger small; first finger shorter than second, fourth longer than first or second; subarticular tubercles and carpal tubercles large; tibiotarsal articulation reaches tip of snout; toes a little more than half webbed, last two joints of fourth and last joints of the others free; disks of toes larger than those of fingers; fifth toe very little longer than third; subarticular tubercles and the two metatarsal tubercles well developed; skin with a few small tubercles above; below, entire surface granular.

Color.—Above dark brown; a small stripe on point of snout and a larger one on lip in front of eye; a greenish white stripe from eye to axilla; sides of body whitish, marbled with brown; below brownish, throat speckled with yellowish; legs with brown bars; posterior aspect of thigh marbled with brown.

Measurements of Polypedates surdus Peters.

	mm.
Length, snout to vent	26
Length of head	10
Width of head	10.5
Foreleg	19.5
Length of hand, with third finger	9
Hind leg	43
Foot and fourth toe	19.5

Remarks.—The species was discovered in Luzon by F. Jagor. It appears to have been founded on a single specimen, and I believe it has not been rediscovered in the Islands.

Genus HAZELIA novum

Upper jaw with teeth; no vomerine teeth; head with well-defined bony ridges; a low supratemporal ridge; tympanum distinct; no ridges across palate in front of œsophagus; fingers unwebbed, with large disks; a distinct kink above disk, caused by a bone intercalated between last two phalanges; terminal phalanges bifurcate; body covered with spiny tubercles; toes partly webbed; pupil horizontal. This genus is named for my wife, Hazel Clark Taylor, who has assisted me greatly in making collections and in the preparation of this work.

Type, *Hazelia spinosa* sp. nov.

This genus combines certain characters of *Philautus* and *Polypedates;* it has the intercalated bone between the last two phalanges on each digit; the vomerine teeth are wanting as in *Philautus* (rarely wanting in *Polypedates*) ; the terminal phalanges are bifurcate, shaped something between a Y and a T; the bony crests on head are not unlike those found in certain species of *Bufo.*

Hazelia spinosa sp. nov. Plate 7, fig. 1.

Type.—No. 406, E. H. Taylor collection; collected at Bunawan, Agusan, Mindanao, P. I., August, 1912, by E. H. Taylor.

Description of type.—No vomerine teeth present; choanæ large, elongate, lying somewhat back under edge of jaw, but plainly visible; tongue elongate, divided behind, with two small rounded "horns;" no papilla present; head longer than wide; snout rather truncate, high, sloping downward and backward toward mouth, upper part extending farther forward than mouth; snout with distinct, prominent canthus rostralis; rather concave between eye and nostril; snout slightly narrower behind nostrils than elsewhere; loreal region rather concave, lores rather vertical on upper part, then sloping to mouth; nostrils very near tip of snout, distance of nostril from tip contained in distance to eye four or five times; eye large, its diameter about equal to its distance from nostril; tympanum very distinct, lying very close to eye, its diameter about four-fifths that of eye; two bony ridges form continuations of the canthi, beginning in front of eye and continuing on either side of interorbital region to occiput; distance between ridges greatest anterior to eye; interorbital region depressed, its width about one and one-half to one and two-thirds times as great as upper eyelid; a slight ridge above tympanum; temporal region slightly concave; fingers unwebbed, with distinct, transversely widened disks; each disk with a distinct groove around outer edge, continuous with a transverse groove crossing near middle of disk below; a decided kink between last two phalanges; first finger shorter than second, which in turn is much shorter than fourth; fourth finger reaches base of disk of third; toes about one-third to one-half webbed, the membrane reaching subarticular tubercle of first and second toes, and a little higher on third; third and fifth toes of unequal length; disks of toes smaller than those of fingers; subarticular tubercles well developed; a prominent inner, and a small outer, metatarsal tubercle; tibiotarsal articulation reaching slightly beyond tip of snout, when carried forward; skin above covered with hard, spiny granules and tubercles, giving a very spiny appearance; skin of anterior part of head grown solidly to skull and bony ridges; tubercles are present on upper surface of limbs and fingers, on side of head, and even under digits; eyelids extremely rugose; chin with minute tubercles; belly granulate; inner aspect of thighs and tibia smooth.

Color in life.—Above brownish, darker on anterior part of head, with scattered lemon yellow to orange spots; two prominent darker-edged interscapular orange spots above and slightly behind tympanum; smaller yellow spots in superciliary region, along lip and canthus rostralis, below tympanum and along both sides of back; one small prominent spot on tip of snout; limbs above brownish; reddish orange on anterior and posterior aspects of arms and legs, with two yellow darker-edged spots on arms, and larger, rather regularly disposed yellow spots on legs; belly, sides, and undersides of limbs orange yellow; fingers and toes with yellow spots.

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Measurements of Hazelia spinosa sp. nov.

	mm.
Total length, snout to vent	41
Width of head	13
Length of head	16
Diameter of eye	5.2
Diameter of tympanum	4
Foreleg	26
Longest finger	13
Hind leg from vent	67.5
Femur	21
Tibia	22
Foot and heel	26
Longest toe	15

Variation.—The specimen here described was collected in Bunawan, Agusan, Mindanao, in 1912. In 1917 I discovered the species in Basilan, at a point on the west coast directly opposite the small island of Great Govenen. Most of the specimens taken were darker than the Agusan specimen, their bellies were orange, with numerous rather large yellowish white spots on sides of the belly and chin. The number and prominence of the dorsal yellow spots vary, some specimens having very few spots on head and legs; the spiny granules on heels and below anus are yellowish. In the type the third toe is distinctly longer than the fifth; in Basilan specimens they are equal or nearly so, and the distance from nostril to tip of snout is less.

Tadpoles.—A few tadpoles of this species were taken with the adults; also an immature specimen, which had just completed its transformation.

Description of tadpole.—Length, with hind legs, 6.5 millimeters; body nearly one and a half times as long as broad, but much shorter than tail; depth of tail in tail length more than four times; nostrils much nearer end of snout than eye; eyes on upper surface of body; distance between them equal to their distance from nostrils; a deep trough-shaped groove between and behind eyes, continued forward as a narrow linear groove to end of snout; in front of eyes, and somewhat below, are two large rounded pouches; mouth narrow; inside the mouth, and almost concealed, are two series of teeth which are a deep dark brown; the upper is curved with only a very small angle; the lower series rather V-shaped; these teeth plates seemed to be wanting in older specimens of the tadpoles. The specimens are in a rather indifferent state of preservation, and I am unable to determine the character of the upper and lower labial teeth.

Color in life.—Dark brown to black; belly rather lighter; older specimens have minute yellow spots, and by the time the anterior limbs have sprouted, the shoulder spots are evident.

Remarks.—The adults and tadpoles from Basilan were taken in a small hole filled with water and rotting leaves in a tree trunk about one-half meter from the ground. No specimens had been observed, but when the hole was emptied the adults and tadpoles were taken from the bottom. The adults are very active and jump with great rapidity; it is probable that their apparent rarity is due to the fact that for the most part they are arboreal; they feed largely on ants. It is noteworthy that among the leaves and trash found in the water there were great numbers of aquatic ants. In the character of the finger disks this species resembles *Polypedates.* None of the specimens appears to have vocal sacs.

The species is known only from Bunawan, Agusan, Mindanao, and Basilan, in the Philippines.

Genus PHILAUTUS Gistel

Philautus GISTEL, Naturg. Thierr. 10 (1848); STEJNEGER, Proc. U. S. Nat. Mus. 28 (1905) 346;[24] BARBOUR, Mem. Mus. Comp. Zool. Harvard Coll. 44 (1912) 69.
Ixalus DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 523; GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 74; COPE, Nat. Hist. Rev. (1865) 116; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 93.
Orchestes TSCHUDI, Class. Batr. (1838) 76.
Leptomantis PETERS, Mon. Berl. Ak. (1867) 32.

"Pupil horizontal. Tongue free and deeply notched behind. Vomerine teeth none. Tympanum distinct or hidden. Fingers free or webbed at the base; toes webbed; tips of fingers and toes dilated into regular disks. Outer metatarsals separated by a groove or narrow web. Omosternum and sternum with a bony style. Terminal phalanges obtuse." (*Boulenger.*)

Remarks.—This genus is closely related to *Polypedates* Tschudi and *Staurois* Cope. External differences between the species of the genera are indeed meager, as certain *Polypedates* have no vomerine teeth and these are also wanting in *Staurois.* The Philippines are rich in species of this genus, no less than seven having been described heretofore, and two new ones are included in this catalogue, both quite clearly differentiated from other known forms.

[24] Stejneger has shown that this name must take precedence over *Ixalus* Duméril and Bibron, which is preoccupied by *Ixalus* Ogilby, 1836, for a genus of mammals.

Key to the Philippine species of Philautus Gistel.

a^1. Fingers free; first finger shorter than second, not opposed to others.
- b^1. Toes webbed at base.
  - c^1. Heel reaches beyond tip of snout; snout with conical projection; tympanum dim, less than one-half eye; interorbital space wider than eyelid; skin shagreened above; 29 mm; Mindanao. P. woodi Stejneger.
  - c^2. Heel reaches eye; snout rounded; tympanum dim, about one-third of eye; interorbital space equals upper eyelid; tubercle on eyelid and heel; skin entirely smooth above; male with vocal sacs; 34 mm; Canlaon Volcano, Negros.......... P. hazelæ sp. nov.
- b^2. Toes one-third webbed.
  - c^1. Heel reaches beyond tip of snout; tympanum hidden; skin shagreened above; interorbital space broader than eyelid; 20 mm; Leyte .... P. leitensis (Boulenger).
  - c^2. Heel reaches nostril or tip of snout; skin smooth above; tympanum distinct, one-third to two-fifths eye; 29 mm; Mount Dulangan, Mindoro .... P. mindorensis (Boulenger).
- b^3. Toes one-half webbed. Heel reaches far beyond tip of snout.
  - c^1. Two converging ridges on shoulders; skin rough; tympanum distinct, equaling two-fifths eye; interorbital space wider than eyelid; male with vocal sac; 21 mm; Palawan. P. longicrus (Boulenger).
  - c^2. No converging ridges; skin smooth; tympanum one-fourth size of eye; 18 mm; Mindoro.......... P. schmackeri (Boettger).
- b^4. Toes nearly entirely webbed; snout pointed; tympanum small, covered with skin; skin smooth, with granules on back and eyelid; 22 mm; eastern Mindanao.......... P. acutirostris (Peters).

a^2. Fingers partially webbed; first finger shorter than second and opposed to third and fourth.
- b^1. Fingers one-third to one-half webbed; first opposite rest; toes nearly entirely webbed; tympanum one-third eye, covered with skin; male with vocal sac; 34 mm; Agusan River, Mindanao. P. bimaculatus (Peters).
- b^2. Fingers not more than one-fifth webbed; first two opposite third and fourth; toes two-thirds webbed; tympanum distinct, about three-fifths eye; skin smooth; 39 mm; Bongao, Sulu Archipelago. P. montanus sp. nov.

Philautus woodi Stejneger.

Philautus woodi STEJNEGER, Proc. U. S. Nat. Mus. 28 (1905) 346.

Description of species.—(From Stejneger.) "Snout longer than diameter of eye, with a pointed conical projection forming a distinct 'nose'; nostrils located nearer the tip of the snout than the eye; canthus rostralis sharp; lores very concave, the concavity continued forward beyond the nostrils; interorbital space wider than upper eyelid; tympanum scarcely distinguishable, apparently not larger than half the diameter of the eye; fingers free, first considerably shorter than second, which is to the same extent shorter than fourth; disks of fingers rounded, large, especially those of third and fourth fingers; toes webbed at base only; disks well developed, about the size of those of second finger; subarticular tubercles well developed; a small oval inner metatarsal tubercle, no outer; no tarsal fold; hind legs being carried forward along the body, the tibio-tarsal articulation reaches a considerable distance beyond the tip of the snout; skin finely shagreened above, coarsely granular on the entire lower surface, including the throat, underside of limbs, and even hands and feet; a strong glandular fold from eye to shoulder; no dorsolateral fold."

Color.—(In formalin and transferred to alcohol.) "Above dark chocolate brown, with a hair fine pale line from tip of snout along the entire middle line of the body; snout from tip to a line across the middle of upper eyelids pale cinnamon in strong contrast; a large dusky mark behind this pale area on the interorbital space and involving the upper eyelids, though visible only with difficulty on account of the dark color of the rest of the upper surface; whole loreal and temporal area dark brown, apparently a shade darker than the back; flanks, anterior and posterior aspects of the thighs, underside of tibia and foot with a strong suffusion of a deep saturated burnt sienna; underside whitish with a number of irregular spots or patches of brown; a few irregular white spots on the sides of the body."

Measurements of Philautus woodi Stejneger.

	mm.
Total length, from tip of snout to vent	29
Width of head	12.5
Foreleg	19
Hind leg, from vent to tip of longest toe	55

Remarks.—Stejneger records variations in a second specimen as follows: "The entire dorsal surface is of the same color as the prefrontal area, so that the sides are marked by a very broad dark brown band from the nostrils backward. The transverse dark frontal band consequently also stands out in strong contrast." It is presumably most closely related to *Philautus leitensis* from Leyte. It differs in the long acuminate and projecting snout, and the lesser extent of the webbing of the toes. The color is different. The types were collected on Mount Apo, Davao, Mindanao, at an elevation of nearly 2,000 meters, by E. A. Mearns, June 20, 1904. They are at present in the United States National Museum. The species has not been rediscovered.

Philautus hazelæ sp. nov. Plate 3, fig. 2.

Type.—No. F293, E. H. Taylor collection; collected at an elevation of about 1,000 meters, on Canlaon Volcano, central northern Negros, P. I., December 25, 1916, by E. H. Taylor.

Description of type.—Vomerine teeth wanting; choanæ very small, near outer edge of the palate; tongue oval, the anterior part forming a rounded moundlike prominence, notched behind, forming two distinctly rounded horns, widely separated at base; head short, neither snout nor occipital region concave; canthus rostralis distinct, rather angular; loreal region concave, sloping obliquely to mouth; eye large, pupil horizontal, diameter of eye slightly less than distance from eye to end of snout; nostril much nearer end of snout than eye; distance between nostrils equals their distance from eye; interorbital space about equals width of upper eyelid; tympanum, one-third to two-fifths the diameter of eye; skin of body, above, smooth, shiny; sides, belly, and underpart of thighs strongly granular; chin and underpart of arms smooth; a single, distinct rounded tubercle on posterior part of eyelid; a supratemporal fold from eye to arm; a short glandular fold behind and below tympanum, at angle of mouth, and another short fold above and in front of arm; a very prominent tubercle at end of tibia, with several smaller tubercles about it; fingers quite free with large transversely oval pads, much larger than tympanum; first finger only about two-thirds second, its disk very small but a little larger than the subarticular tubercles; second finger shorter than fourth; disk of fourth barely reaches base of disk of third; subarticular tubercles well developed, tubercles on palm not well defined; toes with a trace of web; toes with disks of unequal size; disk on fourth toe largest, but not equal to size of largest finger disk; an elongate tubercle on inner metatarsus, more than half the length of first toe; a very dim outer metatarsal tubercle; fifth toe longer than third; tibiotarsal articulation when brought forward reaches eye or a little beyond; each disk with a distinct groove around edge. Males with internal vocal sacs.

Color in life.—Above dark brown with a large, more or less regular, slate-black mark on back; head with a triangular spot on interorbital region; two elongate curving stripes on back; legs and digits barred with brown; belly bright canary yellow, mottled, reticulated, and spotted with brown; posterior part of belly and underpart of limbs and sides brown, with minute yellow punctations; labial region above with darker marks, below bordered by a rim of small irregular cream dots; groin with larger blotches of yellow.

Measurements of Philautus hazelæ sp. nov.

	mm.
Length, snout to vent	34
Length of head	13
Width of head	14
Length of snout, from eye	5
Depth of snout, in front of eye	4.8
Diameter of eye	4.9
Diameter of tympanum	1.7
Diameter of largest finger disk	2.2
Foreleg	21.5
Longest finger, from wrist	11.1
Hind leg	53.5
Femur	17
Tibia	17
Longest toe, from metatarsal tubercle	16.8

Variation.—Color variations are very marked; practically no two specimens in my collection can be found alike. Several resemble the type in color and markings. No. F290 is gray, darker on loreal region, with a dim stripe on interorbital region; very dim, darker bars on limbs; belly grayish, with minute spots or reticulations of yellow; groin with yellow spots. Nos. F287, F297, F299, and F301 resemble No. F290 in general details. No. F296 is dark black-brown above, with an orange stripe from tip of snout to anus; below dusky brown, yellowish in groin. No. F291 is of a uniform pinkish drab color, with a few scattered black spots; irregular black stripes on both sides, strongly contrasted with the back color; yellowish below, with dusky markings; yellow spots in groin. No. F285 has the ground color gray, with a broad black band across head behind eyes, and a narrow one in front of eyes; a third shorter transverse stripe on shoulders, and another in the middle of the back, front limb strongly barred, hind limb dimly barred; groin with distinct yellow spots.

Although the type does not show them, many of the specimens have two small, rounded, distinct tubercles on shoulders, separated by a distance a little greater than the interorbital distance; occasionally a second pair is visible in the posterior third of back, more widely separated than the anterior pair; the tubercles on eyelid and on heel are constant. Most of the specimens have a small glandular swelling on the tip of the lower jaw. Some have the chin smooth; others granular, but with granules smaller than those of belly and thigh. In numerous specimens there are faint raised rugosities in the place where the vomerine teeth usually appear, which in one or two cases have the appearance of slight series of vomerine teeth. This again emphasizes the fact that the vomerine teeth are not in themselves a generic character, and in many cases they cannot be relied upon even as a specific character.

A specimen recently captured in Culasi, Antique Province, Panay, in the mossy forest at 1,000 meters, by R. C. McGregor, is worthy of note; the eye has more than one tubercle, and the two pairs of tubercles on the back are quite distinct. In size it is much smaller than any specimen from Canlaon, measuring only about 15 milimeters from snout to vent. The color above is gray, with an interorbital band, with a small transverse black spot on shoulders, and a larger irregular spot in the middle of the back; on the sides of the head and low on the sides of the body are numerous black spots or reticulations; the arm is light with strong bars across hand and digits; hind leg and foot lightly barred with darker; yellowish spots in groin. There is no evidence of vomerine teeth. The swelling on the tongue appears to be wanting; the tubercle on heel and the swelling on the tip of lower jaw are present. Although apparently a very immature specimen, I have no hesitancy in referring it to this species.

Remarks.—This species abounds on Canlaon Volcano. It appears to breed in the axils of a particular species of wild abacá, in which habitat all the specimens were found. The axils appear always to be filled with water; no tadpoles were taken, but some very young specimens were found. All were captured in December. The color markings apear to have no fixed pattern, great variation in color and markings being encountered. The yellow spots in the groin are usually present. The skin on the head and back is very shiny and smooth. The specimen described appears to be a full-grown female.

The characters which clearly distinguish this species from other Philippine species of this genus are the much shorter limbs; the small tympanum; the smooth, shiny skin; the supraorbital tubercle and the tubercle on heel; the very small first finger. Many other, less obvious characters are evident on a comparison of descriptions. The variation in markings and colorations in this species leads me to regard markings in this group as of little value in determining species. The webbing of fingers and toes seems to place this species near to *Philautus woodi* Stejneger from Mount Apo, Mindanao.

Known from Negros and Panay.

Philautus leitensis (Boulenger.) Plate 1, fig. 3.

Ixalus leitensis BOULENGER, Ann. & Mag. Nat. Hist. VI 19 (1897) 107.

Description of species.—(From No. B38, Bureau of Science collection; collected on Biliran Island, May, 1914, by R. C. McGregor.) Snout subacuminate, not projecting; head as broad as long; canthus rostralis distinct, loreal region somewhat concave, sloping rather than vertical; eye large, diameter of orbit minutely less than length of snout; tympanum partially outlined, covered with skin, very close to eye; nostril somewhat nearer tip of snout than eye; interorbital region distinctly wider than upper eyelid; a strong fold from eye to insertion of arm; skin finely shagreened above on head, back, and sides; belly strongly granular; granules large, mosaiclike; chin and throat smooth; fingers free, with large disks, first very small and slender, second shorter than fourth; a row of blunt tubercles on outer side of anterior part of arm; subarticular tubercles well developed; hind leg long; tibiotarsal articulation reaching slightly beyond tip of snout; toes about one-third webbed, third toe extending minutely farther than fifth; disks well developed; subarticular tubercles large; sole granular; a strong inner metatarsal tubercle; a row of indistinct tubercles along outer side of foot and heel; a rather prominent tubercle on end of tibia.

Color in formalin.—Above very light yellow-brown, with scattered dark brown spots, or groups of dots; a spot between eyes, one behind occipital region, one on either side of middle of back; a large spot in groin continuing on anterior part of thigh; posterior side of femur, tibia, and underside of tarsus brown; limbs dimly barred or spotted with brown above; belly immaculate cream.

Measurements of Philautus leitensis (Boulenger).

	mm.
Snout to vent	26
Length of head	11.5
Width of head	11.3
Length of snout, from eye	6
Depth of snout, in front of eye	3.8
Diameter of eye	5.2
Largest finger disk	2
Foreleg	18.5
Hind leg	45.
Femur	13.5
Tibia	15
Longest toe, from metatarsal tubercle	10

Remarks.—This specimen appears to be the second one known. The type was discovered in Leyte by John Whitehead and was presented to the British Museum.

Philautus schmackeri (Boettger.)

Ixalus schmackeri BOETTGER, Kat. Bat.-Samml. Mus. Senck. Nat. Ges. (1892).

Description of species.—Tongue pear-shaped, deeply notched behind, without papilla; head large, broader than back; snout sharply pointed, a little longer than diameter of eye; canthus angular, loreal region slightly depressed; nostril much nearer end of snout than eye; interorbital distance broader than an eyelid; tympanum distinct, about one-fourth the size of eye; fingers without web, first shorter and much slighter than second, third especially long and well developed; toes half webbed; toes with well-developed disks distinctly larger than tympanum; subarticular tubercles well developed; a slight inner metatarsal tubercle, tibiotarsal articulation reaching much beyond tip of snout; skin above smooth; below granulated; a light curved skin fold over eye to shoulder.

Color.—Above dark olive brown; a greenish white line from point of snout above nostrils, across edges of eyelids, over tympanum to side of body, there spreading as a large rhomboidal spot of lighter color; in middle of back the dark brown color of the back takes the shape of an hourglass; a large bright yellowish white spot on knee and elbow; legs above banded with darker brown; edges of lips dark brown with pure white spots; entire underside of body marbled with brown; neck brown, with light dots and a band across belly spotted and marbled with black.

Measurements of Philautus schmackeri (Boettger).

	mm.
Total length of body	18.5
Length of head	8.5
Width of head	8
Diameter of eye	3.25
Tympanum	.75
Foreleg	10
Hind leg	37
Femur	12.5
Tibia	13
Disk of fourth toe	1

Remarks.—The type specimen was collected on Mount Halcon, Mindoro. The name of the collector appears to be unknown.

The type was presented to the Senckenberg Museum by B. Schmacker, of Shanghai, in 1889. It is for him that the species was named. The species according to its author is characterized by the very long hind limbs and the very distinctive color and markings. The above description is taken from the type description.

Philautus mindorensis (Boulenger).

Ixalus mindorensis BOULENGER, Ann. & Mag. Nat. Hist. VI 19 (1897) 107.

Description of species.—(From Boulenger.) "Snout subacuminate, not projecting, as long as the diameter of the orbit; canthus rostralis distinct; loreal region concave; nostril slightly nearer the tip of the snout than the eye; interorbital space broader than the upper eyelid; tympanum distinct, one third to two fifths the diameter of the eye. Fingers free; toes one third webbed; disks as large as or a little smaller than the tympanum; a small inner metatarsal tubercle. Tibio-tarsal articulation reaching the nostril or the tip of the snout. Skin smooth above; throat and belly granulate."

Color.—"Grey above, sides paler, sometimes with a dark brown lumbar streak; temples, and sometimes the lores, dark brown; a white streak along the upper lip, or an oblique white streak below the eye; limbs with more or less distinct dark cross-bands; lower parts white, uniform or spotted or marbled with brown.

"From snout to vent 29 millim."

Remarks.—Several specimens from Mindoro (Mount Dulangan, 5,000 feet) are in the British Museum, collected by John Whitehead. I have seen no specimen of this species.

Philautus longicrus (Boulenger).

Ixalus longicrus BOULENGER, Ann. & Mag. Nat. Hist. VI 14 (1894) 88.

Description of species.—(From Boulenger.) "Snout pointed, as long as the diameter of the orbit; canthus rostralis angular; loreal region concave; nostril nearer the end of the snout than the eye; interorbital space broader than the upper eyelid; tympanum distinct, about two fifths the diameter of the eye. Fingers free, disks a little smaller than the tympanum; toes half-webbed. Tibio-tarsal articulation reaching far beyond the tip of the snout; femero-tibial articulation reaching the shoulder. Above rough with small warts; two oblique glandular ridges.

converging behind, between the shoulder[s]; throat smooth; belly and lower surface of thighs granulate."

Color.—"Grey above, with a large X-shaped dark marking or a pair of)(-shaped bands on the back, a dark cross band or triangular blotch between the eyes, and regular cross bands on the limbs; a black light-edged spot on the knee; a streak below the canthus rostralis, a bar below the eye, and the whole temporal region blackish; dirty white beneath, throat finely speckled with brown; a series of small round white spots on the lower lip. Male with internal vocal sacs.

"From snout to vent 21 millim."

Remarks.—According to Boulenger the species is most closely related to *Philautus schmackeri* (Boettger). Three specimens were collected in Palawan by A. Everett.

I observed a specimen, which probably belonged to this species, in a mass of small plants just above a high waterfall in northern Palawan. I succeeded in getting the specimen but slipped while doing so. The ensuing fall liberated the specimen, which escaped by leaping over the waterfall.

Philautus acutirostris (Peters).

Ixalus acutirostris PETERS, Mon. Berl. Ak. (1867) 32; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 99; BOETTGER, Ber. Senck. Nat. Ges. (1886) 123; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 449.

Description of species.—(After Peters.) Snout pointed, canthus rostralis distinct; nostrils as far from each other as from end of snout; distance between nostrils contained in their distance from eye twice; tympanum very small, partly covered by skin; small granules upon the smooth skin of body as well as on eyelid; back part of the thigh and belly densely granulated; web on feet goes to the base of last joint on third and fifth toes.

Color.—Brown, and on the sides gray; small white dots present. Between the eyes an indistinct, brown, triangular spot, with a distinct spot near its posterior border; anterior and posterior side of thigh brown; below yellowish white.

Measurements of Philautus acutirostris (Peters).

	mm.
Total length	22
Foreleg	15
Hind leg	40

Remarks.—This species is known from two specimens, collected by Carl Semper in Mindanao.

Philautus bimaculatus (Peters).

Leptomantis bimaculatus PETERS, Mon. Ber. Ak. (1867) 32.
Ixalus ? bimaculatus BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 106.

Description of species.—(After Peters.) Male with vocal sac, the openings small, not far from corner of mouth; tongue forked behind; snout scarcely longer than diameter of eye, with a distinct canthus rostralis, truncate in front; nostrils lateral, lying somewhat behind angle formed by the canthus rostralis and anterior end of snout; distance between nostrils is almost equal to their distance from eyes; tympanum small, the diameter about one-third diameter of eyes, and covered with skin; eyes very large, with pupil horizontal; body skin smooth; submental region with large granules; abdomen finely granulate; disks of fingers round, larger than toe disks; first finger placed opposite to the others, thickest at its base; second and third fingers one-third webbed; third and fourth half webbed; toes almost wholly webbed, reaching two-thirds of the distance on last joint of fourth toe; sole of foot smooth, a small projection covered with skin at its base; the insertion of sacral joint small.

Color.—Above violet-brown with unequal dark spots and transverse bands; a band between eyes; joints of limbs with darker transverse bands; under eye a characteristic, broadened, sharply truncate, yellowish white spot; a second, much smaller, immediately behind and under corner of mouth; below yellowish white.

Measurements of Philautus bimaculatus (Peters).

	mm.
Total length	34
Head length	12
Foreleg	25
Hind leg	62

Remarks.—Two specimens, the types, from the upper Agusan Valley, Mindanao, are known.

Philautus montanus sp. nov. Plate 3, fig. 5.

Type.—No. 29, Bureau of Science collection; collected on Mount Bongao, Bongao, near south end of Tawitawi, at an elevation of about 700 meters, by E. H. Taylor.

Description of type.—Vomerine teeth wanting; choanæ large, prominent, separated from inner eye prominences by a distance equal to one-half their diameter; tongue elongate with a large V-shaped notch, making two rather long horns behind; head longer than broad, bluntly pointed; canthus rostralis rather rounded; diameter of eye equal to distance of eye from nostril; nostril two and one-half times farther from eye than from end of snout; loreal region sloping obliquely, slightly concave; diameter of tympanum a little more than one-half diameter of eye, separated from eye by a distance equal to one-third its diameter; interorbital region one and one-half times width of an upper eyelid; skin smooth above, on head, back, and sides; chin smooth; posterior part of belly and thigh strongly granular; a slight supratemporal fold; arms short with a very narrow insertion: fingers broad, slightly webbed at base, with well-developed digital disks; disks equal to about two-thirds diameter of tympanum; first finger much shorter than second, its disk only slightly smaller than that of second; these two digits rather opposed to third and fourth; fourth finger reaches a little beyond base of disk of third; an indistinct skin fold on outer side of fourth digit, continued to elbow on outer side of arm; no inner web on arm; large nuptial excrescence on first finger; a well-defined kink at base of disks; toes two-thirds webbed, membranes reaching to base of toe disks only on outer side of second toe; fifth toe slightly longer than third, its disk reaching last subarticular tubercle on fourth toe; a very small, conical, inner metatarsal tubercle, about one-sixth the length of first toe; no outer tubercle; no fold on outer toe or along foot; subarticular tubercles well developed, not approaching disks in size; tibiotarsal articulation reaches tip of snout.

Color in life.—Above uniform, shiny, lavender-gray, with numerous very small, not clearly outlined, yellow spots; tip of snout darker than back; lores and upper lip gray, powdered with minute brown dots; a creamy yellow spot in front and somewhat below tympanum; latter light brown; irregular, distinct, dark spots from eye above arm and along sides, and areas of creamy yellow; belly dirty white to cream; chin with numerous small dusky spots; belly spotted; underside of limbs powdered with brown; anal region with a dark area, surrounded with a lighter yellow rim; arm and fingers with purplish brown bars; leg and foot barred with same color.

Measurements of Philautus montanus sp. nov.

	mm.
Length, snout to vent	39
Length of head	15
Width of head	13.9
Length of snout	7
Diameter of eye	5.9
Diameter of tympanum	3.2
Depth of snout, in front of eye	5
Diameter of finger disk	2.5
Foreleg	26
Hind leg	65
Longest finger	11
Femur	22
Tibia	22
Longest toe	15

Remarks.—Only a single specimen was taken. It was found in a small pool of water, near the top of Bongao Peak, on the small island of the same name. No other specimen was seen. This species appears to be most closely related to *Philautus vittiger* Boulenger, from Java, and the differences are not great when compared with Boulenger's description. *P. montanus* is probably a larger species, and the markings are entirely different.

Genus CORNUFER Tschudi

Cornufer TSCHUDI, Class. Batr. (1838) 28; DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 616; GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 84; COPE, Nat. Hist. Rev. (1865) 115; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 107; Ann. & Mag. Nat. Hist. IX 1 (1918) 373.

Hylodes DUMÉRIL, Ann. Soc. Nat. 19 (1853) 177.

Halophila GIRARD, Proc. Acad. Nat. Sci. Philadelphia 6 (1853) 423.

Platymantis GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 93; BOULENGER, Ann. & Mag. Nat. Hist. IX 1 (1918) 373.[25]

[25] Boulenger has recognized Günther's genus *Platymantis* as a genus distinct from *Cornufer* Tschudi. In the latter genus he includes for the most part large-disked forms. He includes the four Philippine forms *C. guentheri*, *C. jagori*, *C. worcesteri*, and *C. corrugatus*, the latter probably through error since he also includes this species with *Platymantis*, together with *P. meyeri*. I have been unable to examine a specimen of *C. jagori*, but it is described as having small but distinct disks, probably similar to those of *C. corrugatus*. The new species described in this work, *C. laticeps*, would also be referred to this group.

With my present study of the group I do not regard the separation of these groups as warranted, and doubt greatly that the character of the disks alone is more of a generic character than are vomerine teeth, the character of the nostril, or the webbing of the feet. The character of the disks appears to be the only difference between the two genera.

"Pupil horizontal. Tongue free and deeply notched behind. Vomerine teeth. Tympanum distinct. Fingers free; toes free or slightly webbed, the tips more or less dilated. Outer metatarsals united or separated by a groove. Omosternum and sternum with a bony style. Terminal phalanges T-shaped." (*Boulenger.*) Polynesia, western Malayan region, and the Philippines.

Key to the Philippine species of Cornufer Tschudi.

a^1. Tips of fingers dilated into large disks.
- b^1. Tongue with papilla; tibiotarsal articulation reaches nearly to tip of snout; with or without granules on belly.... C. guentheri Boulenger.
- b^2. Tongue without papilla; tibiotarsal articulation reaches nostril; entire underside of body granular.............................. C. worcesteri Stejneger.

a^2. Tips of fingers with small disks, smaller than or equal to toe disks; tibiotarsal articulation reaches beyond snout.
- b^1. Tympanum two-thirds diameter of eye; first finger as long as second. C. meyeri (Günther).
- b^2. Tympanum two-fifths diameter of eye; first finger shorter than second. C. jagori (Peters).

a^3. Tips of fingers with small disks; tibiotarsal articulation not reaching tip of snout.
- b^1. First finger longer than second; skin on back with distinct, regular, elongate, longitudinal folds; snout longer than eye. C. corrugatus (Duméril).
- b^2. First finger longer than second; skin very rough with irregular folds; snout length equal to diameter of eye................ C. laticeps sp. nov.

Cornufer guentheri Boulenger. Plate 8, figs. 1 and 1*a*.

Cornufer guentheri BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 108, pl. 11, fig. 3; BOETTGER, Ber. Senck. Nat. Ges. (1886); CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 450.

Description of species.—(From No. 550, E. H. Taylor collection; collected at Bunawan, Agusan, Mindanao, P. I., May, 1913, by E. H. Taylor.) Vomerine teeth in two short oblique series

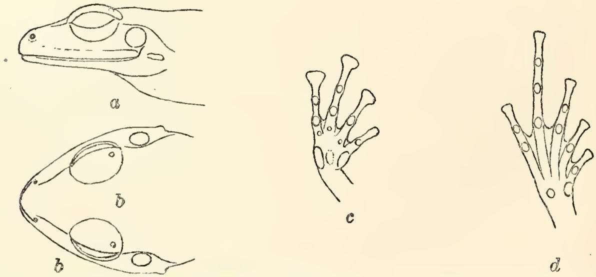

FIG. 3. *Cornufer guentheri* Boulenger. *a*, side of head; *b*, top of head; *c*, hand; *d*, foot. × 2.

beginning on inner edge, but lying almost entirely behind posterior level of choanæ, separated from each other by a distance as great as, or greater than, the length of a single series; a distinct conical tubercle on anterior median part of tongue; head as long as broad or slightly longer; canthus rostralis distinct, slightly angular; loreal region sloping obliquely, somewhat concave behind nostril; diameter of eye slightly less than length of snout, reaching slightly beyond nostril; nostril one and one-third times farther from eye than tip of snout; tympanum small, circular, distinct, two-fifths to one-half diameter of eye, separated from eye by a distance equal to three-fourths its diameter; interorbital region less than the width of a single eyelid; eyelids bounded above by slight grooves; a slight, shallow, longitudinal groove on snout, continued to between nostrils; skin of back smooth; sides somewhat granular, or with short longitudinal folds; a large conical tubercle on posterior part of upper eyelid, with a few smaller indistinct tubercles; a very slight, distinct supratemporal fold; skin of belly and chin smooth; posterior aspect of thighs strongly granular; fingers free, slender, with large transversely widened disks, except disk on first, which is very small, scarcely wider than balance of digit; first finger very short, reaching about halfway between subarticular tubercle and disk of second finger; second finger very slightly shorter than fourth, neither reaching base of disk of third; diameter of largest finger disks greater than tympanum; subarticular tubercles large, rather flattened; toes slightly webbed at base, the membranes not reaching first subarticular tubercles; toes with small disks, very much smaller than finger disks; an elongate, oval, inner metatarsal tubercle, and a small, round, outer tubercle; third toe longer than fifth; tibiotarsal articulation reaches between eye and nostril.

Measurements of Cornufer guentheri Boulenger.

	mm.	mm.
Length, snout to vent	35	36.5
Length of head	15	15
Width of head	14.2	14.1
Length of snout	6.1	6.2
Diameter of eye	5.9	6
Diameter of tympanum	2.4	2.5
Diameter of finger disk	2.2	2.2
Foreleg	23	22
Longest finger	10	10
Hind leg	54	58
Longest toe	15	15.5
Tibia	17	18

Variation.—A second specimen, whose measurements are given in the second column, was taken in a nearby locality; it differs from the first in having a rather broad yellowish white line from point of snout to anus, balance of back cinnamon brown, snout and lores slightly granular. The dark spots on head are dim brownish; the tympanum is slightly larger, and the hind leg slightly longer, proportionally. They both differ from the type in having the entire under surface, except thigh, smooth instead of granular.

Remarks.—Both specimens are from Bunawan. They were found under loose bark, at the bases of large forest trees away from the immediate vicinity of water. No other specimen was observed. The type is from Dinagat Island and was collected by A. Everett. The specimen here described differs slightly from the type; in the type the tympanum equals half the diameter of the eye, and the tibiotarsal articulation reaches near to tip of snout. The skin above has granular folds in the type which are apparently absent in our specimen, save on the sides. The coloration and markings are obviously variable.

This species is similar to *Cornufer worcesteri* Stejneger, from which it differs in the following manner: Tongue without papilla; interorbital region somewhat wider, and entire underside of body granular. The last two characters are variable in many species; and, were it not for the absence of the papilla on tongue, I should be inclined to regard *C. worcesteri* as being identical with *C. guentheri.* Since the two species were founded on single specimens (Stejneger's in an admittedly indifferent state of preservation), larger collections may prove that they are the same species. My two specimens, which also differ somewhat from Boulenger's description as well as from each other, have distinct papillæ, but these are less distinct in No. 551 than in the described specimen.

Cornufer worcesteri Stejneger.

Cornufer worcesteri STEJNEGER, Proc. U. S. Nat. Mus. 28 (1905) 345.

Description of type.—(From Stejneger.) "Vomerine teeth in two oblique series behind the level of the hinder edge of the choanæ; orbital diameter slightly less than distance of orbit from tip of snout; interorbital space considerably wider than upper eyelid; canthus rostralis rounded; lores concave; crown flat; tympanum nearly circular, about one-half the diameter of the eye; fingers free, first considerably shorter than second, which is shorter than fourth; disks rather large; toes webbed at the base; disks well developed, though not quite so large as on the fingers; hind limb being carried forward, the tibiotarsal joint does not reach the tip of the snout, only to about the nostrils; skin smooth above, (possibly with some longitudinal folds, but that cannot be decided on account of the state of the specimen) coarsely granular on the whole underside, including the throat; a distinct tubercle on the upper eyelid."

Color.—"Above pale brownish gray with small, irregular, dark brownish spots; snout decidedly brownish; a very distinct blackish brown band across the top of the head at the anterior end of the upper eyelids, involving them and continuing below the eye to the edge of the lip; tympanic region dark, but loreal region pale brown as the snout and without dark stripe; underside pale, finely dusted over with brownish; limbs with traces of dark cross bars."

Measurements of Cornufer worcesteri Stejneger.

	mm.
Total length	28
Width of head	12
Length of foreleg	17
Length of hind leg, from vent to tip of longest toe	45

Remarks.—The type specimen is in an indifferent state of preservation. According to Stejneger the species is most closely related to *Cornufer jagori* Peters, from Samar. The toe and finger disks are larger. The coloration seems to be distinctive, especially the frontal crossband.

Cornufer meyeri (Günther). Plate 8, fig. 3.

Platymantis meyeri GÜNTHER, Proc. Zool. Soc. London (1873) 171.
Cornufer meyeri BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 109, pl. 11, fig. 4; BOETTGER, Ber. Senck. Nat. Ges. (1886) 124; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 450.

Description of species.—(From No. 69, Bureau of Science collection. Taken from the belly of a specimen of *Boiga dendrophila* from Luzon.) Vomerine teeth in two slightly oblique groups, lying almost wholly behind the posterior level of choanæ, the series rather short, somewhat rounded, separated from each other by a distance greater than the length of a single series; tongue broad, notched behind, with a large well-developed papilla on anterior median line; head much longer than wide; canthus rostralis only slightly angular; loreal region strongly concave; interorbital space slightly less than width of upper eyelid; diameter of eye a little less than length of snout; nostrils as far from each other as their distance from eye; nostril little more than one and one-half times as far from eye as from end of snout; diameter of tympanum from one-half to two-thirds of eye; tympanum separated from eye by a distance greater than half its diameter; skin with short glandular folds, irregularly placed on body; a distinct supratemporal fold from eye to shoulder; limbs rather granular or with small folds; belly, chin, and underside of thighs perfectly smooth; posterior aspect of thighs and anal region granular; fingers long, slender, the first equal in length to the second; fourth extending slightly farther than first or second, all three reaching beyond first subarticular tubercle of third; disks small, slightly wider than digits; subarticular tubercles large, well developed, the middle one larger than the finger disks; carpal tubercles large, those on inner finger largest, those on middle finger second in size; no webs; no skin fold on

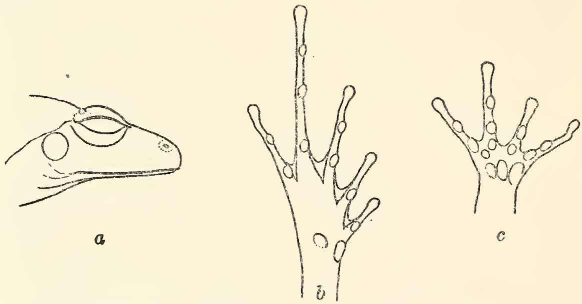

FIG. 4. *Cornufer meyeri* (Günther). *a*, side of head; *b*, foot; *c*, hand. × 2.

outer side of fingers; toes long, slender, with a rudiment of web which does not reach beyond base of lower subarticular tubercles; disks distinctly wider than those on fingers; third toe longer than fifth; fifth reaching slightly beyond second subarticular tubercle of fourth toe; metatarsal tubercles strongly developed, but small; an outer round, and inner oval, tubercle less than one-third length of first toe; tibiotarsal articulation carried forward reaches beyond tip of snout.

Color in alcohol.—Above brownish slate, not uniform, with two distinct dorsolateral light lines from on eyelids to near end of body; upper part of arm whitish; subarticular tubercles of hands light; posterior part of thighs reddish brown; limbs bluish to grayish slate, femur with a few indistinct bars of darker color; tubercles of feet gray; belly dirty white, reticulated with dusky; indistinct spots on lips.

Measurements of Cornufer meyeri (Günther).

[The second measurements recorded are also from a Luzon specimen.]

	mm.	mm.
Length, snout to vent	41	38.4
Length of head	16.5	15
Width of head	14.5	14.5
Length of snout	7	6.5
Diameter of eye	6	5.9
Diameter of tympanum	3.5	3.5
Depth of snout, in front of eye	5	4.5
Foreleg	29	27.5
Longest finger	11.4	11
Hind leg	80	76
Tibia	24	23
Femur	19	19
Longest toe	23	22
Heel and foot	35.5	32.5
Diameter of toe disk	1.5	1.5

Variation.—There are many specimens of this species from Mindoro, Lubang, Luzon, and Negros in the collections studied. They agree fairly well in proportions, but the specimen here described is larger than any other in the collection. The specimens from Negros appear to have a deeper head and body than do those from Luzon and Mindoro. Practically no two specimens can be found with the same color patterns. Some are deeply reticulated with brown below, others uniformly light with no markings; some show a certain regularity in the arrangement of the longitudinal folds on the shoulders; a few from various localities have narrow median lines on the body, and others are marked with two lateral lines; others are uniformly colored above. Obviously, color markings are very unreliable characters in this group of frogs.

Remarks.—This species appears to be common in the localities named. The frogs are usually found moving about in the forest, away from the immediate vicinity of water. The type, collected by A. B. Meyer, is from "Laguna de Bay." Specimens are reported by Boettger from Mindoro and Leyte. Apparently it is strictly a Philippine species.

Cornufer jagori (Peters).

> *Halophila Jagorii* PETERS, Mon. Berl. Ak. (1863) 456.
> *Cornufer jagori* BOULENGER, Cat. Batr. Brit. Mus. ed. 2 (1882) 109; BOETTGER, Ber. Senck. Nat. Ges. (1886) 124.

Description of species.—(From the type description.) Vomerine teeth in two oblique series, lying between and behind posterior level of choanæ; choanæ small; tongue heart-shaped, with two points behind; diameter of eye almost equal to length of snout; tympanum roundish, about two-fifths diameter of eye; body with granules and distinct longitudinal folds; arm reaches back end of body; fingers entirely free, with small but distinct digital disks; first finger a little shorter than second and scarcely longer than fourth, third longest; two distinct longitudinal carpal tubercles; subarticular tubercles strongly defined; hind leg carried forward tibiotarsal articulation reaches beyond snout by one-third the length of tibia; disks of toes distinct; small web between base of toes; two metatarsal tubercles; subarticular tubercles of toes distinct; fifth toe shorter than third.

Color.—Body above dark brown; below whitish with dark brown, strongly defined on neck; lips and limbs with dark spots.

Measurements of Cornufer jagori (Peters).

	mm.
Total length	18.5
Length of head	8
Width of head	6
Foreleg	13
Length of hand, with third finger	5.5
Hind leg	35
Length of foot and fourth toe	16

Remarks.—I have been unable to obtain a specimen of this species. Peters does not mention the presence of a lingual papilla, and it probably does not occur. It would be well, however, to have the type examined to determine this point. It is probable that the type is immature; it is said to be not very well preserved. The type locality is "Insel Samar." The type was discovered by F. Jagor.

Cornufer corrugatus (Duméril). Plate 4, figs. 3, 3*a*, and 3*b*.

Hylodes corrugatus DUMÉRIL, Ann. Sci. Nat. III 19 (1853) 176.

Platymantis plicifera GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 95, pl. 8, fig. 3; Proc. Zool. Soc. London (1877) 132.

Platymantis corrugata PETERS, Mon. Berl. Ak. (1873) 611; PETERS and DORIA, Ann. Mus. Civ. Gén. 13 420.

Cornufer corrugatus BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 110; BOETTGER, Ber. Senck. Nat. Ges. (1886) 123; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 450; MÉHELY, Termes, Fuzetek 20 (1897) 411, pl. 10, fig. 142; BARBOUR, Mem. Mus. Comp. Zool. Harvard Coll. 44 (1912) 70; VAN DAMPEN, Nova Guinea 5 (1906) 167.

Description of species.—(From No. 200, E. H. Taylor collection; collected on Mount Maquiling, near Los Baños, Laguna, P. I., May, 1916, by E. H. Taylor.) Vomerine teeth in two short, oblique groups, somewhat rounded, lying for the most part behind the level of the choanæ; tongue large, oval, not deeply notched behind, the horns rather widely separated at base; a distinct enlarged papilla on tongue; choanæ rather large; head pointed, as wide as long or a little wider, canthus rostralis present, slightly rounded, the edges converging to tip of snout, where they just fail to make an angle; eyes prominent, their diameter less than length of snout, but reaching beyond nostril; distance of nostrils from each other equals their distance from eye; nostrils one and a half times as far from eye as from end of snout; neither snout nor forehead concave; lores sloping gently, not or scarcely concave; interorbital area equal to, or a little less than, a single eyelid; anterior outline of head unbroken by eye, when viewed from above; tympanum equals about two-thirds eye, its outline rather indistinct on upper posterior part; skin of head

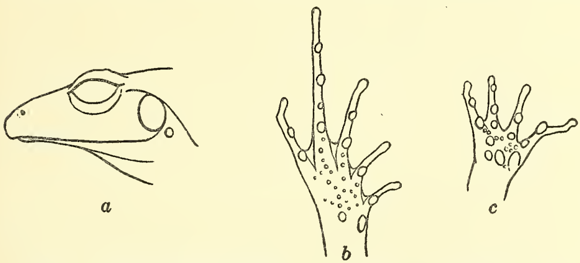

FIG. 5. *Cornufer corrugatus* (Duméril). *a*, side of head; *b*, foot; *c*, hand. × 2.

smooth, granular above eyes; skin on back arranged in rather regular, elongate, symmetrical folds, with shorter folds and scattered tubercles; sides granular; rather prominent tubercles behind and below tympanum; upper part of limbs with more or less distinct rows of granules; belly and posterior aspect of thighs strongly granular; chin and underside of foot dimly granular; a strong supratemporal fold to arm; fingers short, first longer than second and fourth but a little shorter than third, second and fourth subequal; disks very small, smaller than the largest subarticular tubercles; subarticular tubercles on palm large, distinct; digits quite free; toes slender, with a rudiment of web; digits small, about equal to subarticular tubercles; an oval inner metatarsal tubercle and a conical outer tubercle; point of tibiotarsal articulation granular; when brought forward it reaches between eye and nostril, but nearer the latter; male with two internal vocal sacs.

Color in life.—Above reddish brown, with darker regular spots in middle of back; a dark interorbital spot covering part of eyelids; snout light yellow-brown, lighter on canthus; below canthus dark, growing slightly lighter on lip; tympanum brown, with a black area covering upper part, and an area behind, below supratympanic fold, arms and legs barred with brown, with a few distinct black spots on thigh near knee and just above heel; a dark stripe on tarsus and sole strongly contrasted with the lighter color above foot; below cream, posterior aspect of thighs brownish; darker about anus.

Measurements of Cornufer corrugatus (Duméril).

	mm.
Length, snout to vent	41
Length of head	19
Width of head	19
Diameter of eye	5.5
Diameter of tympanum	3.5
Length of snout	7.3
Depth of head, in front of eye	5
Foreleg	26.5
Longest finger	11
Hind leg	76
Tibia	24.5
Femur	22
Longest toe	21
Diameter of disk	1

Variation.—This species, which appears to be distributed over the entire eastern part of the Philippine Archipelago, exhibits considerable variation. The characters that appear invariable are that the first finger is longer than the second, and the tibiotarsal articulation fails to reach tip of snout. The longitudinal folds on the back are usually regular, assuming the same general outlines. However, there are two specimens from Los Baños, Laguna, Luzon, which approach *Cornufer meyeri* (from the same locality) in coloration; the arrangement of the lines on the back differs from the typical *C. corrugatus* in that they are short and, apparently, do not conform to any regular pattern; the lips, both upper and lower, are strongly spotted with black; the lores are black and there is a distinct temporal black spot limited by the supratemporal fold; the spots on the inner sides of limbs are very distinct; there are distinct spots of black on shoulders; a dark stripe is present on heel and foot. Another small specimen from the same locality is identical with the above in color and markings.

Some specimens from Negros and Mindanao, when first taken, were almost uniform flesh pink on the back, with bright carmine spots on the posterior part of thighs and tibia and on the anterior part of femur and about groin. The Mindanao specimens were darkest, and those in the collection from Negros, lightest. There are specimens in my collection from Luzon, Mindanao, and Negros. Boettger reports the species from Tablas. Outside the Philippines, it is known in Ceram, New Guinea, the Kei Islands, the Bismarck Islands, and Halmaheira. I believe it has not been taken in Borneo.

Cornufer laticeps sp. nov. Plate 3, fig. 1.

Type.—No. 197, E. H. Taylor collection; collected at Bunawan, Agusan, Mindanao, September, 1912, by E. H. Taylor.

Description of type.—Vomerine teeth in two short, somewhat rounded series, lying for the most part behind hinder level of choanæ, but arising from their inner posterior edge; tongue nearly as wide as long, with two small, rounded, posterior horns, separated at base; a large papilla on anterior median part; head a little longer than broad; canthus rostralis rounded; lores sloping slightly at top, then very obliquely over lip to mouth, concave behind nostril; eye large, its diameter as long as snout or slightly shorter; nostril twice as far from eye as from end of snout; width of interorbital region equal to about one-half width of a single eyelid; tympanum small, its posterior border not distinct, vertically oval, little more than one-third diameter of eye; skin rough, granular, and tubercular; prominent tubercles on lores, snout, eyelids, sides, and back; a few short longitudinal skin folds on dorsolateral region; a strong supratemporal fold partially covering tympanum; skin of chin smooth; belly smooth except on posterior part, which is granular; underside of thighs smooth, posterior aspect granular; first finger longer than second and equal to fourth; no trace of webs; disks scarcely wider than digits, not larger than subarticular tubercles; no humeral fold or skin fold on outer side of fourth finger; toes with mere rudiment of web; disks on toes larger than those on fingers; subarticular tubercles prominent, conical; third toe extends farther than fifth; fourth very long; a longitudinally oval, inner metatarsal tubercle, and a rounded outer which is smaller; no tarsal fold; no skin fold on outer side of toes; greatest width of body immediately posterior to tympanum; entire outline of head not broken by eye when viewed from above; tibiotarsal articulation reaching to near nostril.

Color in life.—Above brown, mottled and spotted with darker brown; somewhat lighter longitudinal areas on either side of back, and another between eyes followed by a darker area; snout darker; lips barred with lighter and darker bars; a dark brown temporal area; sides lighter than back, spotted with brown; foreleg strongly barred with brown; third and fourth fingers barred with brown; hind legs cinnamon brown with darker bars; toes barred with darker and lighter brown; belly creamy white; chin dusky.

Measurements of Cornufer laticeps sp. nov. Type and two cotypes.

	Type.	Cotype.	Cotype.
	mm.	*mm.*	*mm.*
Length, snout to vent	49	40	40
Length of head	22	17.5	17.5
Width of head	20.2	17.5	17.5
Width of upper eyelid	6.5	5.5	5.2
Diameter of eye	7.5	6	6.2
Length of snout	7.9	6.8	7.5
Diameter of tympanum	3	3	3.2
Foreleg	29	24	24
Longest finger	12.2	10.3	10
Hind leg	81	71	70.5
Femur	25	21	21.5
Tibia	27	23	22
Longest toe	25.5	20.5	21

Variation.—The listed measurements record the chief proportional differences which occur in three specimens. Three other specimens in the collection are of the same size as the two smaller specimens whose measurements are given. In color and markings they vary but little.

This species is related to *Cornufer jagori* (Peters), from Samar, and possibly also to *C. vitianus* Duméril, of the Fiji Islands. From *Cornufer jagori* it appears to differ in having shorter hind legs, the tibiotarsal articulation reaching about to nostril instead of beyond snout, the first finger being distinctly longer than second, the lingual papilla being present, in being much larger in size, and in having greater ruggedness of skin and width of head.

Specimens were collected in the immediate vicinity of water, at low elevations, usually under leaves or logs along the edges of small mountain streams. Many other specimens taken were lost in shipment. Not rare at Bunawan.

ENGYSTOMIDÆ

No maxillary teeth; diapophyses of sacral vertebræ dilated; sternal structure variable. Distal phalanges simple or T-shaped; pupil erect or horizontal. Vertebræ procœlian, without ribs. This family shows very marked variation in numerous skeletal characters; especially in the sternum, and in the articulation of the coccyx. In the Philippines five genera have been recognized, containing in all eight species.

Key to the Philippine genera of Engystomidæ.

a^1. Pupil erect; no precoracoids; tympanum hidden.

  b^1. Tongue elliptic; a cutaneous ridge across palate between choanæ and another in front of œsophagus; fingers free, toes more or less webbed .... Microhyla Tschudi.

  b^2. Tongue oblong; palatine bones forming a bony ridge (sometimes toothed) across palate; two cutaneous ridges across palate in front of œsophagus........ Kaloula Gray.

a^2. Pupil horizontal; precoracoids present; no vomerine teeth.

  b^1. Tongue oval; a dermal ridge across palate, between and in front of Eustachian tubes; fingers free, toes partly webbed; tympanum distinct .... Kalophrynus Tschudi.

  b^2. Tongue elliptical; a very indistinct bony ridge may be present behind choanæ; dermal fold in front of œsophagus; tympanum sometimes wanting; fingers and toes entirely free........ Chaperina Mocquard.

  b^3. Tongue large, rounded, a doubly arched palatal ridge present or absent; a smooth dermal ridge in front of Eustachian tubes, and another behind them; tympanum present; fingers and toes free; no subarticular tubercles........ Phrynixalus Boettger.

For the most part these small toads are terrestrial and burrowing, although one species, *Kaloula conjuncta*, ascends trees and probably makes them a more or less permanent habitat. Several of the species live exclusively on ants. Many of the species exude from their skin a poisonous substance which protects them from being eaten by their enemies.

Several specimens of *Kaloula picta* were placed in a cobra cage, and four of them were eaten by a young female cobra. After finishing the meal she rubbed her head about the cage, seemed extremely restless, frothed at the mouth, and appeared to be in pain. Later two other frogs were seized, partially swallowed and then ejected. When other food, such as a medium-sized *Rana*, was available, the *Kaloula* were not touched by the cobras. A dog will sometimes pick up one of these small toads in his mouth, but immediately eject it in great disgust.

The male *Kaloula conjuncta*, when clasping the female, becomes glued to her back by excretion, either from her back or from his belly. This fact was noted also in *Kalophrynus stellatus*.

Genus MICROHYLA Tschudi [26]

Microhyla TSCHUDI, Class. Batr. (1838) 71; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 163; Fauna Brit. India, Rept. (1890) 491.

Microhyla DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 613; GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 121.

Hylaplesia FITZINGER, Syst. Rept. (1843) 31.

Siphneus FITZINGER, Syst. Rept. (1843) 33.

Dendromanes GISTEL, Naturg. Thierr. (1848) 11.

Diplopelma GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 50.

Scaptophryne FITZINGER, Sitz. Ber. Ak. Wien 42 (1861) 146.

Pupil vertical; tongue elliptical, entire, free behind; a more or less distinct cutaneous ridge across palate between choanæ, and another in front of œsophagus; tympanum hidden; fingers free; toes more or less webbed, sometimes very slightly; tips of fingers and toes blunt or more or less dilated; outer metatarsals united; no precoracoids; no omosternum; sternum cartilaginous; diapophyses of sacral vertebræ moderately dilated; terminal phalanges simple. India, China, Japan, and East Indies.

Remarks.—One species has been reported from the Philippines, on the doubtful authority of J. G. Fischer.[27] I have included the species because of the possibility of its occurrence. It is noteworthy that the genus *Microhyla* is the only representative of the Engystomidæ found in Formosa and the islands to the north.[28] One species is confined to Formosa; a second inhabits the islands between Formosa and Japan proper.

Mycrohyla achatina (Boie).

Hylaplesia achatina BOIE, Isis (1827) 294.

Microhyla achatina TSCHUDI, Class. Batr. (1838) 71; PETERS and DORIA, Ann. Mus. Genov. 13 428; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 166; BOETTGER, Ber. Senck. Nat. Ges. (1886) 124; FISCHER, Jahrb. Wiss. Anst. Hamburg 2 (1885) 80; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 450; BARBOUR, Mem. Mus. Comp. Zool. Harvard Coll. 44 (1912) 71, pl. 7, fig. 27.

Micrhyla achatina DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 614; GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 121.

[26] Of doubtful occurrence in the Philippine Islands.

[27] Jahrb. Wiss. Anst. Hamburg 2 (1885) 80.

[28] In a recent letter M. Lazo, who is making a herpetological collection in the Batan Islands for the Bureau of Science, says that no batrachians of any sort are to be found there. This statement may be questioned and is remarkable if true. The Batan Islands lie between Formosa and Luzon.

Description of species.—(From Boulenger.) "Habit slender. Snout subacuminate, longer than the orbital diameter; interorbital space broader than the upper eyelid. Fingers rather slender, first much shorter than second; toes slender, webbed at the base; tips of fingers swollen into very small, of toes into well-developed disks; subarticular tubercles distinct; two small metatarsal tubercles. The hind limb being carried forwards along the body, the tibio-tarsal articulation reaches the tip of the snout, or beyond. Skin smooth."

Color.—"Brown above; sides and a streak between the eyes dark brown; sometimes the back with rather indistinct chevron-shaped darker and lighter lines and a narrow light vertebral line; limbs more or less distinctly cross-barred; anal region blackish."

Remarks.—This species is included here on the strength of Fischer's report, but not without some doubt. His specimen was presumably from southern Mindanao. The species is known from the Malay Peninsula, Sumatra, Nias, and Java. Barbour's specimen from Java was taken at an altitude of about 1,520 meters. The fact that no more specimens have been found in the Philippines may be due to the paucity of collections from high mountains.

Genus KALOULA Gray

Kaloula GRAY, Zool. Misc. (1831) 38; GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 122.

Hylaedactylus TSCHUDI, Class. Batr. (1838) 85; DUMÉRIL and BIBRON, Erp. Gén 8 (1841) 732.

Plectropus DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 736.

Holonectes PETERS, Mon. Berl. Ak. (1863) 455.

Calohyla PETERS, Mon. Berl. Ak. (1863) 455.

Callula GÜNTHER, Rept. Brit. India (1864) 436; COPE, Journ. Acad. Nat. Sci. Philadelphia II 6 (1867) 192; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 167; Fauna Brit. India, Rept. (1890) 493.

"Pupil erect. Tongue oblong, entire and free behind. Vomerine teeth none; palatine bone forming an acute, sometimes toothed ridge across the palate. Two cutaneous, more or less distinctly denticulated ridges across the palate, in front of the œsophagus. Tympanum hidden. Fingers free; toes more or less webbed, exceptionally free, the tips more or less dilated. Outer metatarsals united. No precoracoids; no omosternum; sternum cartilaginous. Diapophyses of sacral vertebra moderately dilated. Terminal phalanges triangular or T-shaped. East Indies." (*Boulenger.*)

Key to the Philippine species of Kaloula Gray.

a^1. Toes slightly webbed at base; digits dilated, especially fingers; a blunt inner metatarsal tubercle.. K. baleata (Müller).

a^2. Toes one-third webbed, or more.

- b^1. Tips of fingers very small; inner metatarsal tubercle very large, compressed .... K. picta (Bibron).
- b^2. Tips of fingers with very large disks; inner metatarsal tubercle moderately large... K. conjuncta (Peters).

Kaloula picta (Bibron). Plate 9, fig. 4.

> *Plectropus pictus* BIBRON, in Eydoux and Souleyet, Voy. Bonite, Rept. pl. 9, fig. 2; DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 737; STEINDACHNER, Verh. Zool. Bot. Ges. Wien 14 (1864) 257.
>
> *Kaloula picta* GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 123, part.
>
> *Callula picta* BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 168; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1896) 451.

Description of species.—(Described from sixteen males and seventeen females; collected July 11, 1917, in a small pool near an electric light on a street of Manila, by E. H. Taylor.) Palatal

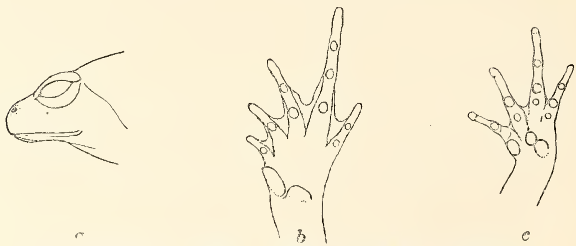

FIG. 6. *Kaloula picta* (Bibron). *a*, side of head; *b*, foot; *c*, hand. × 2.

bones forming two transverse ridges across ridge of mouth immediately behind choanæ, curved backward on inner ends; snout very short and obtusely rounded, canthus rostralis rounded and not prominent; loreal region sloping very obliquely, not or very slightly concave; eye large, the supraocular region prominent; diameter of eye equals distance from eye to apex of snout; distance between nostrils greater than their distance from eye; nostrils halfway between eye and tip of snout; skin of back smooth or granular; granules when present scattered, or sometimes in indistinct longitudinal rows; a minute median dorsal fold sometimes present; granules numerous on posterior aspect of thigh; skin of belly slightly wrinkled, sometimes granular posteriorly; tympanum not or scarcely visible; a distinct fold from corner of eye to in front of foreleg; legs strong, hind legs (tip of toe to anus) longer than distance from snout to anus; fingers free, first much shorter than second, latter nearly same length as fourth; tips of fingers and toes not dilated into disks; subarticular tubercles well developed; toes about one-third webbed, very large; an inner metatarsal tubercle longer than first toe, outer metatarsal tubercle much smaller, prominent, their edges rather sharp and hard; tarsus without fold; males with simple vocal sac which opens by a pair of slits on side of tongue; underside of chin of males with two or three large folds of skin; a slight fold frequently evident across head behind eyes; tongue free and entire behind; pupil vertical; the tibiotarsal articulation reaches eye.

Color in life.—The specimens vary in color from a dull muddy drab to dull red, through varying shades of olive and olive brown. Back with a large irregular blotch of darker color, frequently resembling the silhouette of a man standing upright with two horns on his head; dark laterally, becoming lighter on belly; belly rather light, covered with brownish reticulations, numerous on chin; legs and arms barred with darker; in the breeding males the throat is a dark yellow green, and a wash of greenish color on forelegs is sometimes present; in alcohol the green on throat becomes slate colored.

Measurements of Kaloula picta (Bibron).

	mm.
Length, snout to vent	43
Length of head	12
Width of head	13.5
Diameter of eye	4.6
Length of snout	4.6
Width of body, greatest	25
Foreleg	26.5
Longest finger	12
Hind leg	56
Tibia	15
Longest toe	19

Variation.—The males and females before me may be easily distinguished by the green color on chin of the former. The females are larger and for the most part are heavy with eggs. The skin on chin and throat of the males is stretched and is plicate, or with a single large fold, due to the expansion of the vocal sacs during the breeding season.

Remarks.—There can be no doubt as to the distinctness of the two species, *Kaloula picta* and *K. conjuncta.* None of the specimens at hand, male or female, of the former species has the ends of the digits dilated. During the breeding season these frogs are incredibly common about Manila, even on the streets; they may be taken in quantity at this time, after which they disappear and are very rarely found. They seem to be wholly terrestrial or subterrestrial. The species is known in Luzon, Negros, and Mindoro. Three specimens in my collection, presented to me by W. Schultze, are said to be from Dumaran Island, near Palawan. This locality I believe doubtful.

Kaloula baleata (Müller).

Bombinator baleatus MÜLLER, Verhandel. Batav. Genootsch. (1836) 96.
Hylaedactylus baleatus TSCHUDI, Class. Batr. (1838) 85; DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 734.
Kaloula baleata GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 122; STEINDACHNER, Novara, Amph., 68; BARBOUR, Mem. Mus. Comp. Zool. Harvard Coll. 44 (1912) 72.
Callula baleata BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 169; BOETTGER, Ber. Senck. Nat. Ges. (1886) 124; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 451.

Description of species.—(From Boulenger.) "Snout short, rounded, as long as the orbital diameter; interorbital space broader than the upper eyelid. Fingers moderate, the tips strongly dilated, truncated; first finger shorter than second; toes rather short, webbed at the base, the tips swollen into small disks; subarticular tubercles distinct; metatarsal tubercles two, oval, inner large, compressed, with blunt edge. The hind limb being carried forwards along the body, the tarso-metatarsal articulation reaches between the shoulder and the eye. Skin smooth, or with small flat warts on the upper surfaces; a fold from the eye to the shoulder, and another, more or less indistinct, across the head behind the eyes. Male with a subgular vocal sac."

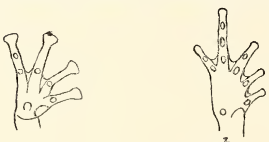
a b

FIG. 7. *Kaloula baleata* (Müller). After Boulenger. *a*, hand; *b*, foot.

Color.—"Brown, olive, or blackish above, uniform or variegated with darker; frequently large whitish spots on the armpits, on the loins, and on the limbs; beneath brown, variegated with whitish."

Remarks.—This species is known from Java, Celebes, and the Philippine Islands. Two specimens in the British Museum were collected by Dr. A. B. Meyer, at Laguna de Bay. It is noted that Meyer also collected this species in Celebes and that specimens from that locality also are in the British Museum. As the species has not been rediscovered in the Philippines, I rather suspect that a change of labels has occurred, and that the so-called Philippine specimens are in reality from Celebes.

Kaloula conjuncta (Peters). Plate 9, fig. 1.

Hylaedactylus (*Holonectes*) *conjunctus* PETERS, Mon. Berl. Ak. (1863) 455.

Kaloula picta (B. female) GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 123, part.

Hylaedactylus conjunctus STEINDACHNER, Vehr. Zool. Bot. Ges. Wien 14 (1864) 256, pl. 11, fig. 5.

Callula conjuncta BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 168; MÜLLER, III Nacht. Cat. Herp. Samml. Basel. Mus. (1883) 4; COPE, Journ. Acad. Nat. Sci. Philadelphia II 6 (1867) 192; BOETTGER, Ber. Senck. Nat. Ges. (1886) 124; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 451.

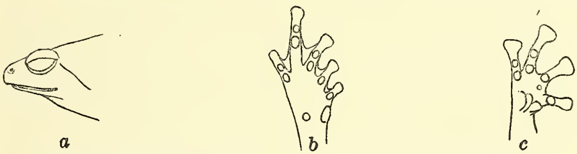

FIG. 8. *Kaloula conjuncta* (Peters). *a*, side of head; *b*, foot; *c*, hand. ×1.

Description of species.—(From No. 798, E. H. Taylor collection; collected at Bunawan, Agusan, Mindanao, P. I., July 10, 1912, by E. H. Taylor.) No vomerine teeth; choanæ large, transversely elongate, distance between them only a little more than half distance between nostrils; beginning on posterior outer edges of choanæ are denticulated dermal ridges, which barely fail to meet medially; they border the choanæ behind; in the posterior palate are two dermal ridges in front of œsophagus, the posterior nearly straight, the anterior rather arched; tongue elongate, oval, not notched behind, free behind; male with internal vocal sac; head short, much wider than long; diameter of eye equal to its distance from tip to snout; snout truncate; nostrils rather widely separated, distance between them greater than their distance from eye; canthus rostralis rounded, lores slightly sloping; interorbital distance equal to one and one-third times the width of upper eyelid; pupil horizontal; tympanum almost entirely hidden; skin of body above smooth, as well as on limbs and underside of body, except about anal region and posterior part of thighs; a few indistinct smooth granules follow the dorsolateral line; a smooth fold from eye to insertion of arm; fingers entirely free, tips distended into large disks at least two-thirds diameter of eye; first finger much shorter than second, which in turn is somewhat longer than fourth, with a slightly larger disk; second finger fails to reach disk of third; subarticular tubercles well developed; an indistinct tubercle on base of first finger, and a large flat tubercle on palm; legs moderate, toes about one-half webbed, provided with disks smaller than those on fingers; third toe, which is much longer than fifth, reaches first subarticular tubercle of fourth; subarticular tubercles of toes rather dim; a blunt, rather indistinct inner metatarsal tubercle; a small dim outer tubercle; skin of body joins femur about halfway from end; a slight fold on heel; hind leg brought forward the tibiotarsal articulation fails to reach angle of jaw.

Color in life.—Above grayish brown, not uniform; back with a large, rather regular spot, two branches of which touch the eyelids; it forks near the middle of back, each branch going to groin, and continues across the limb when folded; two irregular spots on either side of rump; loreal region rather darker; a dark, irregular, broken line from eye to groin, below which the color is slightly darker brown than on back; a dark spot on insertion of arm, one on elbow and one across wrist; a transverse light spot at upper base of digits; a dark spot on foot; posterior part of thigh dark; the dark color arching to include anus; below dull dusky brown, with darker brown marblings, spots, and reticulations.

Measurements of Kaloula conjuncta (Peters).

	mm.
Length, snout to vent	47.5
Length of head	14
Width of head	17
Interorbital width	6.1
Length of snout	6
Diameter of eye	6
Depth of head, in front of eye	6
Foreleg	37
Longest finger	16
Diameter of disk on third toe	4
Hind leg	72
Femur	22
Tibia	20
Foot	31
Longest toe	21
Largest toe disk	2.5

Variation.—No. 28, Bureau of Science collection, exhibits a remarkable variation; the skin of the back is puffed out so as to form a huge sac, as has been recorded by Günther in *Cacopus globosus* of India.[29] In this specimen, a female, it would appear that the large dorsal skin sac was filled with air or fluid in life. It agrees in practically all characters with the specimen described; the color pattern is very dim; the dermal folds on palate are identical in arrangement; the denticulation on anterior folds is more evident. The specimen is a very large one, by far the largest example in the collection. Length, snout to vent, 68 millimeters; foreleg, 56; hind leg, 96. The locality is Manila.[30]

I have sixteen females and eight males from Mindanao. A much larger series was collected, but the specimens were lost. The male differs from the female in that the former has a vocal sac, the chin is black, and the skin is somewhat distended and sometimes in folds; the toes are at least two-thirds webbed, the membrane frequently reaching the outer base of digits on first, second, and third toes, and the inner base of fifth. At first I believed I was dealing with distinct species, but when I found them breeding it was obvious that they were males and females.

A specimen collected by myself in Bubuan Island (Tapiantana Group), Sulu, is much darker, and the typical markings on the back are very distinct; there is a hair line from snout to vent along the middle of back.

One specimen, No. 790 E. H. Taylor collection, exhibits a series of small, light, dark-edged spots on the back and, especially, on the sides; the specimen is somewhat dried, but the webbing of the toes seems a little less than in normal specimens. The marking on the back is very indistinct. The specimen is from Guimaras Island. A Negros specimen has the upper surface covered with rough tubercles, and the posterior part of the belly granular.

Remarks.—This species was described from a Luzon specimen, but I have been unable to find it in that island. In Mindanao, however, it is extremely common at certain seasons. It is known to the Manobos as *coquat.* At Bunawan, Agusan, the breeding season for this frog began November 28, 1912, after a storm with heavy rainfall. From the time of my arrival in June to that date I had not observed a single specimen. During the night of the 27th, a large depressed area in the swamp near the house filled with water, and thousands of these toads collected from all

[29] Rept. Brit. India (1864) 416.

[30] The specimen was collected by Mrs. Graham, who presented it to the Bureau of Science together with certain Philippine snakes (*Dryophiops philippina*). I believe there is no doubt as to the locality, although I have been unable to verify it.

parts of the forest. Their croaking made an ominous roar, easily heard a kilometer away. The note is *chuck-chuck-chuck* rapidly repeated. Males seem to occur in larger numbers than females; not infrequently females were observed mounted by four or five males. The male exudes a sticky substance on the belly which fastens him to the female. Occasional specimens were found mounted by males of *Kalophrynus stellatus* that were breeding at the same time. While the eggs were being deposited, the frogs swam about on the surface of the water.

The species is arboreal and burrowing. When a small *Pandanus* tree, about 7 meters high was cut, twelve specimens were taken from the axils of the leaves. Others were unearthed by my collectors from about peanut and *camote* vines. They appear to feed largely, if not wholly, on ants. The type is from Luzon.

Genus KALOPHRYNUS Tschudi

Kalophrynus TSCHUDI, Class. Batr. (1838) 36; GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 54; COPE, Journ. Acad. Nat. Sci. Philadelphia II 6 (1867) 195; STEJNEGER, Proc. U. S. Nat. Mus. 33 (1908) 575.
Berdmorea STOLICZKA, Proc. As. Soc. Bengal (1872) 146.
Calophrynus BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 157.

No teeth in jaws; no vomerine teeth; a dermal ridge across palate between or behind choanæ; one or two dermal denticulated ridges between, and in front of, Eustachian tubes; head small; mouth small; tongue oval, free or notched behind; tympanum distinct; skin of back thick and glandular like a parotoid; pupil horizontal; fingers free, toes partially webbed, digits without disks; outer metatarsals united, coracoids broad, abutting; precoracoids weak, parallel with latter; omosternum and sternum cartilaginous; diapophyses of sacral vertebræ moderately dilated; terminal phalanges simple.

The genus is known from southern China, Borneo, and the Philippines. Two species have been described from the Philippines; one from Mindanao, the other from either Culion or Samar.

Key to the Philippine species of Kalophrynus Tschudi.

a^1. Snout pointed; tongue nearly circular; tibiotarsal articulation reaches tympanum; tympanum four-fifths eye; no sacral spots.
K. acutirostris (Boettger).

a^2. Snout pointed or blunt; tongue oval; tibiotarsal articulation reaches eye; tympanum about three-fourths eye; two black, white-edged sacral spots .... K. stellatus Stejneger.

These small toads are terrestrial. When taken in the hand alive they exude a white viscous fluid from the entire surface of the back, which sticks to the hand with great tenacity and takes much effort to remove.

Kalophrynus stellatus Stejneger. Plate 9, fig. 2.

Kalophrynus stellatus STEJNEGER, Proc. U. S. Nat. Mus. 33 (1908) 575.

Description of species.—(From No. 216, E. H. Taylor collection; collected at Bunawan, Agusan, Mindanao, P. I., June, 1912, by E. H. Taylor.) Tongue roundly oval, not notched behind; no vomerine teeth; a strong, smooth, distinct dermal ridge running across palate just posterior to choanæ, forming a slight angle medially and not separated medially; choanæ concealed under overhanging jaw; a strongly denticulated dermal ridge running straight across palate in front of œsophagus between the Eustachian tubes; a second arched dermal ridge in front of this, much shorter, the space between triangular; head triangular, slightly wider than long; canthus rostralis roundly angular; loreal region nearly vertical; snout pointed; nostril nearer tip of snout than eye; distance between nostrils greater than their distance from eye; eye large, prominent, its diameter equal to its distance from snout; tympanum large, distinct, very close to eye, its diameter about three-fourths of diameter of eye; interorbital space one and one-half times the width of a single eyelid; skin of back very thick, glandular, covered with small granules; a few larger granules on eyelid; chin and breast rather smooth; belly and underpart of thighs very strongly granular, the granules large and fairly uniform; a distinct supratympanic fold, which limits the thick padded skin of occiput; no dorsolateral fold; fingers short, first and fourth equal, neither extending as far as third; second reaching first subarticular tubercle of third; tips slightly swollen; subarticular tubercles strong, somewhat keeled; toes short; third, distinctly longer than fifth, does not reach farther than second subarticular tubercle of fourth; a well-defined inner metatarsal tubercle, about two-thirds the length of first toe; outer tubercle very indistinct; toes about one-third webbed, the membrane reaching halfway up on digits, on the outer side of first three digits, and on inner side of fifth; fails considerably to reach second tubercle on fourth.

Color in life.—Above pinkish gray, mottled and marked with somewhat darker color; an irregular darker stripe runs from right eyelid to left groin, and another from left eye to right groin, crossing on shoulders. At end of each stripe is a distinct, round, light-edged black spot; balance of area mottled with irregular, lighter-edged markings; a distinct dark stripe across femur and another across tibia, which form continuations of the two dorsal stripes when limbs are folded; a dark spot on outer side of foot, on elbow and wrist; fingers barred with dark and light bars; side of head and body dark black-brown, bordered above by a continuous lighter line, which limits the dorsal color; chin carmine to red-brown; posterior part of body reddish yellow; a few scattered bright yellow-orange spots on breast and belly; heel and underside of wrist dark. In the anal region there is a transverse lighter line, which limits the upper body color; below this line darker on posterior part of thighs.

Measurements of Kalophrynus stellatus Stejneger.

	mm.
Length, snout to vent	45
Length of head	14.5
Length of snout	5.5
Width of head	16
Diameter of eye	5.5
Diameter of tympanum	4
Interorbital width	5.8
Width of body, greatest	28
Foreleg	32.5
Longest finger	13
Hind leg	63
Femur	20.5
Tibia	20
Foot	23
Longest toe	16.5

Variation.—There are twenty-eight specimens in my collection from Bunawan, all taken in the same immediate locality. They exhibit very striking variations in color and markings and slight variations in amount of webbing of toes, the pointedness of the nose, and comparative length of limbs. The typical pattern is the one described. The sacral spots are usually present, of varying size; but in one specimen they are entirely wanting, and in another the spot is wanting on one side and represented on the other by a very small dark area. In some specimens the nose is sharply pointed, ending in a small tuberclelike prominence; in others it is bluntly pointed, and in still others the snout is rather truncate; in some the skin is comparatively smooth, in others uniformly granular. The thick glandular structure of the skin is more evident in the largest specimens. It appears as a huge parotoid covering the entire back and sides. One specimen shows two distinct lateral black spots other than the inguinal spot.

Remarks.—The type of *Kalophrynus stellatus* measures only

24 millimeters and is doubtless an immature form of the specimen described here. The variations are obvious. Stejneger states that there is no supratympanic ridge. In young specimens in my collection the fold is very dim, but distinct in older ones; the "small star-shaped spots" are rarely evident on the back, but on breast and belly they are usually numerous, although frequently entirely wanting. The smallest specimen in the collection measures only 15 millimeters.

It is not improbable that *Kalophrynus stellatus* and *K. acutirostris* are merely variations of the same species. It will be noted that I have described a specimen of very nearly the same size as the type of *K. acutirostris.* The limbs are distinctly longer than in Boettger's species.

Kalophrynus stellatus is common in western Mindanao, especially in the swampy forests of the upper Agusan country. They are usually encountered hopping about during or after a rain; they are very clumsy and very easily captured. During the breeding season of *Kaloula conjuncta* at Bunawan several male specimens of *Kalophrynus stellatus* were taken clasping females of the other species. In spite of their being common I failed to discover their tadpoles. Several females in the collection, including the one described, are packed with eggs. The eggs are small, measuring about 1 millimeter in diameter.

This species is known from Bunawan, Agusan, in Mindanao, and from Basilan. Three specimens were collected by myself in the latter island, which is the type locality. The types were collected by E. A. Mearns.

Kalophrynus acutirostris (Boettger).

Calophrynus acutirostris BOETTGER, Zool. Anz. 20 (1897) 165.
Kalophrynus acutirostris STEJNEGER, Proc. U. S. Nat. Mus. 33 (1908) 576.

Description of species.—(After Boettger.) No vomerine teeth present, tongue almost circular, as wide as long; snout sharp, peak-shaped; the outer metatarsal tubercle very indistinct; thighs comparatively short; the tibiotarsal articulation reaches only to the posterior edge of the tympanum; skin on back finely granulated, the granules of equal size; tympanum four-fifths of eye; head wider than long.

Color.—Above grayish red with very indistinct, darker, islandlike branched spots; head and sides of back darker, almost blackish, bordered above with a fine whitish longitudinal line; in the anal region a whitish transverse line; thighs with darker transverse bands; no round, dark, light-bordered inguinal spot.

Measurements of Kalophrynus acutirostris (Boettger).

	mm.
Length, snout to vent	44
Head length	12
Width of head	15
Diameter of eye	5
Tympanum	4
Foreleg	27
Hind leg	51
Femur	19
Tibia	17.5
Foot	23

Remarks.—This species differs from *Kalophrynus pleurostigma* Tschudi in having the subcircular tongue, the snout more protracted, the hind legs shorter, and the inguinal spots lacking. It also differs from *K. stellatus* in having the subcircular tongue, the snout pointed, the hind legs shorter, and no sacral spots. The species is known from a single specimen. It is from either Samar or Culion ("entweder von Culion oder von Samar");[31] the exact locality is no longer known.

Genus CHAPERINA Mocquard

Chaperina MOCQUARD, Mem. Soc. Zool. France 5 (1892) 194; Le Natural 14 (1892) 35.

Tongue elliptical, not forked behind, free; no vomerine teeth; rather indistinct body ridge across the palate behind choanæ sometimes present; on posterior part of palate in front of œsophagus one or two dermal folds, choanæ rather large, hidden under edges of maxilla; tympanum present or wanting; fingers and toes entirely free, dilated into small disks; no paratoid gland; inner metatarsal tubercle present; terminal phalanges T-shaped; outer metatarsals united. Pupil horizontal; precoracoids present, very slender; sternum cartilaginous; no omosternum. Transverse process of sacrum rather strongly dilated.

Remarks.—This genus was established for *Chaperina fusca* Mocquard from Sintang, Borneo. Mocquard states that it is most closely related to *Sphenophryne* Peters and Doria. Two species are known from the Philippines, both new. *Chaperina beyeri* is closely related to *C. fusca* but appears to differ in certain organic characters, such as the presence of a distinct dermal soft spine on the heel and the absence of tympanum.

[31] Boettger, loc. cit.

Key to the Philippine species of Chaperina Mocquard.

a^1. Black above, with or without yellow specks; yellow below reticulated with black; dermal spine on heels; belly smooth........ C. beyeri sp. nov.

a^2. Brown above, with a median white stripe; two light areas on either side of back and a) (-shaped light mark extending in front on either side of anus; belly granular on dermal spine.................... C. visaya sp. nov.

Chaperina beyeri sp. nov. Plate 3, fig. 3.

Type.—No. 557, E. H. Taylor collection; collected in upper Agusan, Mindanao, between Agusan and Simulao Rivers (probably in Davao or near the Davao–Agusan line), June, 1913, by E. H. Taylor.

Description of type.—Vomerine teeth wanting; choanæ moderate, rather hidden under edges of jaw; a small bony ridge across palate in front of eyes and behind choanæ, somewhat angular medially; a small dermal ridge, rather indistinct in hinder part of palate; head wider than long; snout short, truncate; nostrils nearer tip of snout than eye, distance between them much greater than their distance from eye; eye rather small, diameter somewhat less than length of snout; pupil appears round; interorbital width more than one and two-thirds times eyelid; tympanum wanting, but a slight depressed area in temporal region evident in dried or overpreserved specimens; a distinct groove from tympanic region to arm with a very indistinct fold above the groove; fingers unwebbed, with well-developed disks; first finger very short, with only small terminal disk, and only reaches base of second; fourth longer than second, reaching base of disk on third; subarticular tubercles large; elbow with a distinct dermal spine; toes unwebbed, with distinct terminal disks; first toe reaches subarticular tubercle of second; third much longer than fifth; heel with a distinct, sharp, dermal spine; hind limb brought forward, the tibiotarsal articulation reaches eye; skin smooth both on entire upper and on lower surface. Male apparently without vocal sac.

Color in life.—Above dark brown to blackish; on sides of head and body, on posterior part of back, and above limbs are small lemon yellow dots of varying size; limbs very dimly marked with irregular darker bars; dermal spines on limbs yellow; belly and underside of limbs yellow to orange spotted, and reticulated with brownish, forming rather rounded yellow spots; a distinct light spot at base of digital disk above and below; subarticular tubercles black, some with a dividing whitish line.

Measurements of Chaperina beyeri sp. nov.

	mm.
Length, snout to vent	23
Width of head	7
Length of head	6
Width of body	12
Length of snout	3
Diameter of eye	2.5
Tibia	12
Foreleg	13
Hind leg	33.5

Variation.—Specimens from Palawan agree very well in most characteristics; some are darker, almost coal-black with practically no yellow or white dots above, while others are lighter, gray-brown, with black-brown bars on legs, and very indistinct markings on back; males appear to have more dusky markings on throat than females. Mindanao specimens have the ground color of throat dark, with roundish yellow spots.

Tadpoles.—A good series of tadpoles was taken, from specimens with no legs to those that had completed their transformation. Description of specimen: Total length, 23 millimeters; body, 9; tail, 14; hind legs 10. Eyes very distinct, lateral, distance between them more than twice their distance to end of snout; nostrils close together, nearer tip of snout than eye; spiracle on left side. Owing to the state of preservation I am unable to determine the characters of the teeth and labial denticulation. Color blackish, rather lighter below.

Remarks.—This species was first discovered in June, 1913, in the low mountains along the boundary of Davao and Agusan Provinces, Mindanao, between Agusan and Simulao Rivers. Several adults were taken in a small pool of water in a hole in a tree trunk, only about one-third meter above ground. In May, 1918, several specimens were taken in the extreme northern part of Palawan. Young and adult specimens were found under rocks along nearly dry stream beds in low mountains; later tadpoles were found in a water-filled cavity, nearly a meter from the ground, close to the base of a large tree, not far from the same stream. A good series of tadpoles was taken, as well as a few recently transformed young. In the same pool of water another large tadpole was taken, but I am unable to identify it.

The adults are very agile and, owing to their small size and dark color, are seen only with difficulty. Certainly common in northern Palawan, but probably rare in Mindanao. Known from only these two localities in the Philippines.

I take pleasure in naming this species for Prof. H. Otley Beyer, of the University of the Philippines, who assisted in making collections.

Chaperina visaya sp. nov. Plate 9, fig. 3.

Type.—No. B80, Bureau of Science collection; collected on Biliran Island, P. I., May, 1914, by R. C. McGregor.

Description of type.—Head broader than long; tongue oval, not notched behind; choanæ small, nearly hidden under edge of jaw; no vomerine teeth or palatal ridge; two transverse dermal ridges in front of œsophagus, the anterior rather arched; eye large, its diameter equal to its distance from tip of snout; canthus rostralis rounded; lores vertical, not concave; snout rounded, projecting somewhat; nostril nearer tip of snout than eye; interorbital region nearly twice the width of upper eyelid; tympanum not visible; a very dim fold from eye to foreleg; skin above smooth, with two prominent tubercles on shoulders; numerous other tubercles on posterior part of back, sides and limbs; a skin fold from angle of jaw to foreleg; fingers free, with broad disks, second and fourth nearly same length; subarticular tubercles dim; toes free, with disks smaller than those on fingers; a flat outer metatarsal tubercle, inner dim or wanting; subarticular tubercles dim; the tibiotarsal articulation fails to reach eye.

Color in formalin.—Above variegated brown with a somewhat darker area on head; a median very narrow light line; two rather large light spots on either side of middle of back with an H-shaped mark extending above and on either side of anus. These markings, together with the dorsal, give an appearance of a caricature of a man's face; under surface of belly and limbs dirty white; chin darker than belly.

Measurements of Chaperina visaya sp. nov.

	mm.
Snout to vent	19.5
Width of head	7
Length of head	6.5
Diameter of eye	2.8
Length of snout, from eye	3
Interorbital distance	3.5
Foreleg	12
Hind leg	28
Femur	9
Tibia	9
Longest toe	8.8

Remarks.—The type is the only specimen known. It is with some hesitancy referred to the genus *Chaperina* as it differs somewhat from that genus in the palatal characters. It is not improbably a species of *Sphenophryne.* No specimen of that genus is at hand for study.

Genus PHRYNIXALUS Boettger

Phrynixalus BOETTGER, Zool. Anz. 18 (1895) 17; STEJNEGER, Proc. U. S. Nat. Mus. 33 (1908) 573.

No vomerine teeth; with or without a doubly arched palatal ridge; a smooth dermal ridge in front of Eustachian tubes and another denticulated one behind them; tongue large, rounded, free; tympanum present; fingers and toes free, with disks; no subarticular tubercles; no metatarsal tubercles; pupil horizontal.

Remarks.—In this genus, only *Phrynixalus annulatus* Stejneger is known from the Philippine Islands. This differs somewhat from the genotype, in that it lacks the doubly arched palatal ridge.

Phrynixalus annulatus Stejneger.

Phrynixalus annulatus STEJNEGER, Proc. U. S. Nat. Mus. 33 (1908) 573.

Description of species.—(From Stejneger.) "No vomerine teeth; no ridge between or behind the choanæ which are large, but nearly concealed by the overhanging lip; an indistinct, smooth dermal ridge between the eustachian tubes, and a well-marked denticulated one behind them; tongue large, rounded behind, extensively free (about one-half) behind and on sides; snout somewhat acuminate, projecting; nostrils much nearer tip of snout than eyes; distance from tip of snout to eye greater than diameter of latter; interorbital space nearly twice as wide as upper eyelid; canthus rostralis rounded; lores concave; tympanum rather distinct, its diameter about one-half that of the eye; fingers free, club-shaped, first very much shorter than second, much less widened at the tip than the others, the tips of which are nearly truncate; toes entirely free, the tips dilated, but not quite so much as the fingers; no subarticular tubercles and no metatarsal tubercles; outer metatarsals united; skin smooth above; upper eyelid granular with a larger and more prominent tubercle near the middle of the palpebral edge; underside smooth, except belly which is faintly areolated, and the preanal region, which is granular."

Color (in alcohol).—"Dark brown above, with an indistinct pale band between the anterior half of the upper eyelids followed by a dusky cross-bar; on the shoulders a large, indistinct, W-shaped, dusky mark, the outer arms of which anteriorly reach to the posterior corner of the eyes; an indistinct, large, pale spot on each side of the sacrum; an oblique, pale, dusky-edged line from eye to fore leg; underside paler brown, minutely dotted with whitish; limbs like the body, faintly mottled with dusky, but without distinct cross bars; fingers and toes with a very distinct dusky ring behind the expanded tip or disk, followed by an equally distinct ring of whitish color."

Measurements of Phrynixalus annulatus Stejneger.

	mm.
Total length, tip of snout to vent	14.5
Tip of snout to tympanum	4.5
Width of head	5.0
Length of foreleg	8.5
Length of hind leg, from vent to tip of longest toe	20.0
Length of tibia	6.0

Remarks.—This species was discovered in Davao, Mindanao, in 1904, by E. A. Mearns. Two specimens were taken, one on Mount Apo, at an elevation of about 1,230 meters. This species differs from other members of the genus by the absence of the doubly arched ridge across the palate, and by the difference in the shape of the pupil of the eye.

BUFONIDÆ

No maxillary teeth present; diapophyses of sacral vertebræ dilated; vertebra procœlian and without ribs; the coccyx attached to two condyles; omosternum generally absent; distal phalanges obtuse or T-shaped; pupil usually horizontal.

The true toads belong to this group. It is a large family, cosmopolitan in distribution. There are comparatively few genera in the family. More than three-fourths of the known species belong to the genus *Bufo*. Two genera are known from the Philippines, *Bufo* and *Nectophryne*.

Key to the Philippine genera of Bufonidæ.

a^1. Fingers slightly webbed; toes webbed, the tips more or less dilated into disks; pupil horinzontal; terminal phalanges T-shaped. Nectophryne Buchholz and Peters.

a^2. Fingers free; toes more or less webbed, with or without disks; terminal phalanges simple........ Bufo Laurenti.

Genus NECTOPHRYNE Buchholz and Peters

Nectophryne BUCHHOLZ and PETERS, Mon. Beri. Ak. (1875) 202; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 279; ROUX, Proc. Zool. Soc. London (1906) 58.

Pedostibes GÜNTHER, Proc. Zool. Soc. London (1875) 576.

Toadlike; pupil horizontal; tympanum distinct, partly hidden or absent; fingers and toes partially or wholly webbed, tips dilated into distinct disks; outer metatarsals united; no omosternum; sternum cartilaginous; diapophyses of sacral vertebræ dilated; terminal phalanges T-shaped.

The distribution of this genus is rather unusual, as far as it is known. Species are known from West Africa and from East Africa; six species have been recorded from Borneo, one of which occurs also in the Natuna Islands and Singapore; one species is found in Malabar; and I have recently found a species in Mindanao.

Nectophryne sundana, described by Peters from Borneo, has been considered as a doubtful species by both Boulenger and Roux; in his review of the genus the latter does not include the species but remarks:

> I conclude with a synoptic table for the determination of the known species of *Nectophryne,* not taking into consideration doubtful species, as e. g. *Nectophryne sundana* (Ptrs.) (Boulenger, Cat. Batr. Sal. p. 281.) I have not been able to examine the only existing specimen of this species, which is preserved in the Berlin Museum and comes form Borneo.

It is significant that Roux does not notice the record of this species from Mindanao, recorded by F. Müller [32] and listed by Boettger.[33] It would appear that this specimen has disappeared or, what is still more likely, has been referred to some other species or genus. At any event, I shall not include the species on the strength of the Müller report. Whether or not the specimen that Müller had before him was of the species here described is a matter of conjecture.

Nectophryne lighti sp. nov. Plate 7, figs. 3 and 3*a*.

Type.—No. 189, E. H. Taylor collection; collected at Bunawan, Agusan, Mindanao, P. I., July, 1913, by E. H. Taylor.

Description of type.—Choanæ moderately large, hidden under the overhanging jaw; body not especially slender; head slightly longer than broad; snout distinctly truncate with a groove between the rather raised prominences in which the nostrils are pierced; nostrils near extreme end of snout; in profile the snout slopes back and down to mouth in a rather concave line; eye large, its length a little greater than the length of snout; tympanum large, its greatest diameter about two-thirds that of eye, separated from eye by a distance equal to about one-third its

[32] III Nachtr. Cat. Herp. Samml. Basel Mus. (1883) 7.

[33] Ber. Senck. Nat. Ges. (1886) 125.

greatest length; interorbital distance about twice the width of upper eyelid, much greater than the length of snout; the interorbital area and occipital area raised somewhat; loreal region vertical, concave; skin above with large tubercles, which are moderately smooth, very numerous dorsolaterally and along sides; middle part of back comparatively smooth; a rather prominent parotoidlike tubercle on each shoulder; temporal regions strongly tubercular; top of head, save eyelids, smooth; chin, throat, and belly free from granules; limbs very slender; fingers very slightly dilated at tips, truncate, webbed, the membrane between fingers reaching more than halfway on first and second fingers; first finger about half the length of second; toes about three-fourths webbed, the membrane reaching tip of first and second toes and tip on outer side of third.

Color.—Chestnut brown above, with occasional lighter areas; rather darker on sides; a distinct cream-yellow spot begins below anterior part of eye and continues to below tympanum; three small cream spots behind angle of mouth; limbs lighter, with darker chestnut markings; feet and hands yellowish brown; dusky yellowish brown below, with irregular white spots, which also occur low on sides.

Measurements of Nectophryne lighti sp. nov.

	mm.
Length, snout to vent	15
Length of head	5.2
Width of head	5
Length of snout	1.5
Foreleg	10.8
Hind leg	21
Tibia	65
Femur	6
Longest toe	5

Remarks.—Only a single specimen known. It is from Bunawan, Agusan, where it was taken in a forest among leaves, a few hundred meters from water.

Just what relation this species bears to the Borneo species, I cannot say. It is, however, clearly distinguished by the very numerous large tubercles on its back and sides. It agrees with *Nectophryne guentheri* Boulenger in having the skin of the sides attached to the leg, but differs from the latter not only in size and number of tubercles, but also in having a broader interorbital distance, with apparently no metatarsal tubercles.

The species is dedicated to Prof. Sol F. Light, of the University of the Philippines, who has manifested much interest and given assistance in this work.

Genus BUFO Laurenti

Bufo LAURENTI, Syn. Rept. (1768) 25; WAGLER Syst. Amph. (1830) 206; TSCHUDI, Class. Batr. (1838) 88; DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 662; GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 55; COPE, Nat. Hist. Rev (1865) 102; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 281; STEJNEGER, Bull. U. S. Nat. Mus. 58 (1907) 55.

Hylaplesia BOIE, Isis (1827) 294; PETERS, Mon. Berl. Ak. (1867) 34.

Phrynoides COPE, Proc. Acad. Nat. Sci. Philadelphia (1863) 357.

"Pupil horizontal. Tongue elliptic or pyriform, entire and free behind. Vomerine teeth none. Tympanum distinct or hidden, seldom absent. Fingers free; toes more or less webbed, the tips simple or dilated into small disks. Outer metatarsals united. Omosternum generally missing; if present, cartilaginous; sternum a cartilaginous plate; sometimes more or less ossified along the median line. Diapophyses of sacral vertebra more or less dilated. Terminal phalanges obtuse or triangular." (*Boulenger.*)

Key to the Philippine species of Bufo Laurenti.

a^1. Crown without bony ridges; toes with well-developed disks.
- b^1. First finger shorter than second; toes half webbed; no metatarsal tubercles; two small parotoids on each side.... **B. brevipes** (Peters).
- b^2. First finger much shorter than second, not any or but slight disks; toes webbed to the tips; no parotoids............ **B. muelleri** Boulenger.

a^2. Crown with bony ridges.
- b^1. Cranial ridges distinct, curving behind eye to tympanum; no parietal ridges .... **B. melanostictus** Schneider.
- b^2. Cranial ridges usually confluent with parietal ridges. **B. philippinicus** Boulenger.

Bufo brevipes (Peters).

Hylaplesia brevipes PETERS, Mon. Berl. Ak. (1867) 34.

Bufo brevipes BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 287; BOETTGER, Ber. Senck. Nat. Ges. (1886) 125; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1895) 452.

Description of species.—Habit rather slender; crown without bony ridges; snout obliquely truncate with angular canthus rostralis; loreal region vertical; interorbital space broader than upper eyelid; tympanum rather distinct; sides of body thickly ornamented with tubercles; two small parotoid glands on each side, one on neck, the other near shoulder; foreleg reaches posterior end of body; first finger very short, projecting like a small tubercle; tips of fingers dilated into well-developed disks; third finger 2 millimeters in length; palm of hand smooth; first three toes scarcely extend beyond the swollen interdigital skin; first and last toes as long as corresponding fingers; toes with disks similar to those on fingers; sole of foot smooth, with no metatarsal tubercles present; hind limb brought forward reaches to center of eye. (After Peters.)

Color.[34]—Presumably blackish brown above, with white spots, beneath marbled brown.

Measurements of Bufo brevipes (Peters).

	mm.
Length, snout to vent	18
Foreleg	13
Hind leg	23
Femur	7
Tibia	7
Tarsus	4
Entire foot	10

Remarks.—The types are from Zamboanga, Minadanao, and were collected by Semper. Only the two type specimens appear to have been found. I believe it has not been rediscovered.

Bufo muelleri Boulenger.

Bufo muelleri BOULENGER, Ann. & Mag. Nat. Hist. V 20 (1887) 52.

Description of species.—(From Boulenger.) "Closely allied to *B. pulcher* Boulenger. Crown without bony ridges; snout short, obliquely truncate, with perpendicular lores; interorbital space broader than the upper eyelid; tympanum very indistinct, fingers rather long, somewhat widening and truncate at the end, first much shorter than second; toes rather short, webbed to the tips, which are slightly swollen; metatarsal tubercles, two, flat and very indistinct; the membrane bordering the inner toe extends as a fine fold along the tarsus. The tibio-tarsal articulation reaches the anterior border of the orbit. Skin nearly smooth above, granular inferiorly; no parotoids. Black above with lighter wavy lines or marblings, and with round white dots on the sides and limbs; throat and belly marbled with brown. Male with a subgular vocal sac."

"From snout to vent 30 millim."

Remarks.—The type, a male specimen from Mindanao, is in the British Museum of Natural History. No other specimen is known.

[34] Said to agree with *Bufo borbonicus* Boie.

Bufo melanostictus Schneider.

Bufo melanostictus SCHNEIDER, Hist. Amph. 1 (1799) 216; GRAVENHORST, Delic. Mus. Vratislav. (1829) 57; CANTOR, Cat. Mal. Rept. (1847) 142; GIRARD, U. S. Expl. Exp., Herp. (1858) 92, pl. 5, figs. 10–14; GÜNTHER, Rept. Brit. India (1864) 422; STEINDACHNER, Novara Exped., Zool. 1, Amph. (1869) 42; STOLICZKA, Proc. As. Soc. Bengal (1870) 155; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 306; Fauna Brit. India, Rept. (1890) 505; BOETTGER, Offenb. Ver. Naturk. (1885) 131; FLOWER, Proc. Zool. Soc. London (1896) 911, pl. 44, fig. 3; BOETTGER, Ber. Senck. Nat. Ges. (1886) 125; CASTO DE ELERA, Cat. Fauna Filipinas 1 (1896) 452; STEJNEGER, Bull. U. S. Nat. Mus. 58 (1907) 73, figs. 58–61.

Bufo scaber DAUDIN, Hist. Nat. Rain. (1803) 94, pl. 34, fig. 1; Rept. 8: 194; TSCHUDI, Class. Batr. (1838) 88; DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 699; SCHLEGEL, Abbild. Amphib. (1837) 64, pl. 20, fig. 2; VAN KAMPEN, Zool. Ergeb. Max Weber's Reise 4 (1907) 2, 416.

Bufo bengalensis DAUDIN, Hist. Nat. Rain. (1803) 96, pl. 35, fig. 1; LESSON in Bélang. Voy. Ind. Or., Rept., 334.

Bufo isos LESSON in Bélang. Voy. Ind. Or., Rept., 333; DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 702.

Bufo gymnauchen BLEEKER, Nat. Tijdschrift Nederl. Ind. 16 (1858) 46.

Phrynoides melanostictus COPE, Proc. Acad. Nat. Sci. Philadelphia (1863) 357.

Bufo spinipes STEINDACHNER, Novara Exped., Zool. 1, Amph. (1869) 42.

Bufo meranostictus STEJNEGER, Journ. Sci. Coll. Tokyo 12 (1898) 216 (typ. err.).

Description of species.—(From Stejneger.) "Head with strongly developed bony crests, involving the upper lip, a rostral ridge on end of snout from lip to between nostrils, there bifurcating and continuing on canthus rostralis, along supraorbital border to above the tympanum, forming there a knob-like prominence and sending a branch downward along the anterior border of the tympanum; a slight parietal spur indicated, also a short anteorbital spur or crest; nostrils nearer the tip of the snout than the eye; interorbital space deeply concave, much wider than upper eyelid, which is strongly tubercular and with thickened glandular edges; tympanum vertical, oval or almost pear-shaped, separated from the orbit by a very narrow space, its longest diameter about three-fourths the diameter of the eye; parotoids large, swollen, kidney-shaped; first finger reaches considerably beyond second which does not quite reach as far as fourth; an elongate inner and a much larger outer palmar tubercle;

subarticular tubercles single, prominent; palm, underside, and edges of fingers with numerous pointed tubercles, which, like all the other digital tubercles and the horny tip of the fingers, are blackish brown; heels just meeting when hind legs are placed at right angles to axis of body; metatarsal tubercles reaching posterior corner of eye when hind legs are placed forward along the sides of the body; toes less than one-half webbed, the webs being greatly excised and their edges sharply denticulate; inner metatarsal tubercle prominent, oval, shorter than first toe, outer one large, rounded, less prominent; the single subarticular tuber-

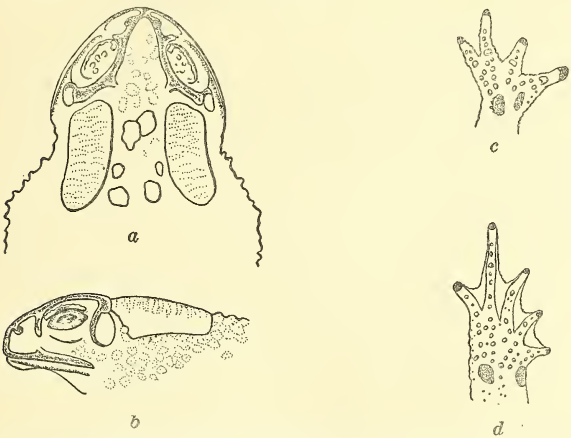

FIG. 9. *Bufo melanostictus* Schneider. After Stejneger. *a,* top of head; *b,* side of head; *c,* hand; *d,* foot.

cles, plantar tubercular asperities, and tip of toes like those on the fore foot; skin strongly tubercular, the tubercles on the back larger, more distant, glandular, rounded, those on sides and limbs more prominent, almost conical, all with a horny dark-brown tip, which on sides and limbs becomes spinous."

Color (*in alcohol*).—"Clay-colored above, more pure pale ocher-yellow underneath, all the crests and nearly all the tips of the tubercles dark brown, as are also the elevated fine vermiculations on the surface of the parotoids; indistinct dusky spots and coarse vermiculations on limbs, sides, throat, and breast."

Measurements of Bufo melanostictus Schneider.

	mm.
Tip of snout to vent	84
Tip of snout to anterior border of tympanum	20
Nostril to tympanum	16
Internaral width	5
Interorbital width	8.5
Longest diameter of tympanum	5.5
Width of head	31
Foreleg	50
Hind leg, from vent to tip of longest toe	99
Tibia	26
Hind foot, from base of inner metatarsal tubercle to tip of longest toe	30
Length of parotoid	20
Width of parotoid	8

Remarks.—This species is included on the strength of Boulenger's record of a female specimen from "Philippine Islands." [35] The fact that no further specimen has been taken in the Philippines leads me to believe that it must be extremely rare here or that the record is in error.

Bufo philippinicus Boulenger. Plate 9, fig. 5.

Bufo philippinicus BOULENGER, Ann. & Mag. Nat. Hist. V 19 (1887) 348, pl. 10, fig. 5; VI 14 (1894) 88.

Bufo divergens MOCQUARD, Nouv. Arch. du Mus. III 2 (1890) 158.

Description of species.—(From No. R1760, Bureau of Science collection; collected at Taytay, Palawan, P. I., April, 1913, by L. E. Griffin.) Choanæ longer than wide, well in view; no vomerine teeth; palate with a transverse denticulated bony ridge, more or less interrupted mesially; head angular, distinctly wider than long; canthus rostralis with low bony crests, which continue back between the eyes to occipital region, where they join the occipital ridges, become confluent with them, and make an angular turn inward; a branch is given off immediately behind eye which curves around, ending at the anterior outer edge of parotoid; posterior part of bony crests higher and thicker than anterior part; distance between crests greatest just posterior to eye; eye large, its length equal to length of snout; eyelid projecting strongly, its width about equal to interorbital space between the bony crests; nostril much nearer tip of snout than eye; canthus rostralis angular, sloping very gently; loreal region not or but slightly concave; tympanum oval, its outline very distinct except on upper border, its diameter about two-thirds eye; distance between tympanum and eye equal to about half

[35] Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 307.

the greatest diameter of latter; parotoids large, very distinct, slightly oblique, one and two-thirds times as long as broad; temporal area behind crests depressed; eyelids strongly tubercular; a prominent tubercle on both anterior and posterior corners of eyelid; entire upper surface with spiny tubercles of unequal size, the largest ones in the median dorsal region; large spiny tubercles behind angle of jaws to above arm; a distinct single tubercle between parotoid and end of occipital crests; entire upper surface of limbs, as well as soles of feet, with spiny tubercles; belly, throat, and underside of limbs with rather uniform small granules; fingers without web; first finger thick, extending farther than second or fourth; a large, keeled, oval tubercle on palm as long as second finger; a smaller conical tubercle on outer base of first finger; subarticular tubercles not very distinctly differentiated from other granules; toes about one-third webbed, third toe distinctly longer than fifth; a strong inner metatarsal tubercle as long as first toe; strong flat oval outer tubercle; subarticular tubercles not well differentiated from other granules; tibiotarsal articulation reaches a little beyond posterior part of parotoid.

Color in alcohol.—Above uniform brownish, no markings being visible; sides dark brown to black; head lighter variegated brown; parotoids lighter brown than back; limbs with very indistinct darker and lighter marks; below dirty yellowish brown, with spots and mottlings of brownish.

Measurements of Bufo philippinicus Boulenger.

	mm.
Length, snout to vent	76
Length of head	21
Width of head	26
Diameter of eye	8.5
Diameter of tympanum	6.1
Length of snout	9
Depth of head, in front of eye	9
Depth of head, at tympanum	11.5
Length of parotoid	13
Width of parotoid	7
Foreleg	43
Longest finger	15
Hind leg	80
Femur	26
Tibia	25
Foot	35.5
Longest toe	22

Variation.—There are three adult specimens of this species in the Bureau of Science collection, two of which were taken from the stomachs of *Boiga dendrophila* Boie, from Palawan.

In one of the specimens the occipital ridges are higher and blunter than in the one described. In a Balabac specimen, which is about half grown, the low ridge following the canthus rostralis and that between the eyes form a distinct angle at the anterior corner of the eye and then a second angle is formed at the union of the occipital ridge with the interorbital ridge; the connection between the supratympanic ridge and the occipital ridge behind the eye is very indistinct; the parotoid gland is as long as its distance to the anterior corner of the eye. The specimen is a male, showing the internal openings to the vocal sacs. There is a rather distinct skin fold from the parotoid back toward the groin, surmounted by rather large tubercles, which is only dimly evident in the specimen described, where the markings are indistinct, and the limbs dimly barred.

A young specimen from northern Palawan (42 millimeters) has distinct markings, but the cranial ridges are dim or wanting. As shown by my specimens, the cranial ridges are variable in arrangement and distinctness and the relative length of limb and body varies.

Specimens collected by myself were found along streams in the low mountains of northern Palawan and Busuanga, during rain storms. The type was collected at Puerto Princesa in Palawan by A. Everett.

PELOBATIDÆ

Upper jaw toothed; vomerine teeth frequently present; diapophyses of sacral vertebræ strongly dilated; terminal phalanges simple; vertebræ procœlous or opisthocœlous; pupil vertical.

The family is widely distributed, but has comparatively few species. It is found in Europe, India, Malasia, and central North America. Only one genus, *Megalophrys*, has been recognized in the Philippine fauna.

Genus MEGALOPHRYS Kuhl

Megalophrys Kuhl, Bull. Sc. Nat. 2 (1824) 83; Wagler, Syst. Amph. (1830) 204; Tschudi, Class. Batr. (1838) 82; Duméril and Bibron, Erp. Gén. 8 (1841) 456; Günther, Cat. Batr. Sal. Brit. Mus. (1858) 36; Cope, Nat. Hist. Rev. (1865) 107; Journ. Acad. Nat. Sci. Philadelphia II 6 (1866) 80; Boulenger, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 442.

Ceratophryne Günther, Cat. Batr. Sal. Brit. Mus. (1858) 136.

Leptobrachium Tschudi, Class. Batr. (1838) 81; Günther, Cat. Batr. Sal. Brit. Mus. (1858) 36; Cope, Nat. Hist. Rev. (1865) 107; Journ.

Acad. Nat. Sci. Philadelphia II 6 (1866) 80; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 440; Fauna Brit. India, Rept. (1890) 510.

Xenophrys GÜNTHER, Rept. Brit. India (1864) 414; COPE, Nat. Hist. Rev. (1865) 107; Journ. Acad. Nat. Sci. Philadelphia II 6 (1866) 80; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 441.

"Pupil erect. Tongue circular or pyriform, entire or nicked and free behind. Vomerine teeth in two small groups, if present. Tympanum distinct or hidden under the skin. Fingers free, toes free or shortly webbed; outer metatarsals united. Sternum with a bony style. Coccyx, if distinct from the sacral vertebra, with simple articulation." (*Boulenger.*)

Key to the Philippine species of Megalophrys Kuhl.

a^1. Eyelid with dermal spine.
  b^1. Males with an internal vocal sac; without vomerine teeth. M. stejnegeri sp. nov.
  b^2. Males with vocal sacs; vomerine teeth present........ M. ligayæ sp. nov.
  b^3. Males without vocal sac; vomerine teeth present.. M. montana (Kuhl).
a^2. Eyelid without dermal spine; no vomerine teeth; males with vocal sac. M. hasselti (Tschudi).

The genus has been admirably reviewed by Boulenger;[36] he has included figures of six species. The species of the genus are confined to southeastern Asia, the Malayan Archipelago, and the Philippines. Whether three or four species should be included in the Philippine fauna is still a question. Before this can be considered settled, a reëxamination of Philippine specimens in European museums referred to *M. montana* will be necessary. I include that species as doubtfully belonging to our fauna.

Megalophrys stejnegeri sp. nov. Plate 10, figs. 1 and 1*a*.

Type.—No. F315 E. H. Taylor collection; collected at Bunawan, Agusan, Mindanao, P. I., August 10, 1912, by E. H. Taylor.

Description of type.—Vomerine teeth wanting; choanæ large, concealed by the overhanging jaw, bounded behind by the bony palatal ridge, the distance between them less than the distance between nostrils; tongue entire without evidence of a nick; (males with vocal sac); head very large, about one and one-half times as long as broad; eyes large, prominent, their diameter distinctly longer than the length of snout; distance between nostrils greater than their distance from eyes; canthus rostralis distinct, angular; loreal region vertical, somewhat concave;

[36] Proc. Zool. Soc. London 1 (1908) 410.

snout small, truncate, projecting over lower jaw with a small tubercular tip; nostril much nearer tip of snout than eye; tympanum irregularly oval, rather indistinct, separated from eye by a distance equal to much more than greatest diameter of tympanum; jaw semicircular in outline, almost hidden when viewed from above; a bonelike ridge from eye to above tympanum; interorbital space little more than one and one-half times the width of upper eyelid (exclusive of horn), its greatest diameter from one-half to two-thirds that of eye; skin of body rather smooth with folds and occasional, irregular tubercles; skin of occiput rather involved in the cranial ossification; a distinct dermal spine, or horn, points outward from the middle of outer edge of upper eyelid, its length a little more than half the width of eyelid; upper eyelid granular; a skin fold follows the bony ridge above tympanum, and continues back and down to near arm; a small dermal spine at angle of jaw; an enlarged, more or less distinct, short glandular fold above insertion of arm; a distinct transverse fold behind head; two dorsolateral skin folds reaching a little more than two-thirds the distance to end of body, and beginning behind the skin fold that delineates the head; breast with two mammalike rounded tubercles, one on either side; skin on chin smooth; belly with scattered blunt tubercles; hind limbs with dim, narrow, transverse granular folds; no tarsal fold; fingers very slightly swollen at tips; first finger slightly shorter than second; second and fourth of nearly equal length; subarticular tubercles very indistinct, forming more or less continuous longitudinal ridges; a dim tubercle at base of first finger; toes slightly dilated at tip, with a mere rudiment of web at base; subarticular tubercles wanting or indistinct; a large, flat, prominent inner metatarsal tubercle; no outer tubercle; tibiotarsal articulation reaches halfway between eye and tympanum.

Color in life.—Above olive brown, anterior part of head slightly lighter than back; a dim, angular, lighter stripe across head; indistinct mottling on head and back; sides with occasional tubercles, usually of darker color, but yellow tipped; a canthal black streak; upper lip mottled brown, a brownish area below eye involving a distinct black spot behind eye; arm strongly barred with dark brown; fingers also barred; hind leg and foot barred brown; chin dusky brown spotted with darker, and with two dim, longitudinal, lighter yellowish lines; two yellow spots on breast; belly yellowish with brown mottlings.

Measurements of Megalophrys stejnegeri sp. nov.

	mm.
Length, snout to vent	64
Length of head, from jaw	21
Width of head	30
Eye to tip of snout	8
Diameter of eye	9
Diameter of tympanum	4.5
Interorbital distance	9.2
Foreleg	39
Longest finger	15.5
Hind leg	86.5
Femur	27
Tibia	23.5
Foot	37
Longest finger	22

Variation.—This species, like *Megalophrys montana*, is variable in many characters. In Mindanao specimens the fingers vary in length. Sometimes the first, second, and fourth fingers are equal, and sometimes they vary progressively in length, but in none of the specimens is the difference great; the nostrils are much nearer tip of snout than eye; the tympanum is not clearly outlined, and is frequently somewhat triangular in shape, with or without a narrow, fairly distinct ridge bounding it in front; the vomerine teeth are constantly absent in the series at hand; a semicircular skin fold is frequently present in the middle of the back, arched forward; in some specimens the tongue has a small nick behind; the males have vocal sacs. The markings vary, chiefly in intensity; the black mark behind and somewhat below eye is invariably present. In younger specimens there are two rather distinctly defined cranial ridges running back from a point where the anterior part of eye meets canthus. These are not visible in the type, which is probably a full-grown female. The yellow tubercles on the posterior side of femur are distinct in some specimens and dim in others.

Remarks.—*Megalophrys stejnegeri* is clearly differentiated from *M. montana* (Kuhl), to which it is closely related, by the presence of vocal sacs in the male. The slits are large and distinctly visible on either side of the posterior part of tongue near angle of jaws. The male has a loud "croak" which, during the breeding season, can be heard for a considerable distance. Nearly all the specimens were discovered by hearing the "croak." During a rain they usually come out of their hiding places. All the specimens captured were taken in low mountains or hills, at elevations not exceeding 300 meters. The tadpoles were taken in small mountain streams, but the specimens preserved were lost. I suspect that many of the Philippine specimens that have been reported as *Megalophrys montana* were really *M. stejnegeri.* Boulenger has reported *M. montana* from Dinagat [37] and Samar; [38] F. Müller [39] and I. G. Fischer [40] both report it from Mindanao.

If the specimens taken were young or females, the vocal sacs may have been overlooked. It is possible, of course, that two species occur in one locality. In view of this possibility I include Boulenger's description of *Megalophrys montana* (Kuhl).

Megalophrys ligayæ sp. nov. Plate 10, figs. 2 and 2*a*.

Type.—No. F325, E. H. Taylor collection; collected in northern Palawan, May, 1918, by Victor Lednicky.

Description of type.—Vomerine teeth in two strong rounded groups lying between the posterior part of choanæ, separated from each other by a distance equal to one and one-half times the length of a single group; separated from choanæ by a distance about half the length of a single group; choanæ not concealed by overhanging jaw; the distance between the Eustachian tubes distinctly greater than their distance from choanæ; distance between choanæ a little less than distance between nostrils; male with vocal sacs, the openings rather elongate slits; openings distinct, about halfway from posterior part of tongue and angle of mouth; tongue rounded, with a distinct nick behind; head much broader than long; snout rather distinctly pointed in front; eye large, its diameter distinctly less than length of snout; nostril halfway between eye and tip of snout, or slightly nearer tip; tympanum moderately distinct, its greatest length about two-thirds of diameter of eye; separated from eye by a distance nearly one and a half times its greatest length; width of eyelid (exclusive of spine) contained one and one-half times in interorbital distance; skin with minute spicules, with larger tubercles on back, sides, and limbs; belly smooth; a short dermal spine on edge of upper eyelid; a distinct fold from eye to above arm; two slightly diverging dorsolateral folds beginning in the occipital region and continuing half the length of body; a rather short dermal spine at angle of mouth; prominent glandular

[37] Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 442.
[38] Proc. Zool. Soc. London 1 (1908) 413.
[39] III. Nacht. Cat. Herp. Samml. Basel Mus. (1883) 11.
[40] Jarhb. Wiss. Anst. Hamburg 2 (1885) 80.

tubercle above insertion of arm, on each shoulder, and in middle of back; several scattered tubercles on back and on upper side of thigh; two prominent glandular mammalike tubercles on breast; skin on head involved in cranial ossification; first finger about as long as second, both extending farther than fourth, tips swollen slightly into blunt disks without grooves; subarticular tubercles not distinct; a rather large swelling at base of first finger; toes apparently entirely free; third distinctly longer than fifth; a large inner metatarsal tubercle as long as first toe; no tarsal fold; hind leg brought forward, the tibiotarsal articulation reaches anterior edge of tympanum.

Color in life.—Above olive gray; a backward curved line across head limits the dark occipital area, which continues backward between the dorsolateral folds to end of body; a narrow black line follows the outer side of the dorsolateral folds some distance; most of the tubercles on back dense black; numerous dark flecks scattered through the ground color; an elongate black spot above insertion of arms; outer edge of upper eyelid and spine black; a black loreal stripe and a narrow, black, yellow-edged line below eye, ending in a black spot behind eye; tip of snout dark; upper lip with elongate, yellow-edged spots confluent with those on lower jaw; limbs with very dim bars above; below, throat brownish with islandlike, yellow-edged spots; belly and underside of hind limbs yellow, with brownish spots; distinct black spots on underside of fore limbs; breast tubercles yellow, as are also the tips of the dermal spines on eye and angle of jaw; heel and foot with black spots.

Measurements of Megalophrys ligayæ sp. nov.

	mm.
Length, snout to vent	60
Length of head, to angle of jaw	23
Width of head, at tympanum	29
Diameter of eye	7.1
Diameter of tympanum	4.8
Eye to nostril	41
Length of snout	9
Tympanum from eye	7
Interorbital distance	9
Eyelid	6
Foreleg	37
Longest finger	15
Hind leg	74
Femur	25
Tibia	18
Foot (entire)	31
Longest toe	20

Variation.—This specimen was collected in Palawan by Victor E. Lednicky. It differs but little from several younger specimens collected by myself in Palawan, now a part of the Bureau of Science collection. A young specimen, which still has a bud of a tail, measures only 13 millimeters in length from snout to vent; the hind legs measure 15 millimeters. It is dark above, throat and chest entirely black, hind legs whitish; tubercles on posterior part of back arranged in a broad V-shaped series, only dimly noticeable in the type. The vomerine teeth are visible in all save the very young specimens.

Remarks.—This species, like *Megalophrys stejnegeri,* differs from *M. montana* in that it has vocal sacs. From *M. stejnegeri* it differs in that it has vomerine teeth, unconcealed choanæ, a longer and more-pointed snout, smaller eyes, a larger and more-distinct tympanum, a flatter head, and a shorter spine above eye. It also differs in color and markings.

The species is rather common in mountain streams. I strongly suspect that specimens from Palawan, collected by Everett and reported by Boulenger,[41] belong to this species. I did not find the tadpoles of this species.

The species is named for Macario Ligaya, the Filipino artist whose careful drawing has contributed much to the value of this paper.

Megalophrys montana (Kuhl).[42]

Megophrys monticola KUHL, Isis (1822) 475.

Megalophrys montana KUHL in Ferussac, Bull. Sci. Nat. 2 (1824) 83; WAGLER, Syst. Amph. (1830) 204; TSCHUDI, Class. Batr. (1838) 82; DUMÉRIL and BIBRON, Erp. Gén. 8 (1841) 458; GÜNTHER, Cat. Batr. Sal. Brit. Mus. (1858) 36; Ann. & Mag. Nat. Hist. IV 11 (1873) 419; BOULENGER, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882) 442; Proc. Zool. Soc. London 1 (1908) 411; F. MÜLLER,[43] III Nacht. Cat. Herp. Samml. Basel Mus. (1887) 11; FISCHER,[43] Jahrb. Wiss. Anst. Hamburg 2 (1885) 80; BOETTEGER,[43] Ber. Senck. Nat. Ges. (1886) 125; WEBER, Ann. Jard. Bot. Buitenzorg 15 (1898) suppl. 2, 5; LAIDLAW, Proc. Zool. Soc. London (1900) 899; ANNANDALE, Fasc. Mal. Zool. 2 (1903) 275; BARBOUR, Mem. Mus. Comp. Zool. Harvard Coll. 44 (1912) 77, pl. 7, fig. 30.

[41] Ann. & Mag. Nat. Hist. VI 14 (1894) 87.

[42] Doubtfully included.

[43] It is possible, but not certain, that these references should be relegated to the synonymy of *Megalophrys stejnegeri* sp. nov. and *M. ligayæ* sp. nov. which differ from *M. montana* in the presence of a vocal sac.

Ceratophrys montana GRAVENHORST, Delic. Mus. Zool. Vratislav. (1829) 47; SCHLEGEL, Abbild. (1837) 29, pl. 10, fig. 3.
Ceratophryne montana SCHLEGEL, Handl. Dierk. 2 (1858) 57.
Megalophrys montana GÜNTHER, Rept. Brit. India (1864) 413, part.
Megalophrys montana var. *aceras* BOULENGER, in Annandale and Robinson, Fasc. Mal. Zool. (1903) 131, pl. 5, fig. 1.

Description of species.—(From Boulenger.)[44] "Tongue entire or feebly nicked behind. Vomerine teeth usually present, in two widely separated small groups just behind the level of the choanae. Head large, $1\frac{1}{2}$ to $1\frac{3}{4}$ times as broad as long, usually defined behind by a more or less distinct transverse fold; snout truncate or obtusely pointed, projecting beyond lower jaw, as long as or a little shorter than eye; canthus rostralis sharp; loreal region vertical or a little oblique, concave; nostril equally distant from eye and from end of snout; interorbital space concave, its width $1\frac{1}{2}$ to 2 times that of upper eyelid (narrower in the very young); tympanum usually feebly distinct, rarely hidden, its diameter $\frac{1}{2}$ to $\frac{2}{3}$ that of eye, from which it is separated by a distance equal to the diameter of the latter. Fingers obtuse or feebly swollen at the end, first as long as or a little longer than second, which measures $\frac{2}{3}$ to $\frac{3}{4}$ length of third; no subarticular tubercles; no distinct metacarpal tubercles. Toes rather short, obtuse or feebly swollen at the end, with a mere rudiment of web or, at most, $\frac{1}{4}$ webbed; no subarticular tubercles; a flat, very indistinct inner metatarsal tubercle. Tibio-tarsal articulation reaching the shoulder, the commissure of the jaws, or the temple; tibia $\frac{2}{5}$ to $\frac{1}{2}$ length from snout to vent; foot as long as or shorter than tibia. Skin of upper parts smooth or with scattered conical warts, old specimens with bony deposits on the head and anterior part of the back; a strong glandular fold from eye to shoulder, usually another on each side of the back; upper eyelid with a sharp, raised edge, which is produced into a more or less distinct point or "horn;" this point may be very indistinct (var. *aceras* Blgr.), or very much developed, measuring nearly $\frac{2}{3}$ diameter of eye; as a rule it does not measure more than $\frac{1}{2}$ diameter of eye; an indication of a similar appendage on the tip of the snout rarely present; * a more or less developed pointed tubercle usually present behind the commis-

[44] Proc. Zool. Soc. London 1 (1908) 411.
"* In a specimen from Java, where the species is most abundant."

sure of the jaws; limbs usually with oblique transverse glandular ridges; throat smooth, belly with small tubercles."

Color.—"Olive-brown above, uniform or variously marked with darker or lighter; a more or less distinct large triangular dark spot between the eyes, the base forwards, and a dark oblique bar below the eye; limbs with more or less distinct dark cross-bars; lower parts pale brown, spotted or marbled with darker; a white tubercle on each side of the breast. Male without vocal sac."

Measurements of Megalophrys montana (Kuhl).

	Male. mm.	Female. mm.
Length, snout to vent	55	88
Length of head, to occiput	19	27
Width of head	29	43
Length of snout	6	8
Diameter of eye	6	8
Interorbital width	10	14
Diameter of tympanum	4	4
Distance between eye and tympanum	6	9
Foreleg	35	53
Hand	16	23
Hind leg	70	110
Tibia	23	35
Foot	21	35

Remarks.—(From Boulenger.) "It is a sluggish and thoroughly nocturnal animal. Nothing has been observed concerning its breeding-habits; but I find the eggs to be large, those in the oviduct of a specimen 83 millim. long measuring 3 millim. in diameter. * * * tadpoles are found in mountain streams with gravelly beds and are remarkable for the funnel-like float formed by the lips, which are beset with minute horny teeth; these are not connected in any way with definite ridges or lamellæ, but radiate along the anterior surface of the funnel. According to Annandale, the funnel-shaped lip is capable of assuming two very distinct forms, according to the position of the tadpole:—(1) When the animal is hanging from the surface-film, as it frequently does, this structure becomes a translucent rhomboidal or lozenge-shaped float, depressed in the center towards the mouth, but otherwise nearly flat; (2) when, on the other hand, the animal is resting on the bottom, the float takes on the appearance of a pair of slender processes, continued upwards on the sides, like a pair of horns. As in other

Pelobatidæ, the spiraculum is sinistral. The tail is more than twice as long as the body, the total length of the largest tadpole being about 40 millim. The coloration is of a very dark brown, even on the belly."

Megalophrys hasselti (Tschudi). Plate 8, figs. 4 and 4*a*.

Leptobrachium hasseltii TSCHUDI, Class. Batr. (1838) 81; GÜNTHER, Cat. Batr. Sal. (1858) 36; BOULENGER, Cat. Batr. Ecaud. (1882) 441; Zool. Rec. (1885), Rept. 24; Proc. Zool. Soc. London (1890) 37; Fauna Brit. India, Rept. (1890) 511; ISENSCHMID, Mitth. Nat. Ges. Bern (1903) 20; VAN KAMPEN, Zool. Jahrb. Syst. 22 (1905) 712.
Rana hasseltii SCHLEGEL, Handl. Dierk. (1858) 56, pl. 4. fig. 71.
Megalophrys hasselti BOULENGER, Proc. Zool. Soc. London 1 (1908) 425.

Description of species.—(From Boulenger, Proc. Zool. Soc. London, 1908.) "Tongue nicked behind. Vomerine teeth absent. Head large, about once and $\frac{1}{4}$ as broad as long; snout rounded, not projecting beyond lower jaw, about as long as orbit; canthus rostralis distinct; loreal region very oblique, concave; nostril a little nearer end of snout than eye; interorbital space a little broader than upper eyelid; tympanum hidden or feebly distinct, its diameter $\frac{1}{2}$ to $\frac{2}{3}$ that of eye, from which it is separated by a space less than its own diameter. Fingers obtuse, not swollen at the end, first and second equal or first the longer, third nearly twice as long as second; subarticular tubercles, if distinct, irregular in their disposition; two moderately large carpal tubercles, inner a little larger than outer. Toes short, obtuse, like the fingers, webbed at the base in females, $\frac{1}{4}$ to $\frac{1}{2}$ webbed in males; third toe not reaching beyond base of antepenultimate phalanx of fourth; subarticular tubercles sometimes distinct, sometimes more or less confluent into an obtuse ridge; inner metatarsal tubercle small, oval, feebly prominent. Tibiotarsal articulation reaching the shoulder; tibia $\frac{1}{3}$ to $\frac{2}{5}$ length from snout to vent; foot as long as head. Skin smooth or with small tubercles above, granular on belly; a glandular fold from eye to shoulder."

Color.—"Brown, grey, or pale olive above, with small or large dark brown spots or marblings, which may be irregular or form a symmetrical pattern; a more or less distinct dark canthal and temporal streak; sides of snout with dark vertical bars; limbs with dark cross-bars; throat and belly dirty white, or brown speckled with white. Male with an internal vocal sac."

Measurements of Megalophrys hasselti (Tschudi).

	Male. mm.	Female. mm.
From snout to vent	47	74
Length of head, to occiput	16	23
Width of head	20	31
Length of snout	6	10
Diameter of eye	5	9
Interorbital width	6	10
Diameter of tympanum	3	6
Distance between eye and tympanum	2	4
Foreleg	33	50
Hand	11	16
Hind leg	53	79
Tibia	16	24
Foot	15	23

"The larva has been first noticed by me, from specimens from Sumatra and Perak, and others have since been obtained in Selangor by Mr. Butler, and in Perak by Dr. Hanitsch. These tadpoles are of the same type as the typical Pelobatids of Europe, but remarkable in being marked all over with numerous deep black dots or round spots. No observations have been made on the breeding-habits, but it is probable that the eggs are laid in the water, being similar to those of *Pelobates*. Eggs from the oviducts of a female 65 millim. long measure 2 millim. in diameter.

"Mr. A. L. Butler observes (Journ. Bombay N. H. Soc. xv. 1904, p. 397) that the larval period of existence is very prolonged, and that the tail does not disappear until the size of about 40 millim. (from snout to vent) is attained."

ILLUSTRATIONS

[Drawings by M. Ligaya; photographs by E. Cortes.]

PLATE 1

FIG. 1. *Oxyglossus lævis* Günther. After Günther, Cat. Batr. Sal. Brit. Mus. (1858), pl. 1, fig. A.
2. *Rana erythræa* (Schlegel). Photograph of a preserved Negros specimen, E. H. Taylor collection; reduced.
3. *Philautus leitensis* (Boulenger). Photograph of a preserved specimen, No. B38, Bureau of Science collection; about natural size.
4. *Rana moellendorffi* Boettger. Photograph of a preserved Palawan specimen, Bureau of Science collection; about natural size.
5. *Rana moodiei* sp. nov. Photograph of the preserved type specimen; reduced.

PLATE 2

FIG. 1. *Rana leytensis* Boettger. Photograph of a preserved specimen; somewhat reduced.
2. *Rana magna* Stejneger. Photograph of a preserved Polillo specimen; greatly reduced.
3. *Rana vittigera* Wiegmann. Photograph of a freshly killed specimen; greatly reduced.
4. *Polypedates leucomystax* (Gravenhorst). Photograph of a newly killed specimen; natural size.

PLATE 3

FIG. 1. *Cornufer laticeps* sp. nov. Drawing of the type; slightly reduced.
2. *Philautus hazelæ* sp. nov. Drawing of the type; natural size.
3. *Chaperina beyeri* sp. nov. Drawing of the type; natural size.
4. *Rana parva* sp. nov. Drawing of the type; natural size.
5. *Philautus montanus* sp. nov. Drawing of the type; natural size.

PLATE 4

FIG. 1. *Polypedates pardalis* (Günther). Photograph of the type of *Rhacophorus rizali* Boettger.
2. *Staurois natator* (Günther). 2*a*, mouth. After Günther, Cat. Batr. Sal. Brit. Mus. (1858), pl. 4, fig. C.
3. *Cornufer corrugatus* (Duméril). 3*a*, mouth; 3*b*, foot. After Günther, Cat. Batr. Sal. Brit. Mus. (1858), pl. 8, fig. 3 (*Platymantis plicifera*).
4. *Rana mearnsi* Stejneger. Photograph of a preserved Negros specimen; much reduced.
5. *Rana similis* (Günther). Photograph of a preserved Luzon specimen; somewhat reduced.

PLATE 5

FIG. 1. *Rana glandulosa* Boulenger. 1*a*, mouth; 1*b*, underside of head, showing arm glands. After Boulenger, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882), pl. 7.

2. *Rana sanguinea* Boettger. Photograph of a preserved Busuanga specimen; somewhat reduced.

PLATE 6

FIG. 1. *Rana everetti* Boulenger. 1*a*, side of head; 1*b*, mouth. After Boulenger, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882), plate.

2. *Polypedates pardalis* (Günther). 2*a*, mouth. After Günther, Cat. Batr. Sal. Brit. Mus. (1858), pl. 6, fig. D.

PLATE 7

FIG. 1. *Hazelia spinosa* sp. nov. Drawing of the type; natural size.

2. *Rana grandocula* sp. nov. 2*a*, side of head. Drawing of the type; natural size.

3. *Nectophryne lighti* sp. nov. 3*a*, side of head. Drawing of the type; × 4.

PLATE 8

FIG. 1. *Cornufer guentheri* Boulenger. 1*a*, mouth. After Boulenger, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882), pl. 11, fig. 3.

2. *Polypedates appendiculatus* (Günther). 2*a*, foot; 2*b*, mouth. After Boulenger, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882), pl. 8, fig. 4.

3. *Cornufer meyeri* (Günther). After Boulenger, Cat. Batr. Sal. Brit. Mus. ed. 2 (1882), pl. 11, fig. 4.

4. *Megalophrys hasselti* (Tschudi). 4*a*, side of head. After Boulenger, Proc. Zool. Soc. London (1898) plate.

PLATE 9

FIG. 1. *Kaloula conjuncta* (Peters). Photograph of a preserved Mindanao specimen; somewhat reduced.

2. *Kalophrynus stellatus* Stejneger. Photograph of a preserved specimen; natural size.

3. *Chaperina visaya* sp. nov. Photograph of the type; enlarged.

4. *Kaloula picta* (Bibron). Photograph of a preserved specimen; natural size.

5. *Bufo philippinicus* Boulenger. Photograph of a preserved specimen; somewhat reduced.

PLATE 10

FIG. 1. *Megalophrys stejnegeri* sp. nov. Drawing of the type; natural size. 1*a*, side of head.

2. *Megalophrys ligayæ* sp. nov. Drawing of the type; natural size. 2*a*, side of head.

TEXT FIGURES

FIG. 1. *Rana erythræa* (Schlegel). *a*, side of head; *b*, hand; *c*, foot. × 1.
2. *Rana mearnsi* Stejneger. *a*, side of head; *b*, top of head; *c*, hand; *d*, foot. × 1.
3. *Cornufer guentheri* Boulenger. *a*, side of head; *b*, top of head; *c*, hand; *d*, foot. × 2.
4. *Cornufer meyeri* (Günther). *a*, side of head; *b*, foot; *c*, hand. × 2.
5. *Cornufer corrugatus* (Duméril). *a*, side of head; *b*, foot; *c*, hand. × 2.
6. *Kaloula picta* (Bibron). *a*, side of head; *b*, foot; *c*, hand. × 2.
7. *Kaloula baleata* (Müller). After Boulenger. *a*, hand; *b*, foot.
8. *Kaloula conjuncta* (Peters). *a*, side of head; *b*, foot; *c*, hand. × 1.
9. *Bufo melanostictus* Schneider. After Stejneger. *a*, top of head; *b*, side of head; *c*, hand; *d*, foot.

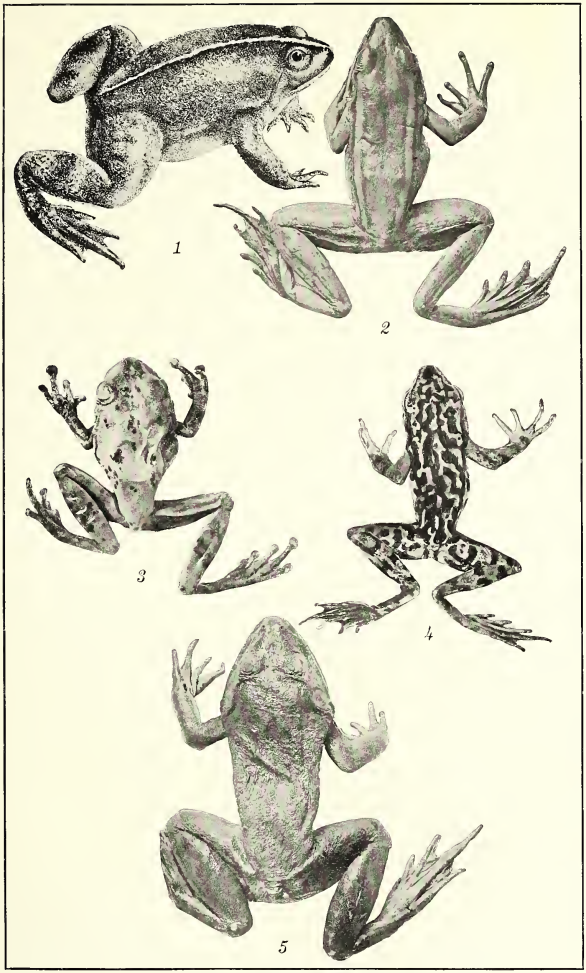

PLATE 1. PHILIPPINE AMPHIBIA.

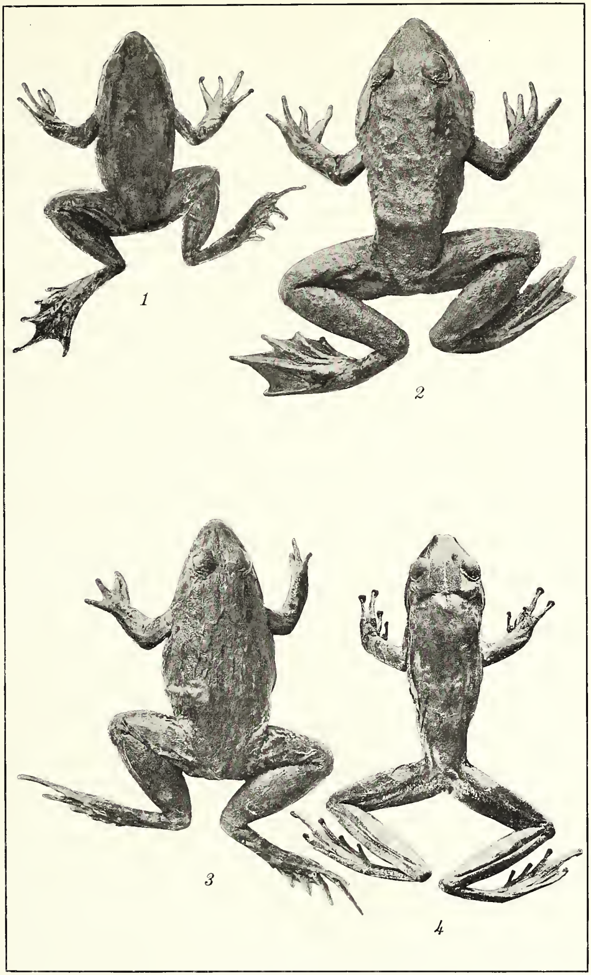

PLATE 2. PHILIPPINE AMPHIBIA.

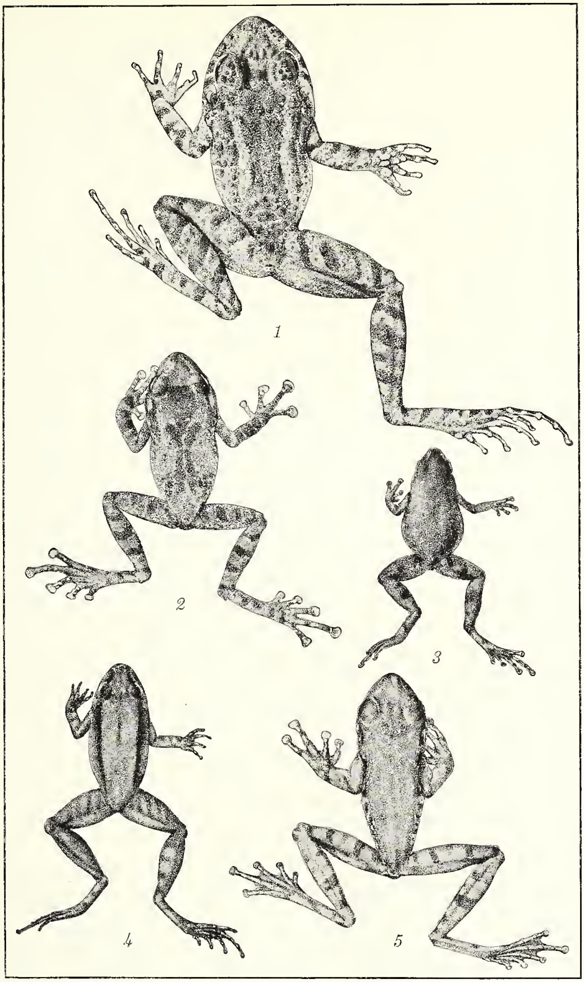

PLATE 3. PHILIPPINE AMPHIBIA.

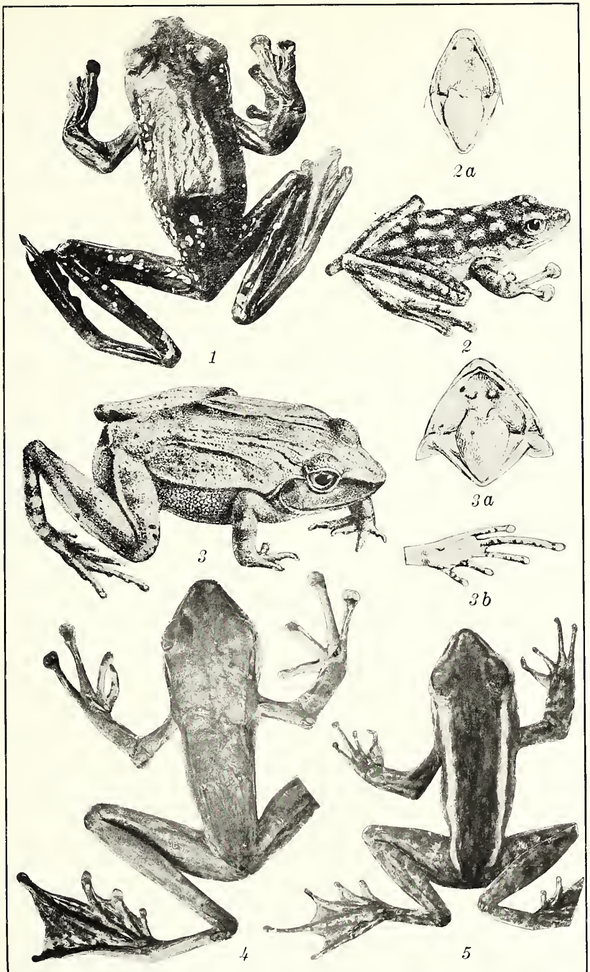

PLATE 4. PHILIPPINE AMPHIBIA.

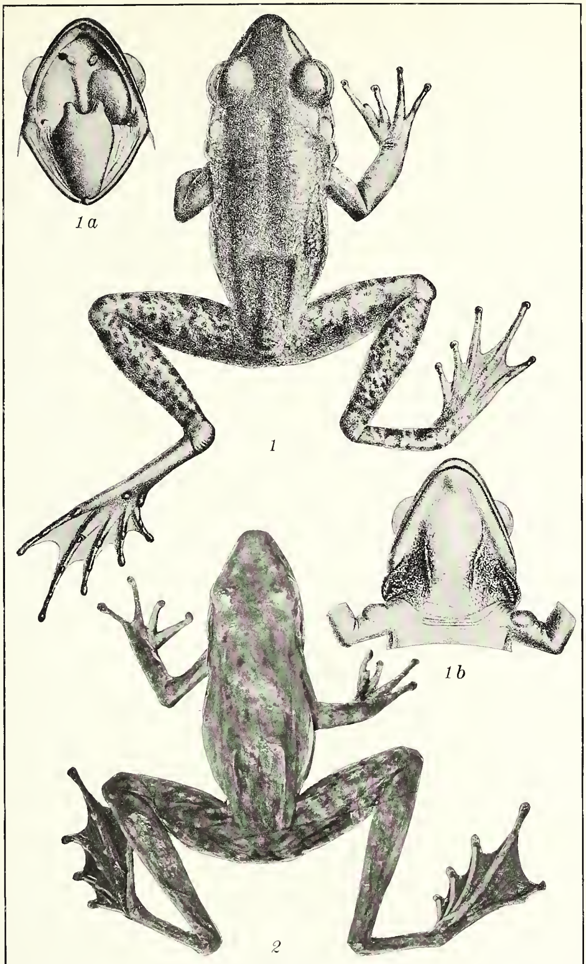

PLATE 5. PHILIPPINE AMPHIBIA.

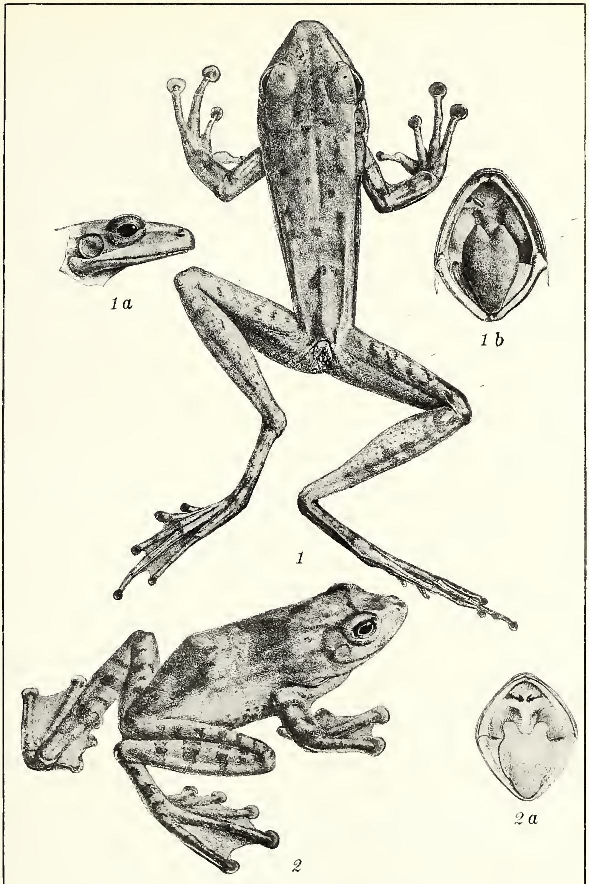

PLATE 6. PHILIPPINE AMPHIBIA.

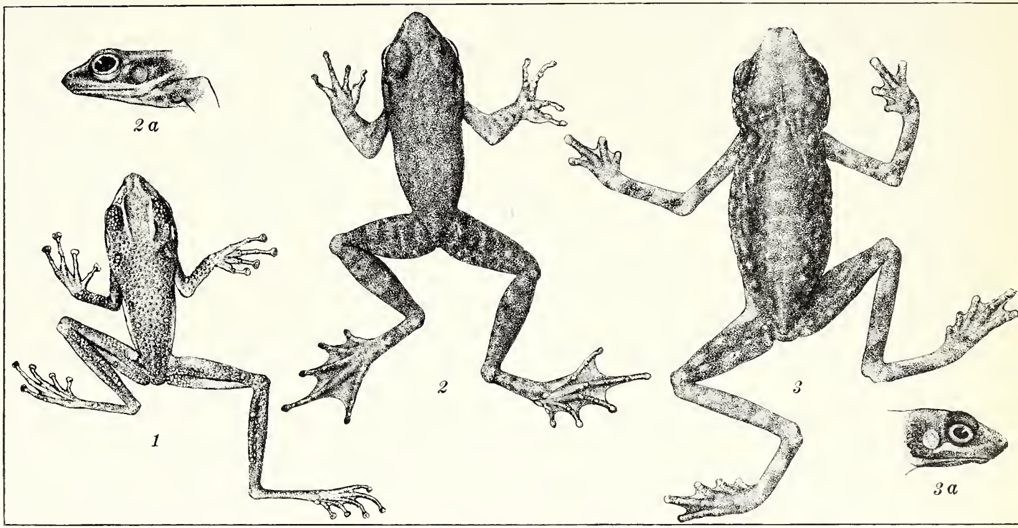

PLATE 7. PHILIPPINE AMPHIBIA.

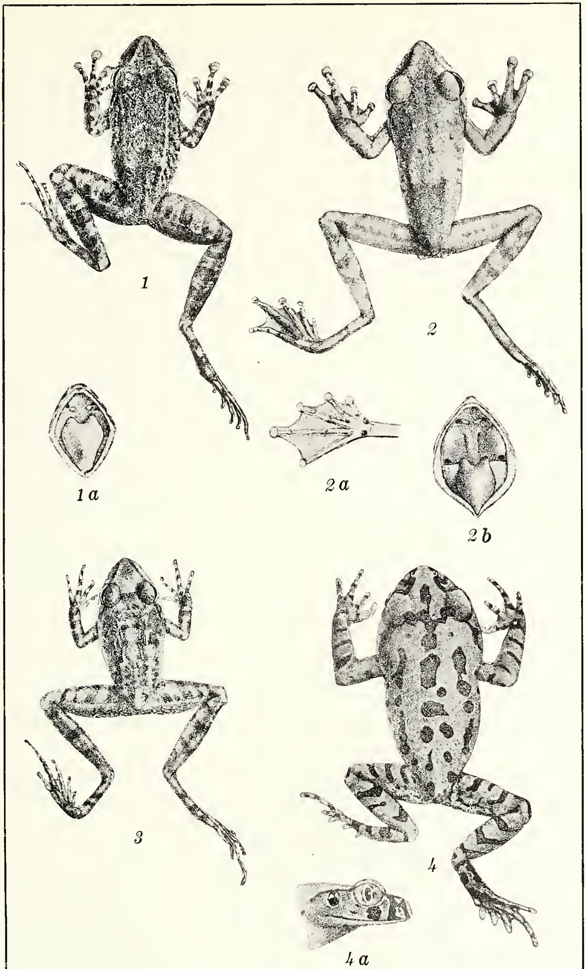

PLATE 8. PHILIPPINE AMPHIBIA.

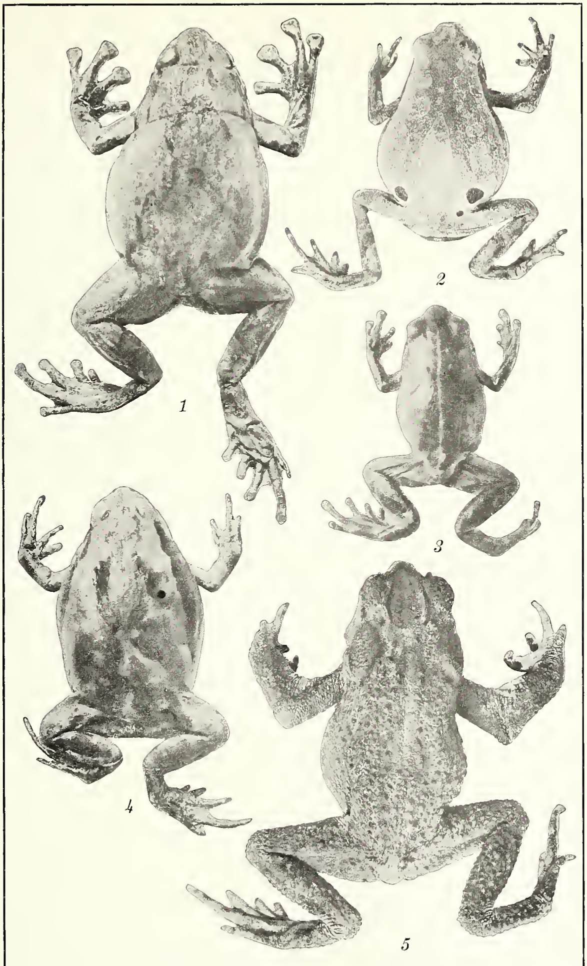

PLATE 9. PHILIPPINE AMPHIBIA.

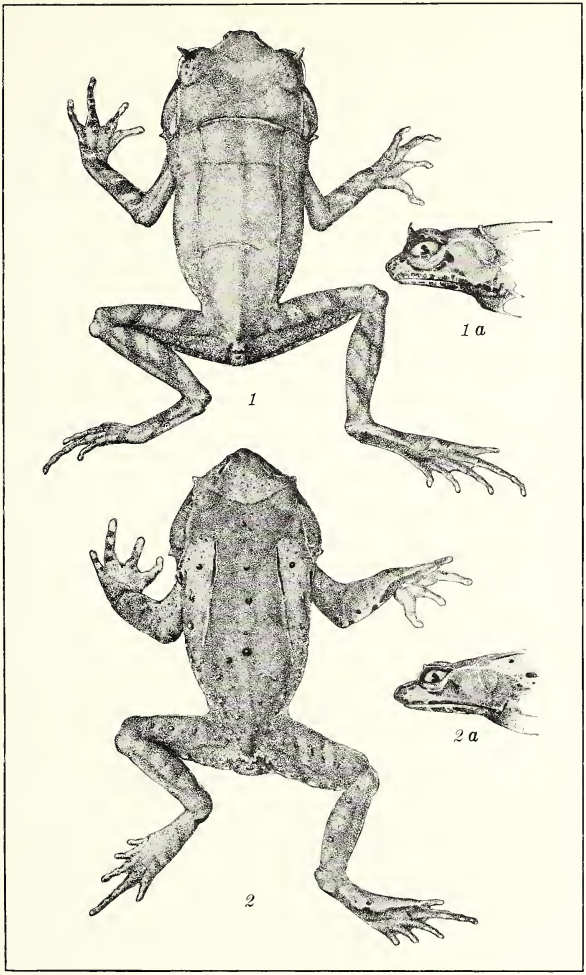

PLATE 10. PHILIPPINE AMPHIBIA.

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 16 APRIL, 1920 No. 4

SOME FEATURES OF THE PHILIPPINE ORNIS

WITH NOTES ON THE VEGETATION IN RELATION TO THE AVIFAUNA

By RICHARD C. McGREGOR
Ornithologist, Bureau of Science, Manila

THIRTY-FIVE PLATES

SCARCITY OF SEA BIRDS IN PHILIPPINE WATERS

Ships from China approach Manila from the north and pass along the western coast of northern Luzon. A few steamers, mostly United States Army transports from California, pass through San Bernardino Strait, between Luzon and Samar, and thus reach the entrance to Manila Bay from the south. By either route Luzon is within sight for two or three days; but no gulls meet the ship to convoy her to port, and other sea birds are very scarce. A few stolid gannets, an occasional man-of-war bird, and an infrequent shearwater or petrel are all that can be expected.

Tubinares appear to be very rare in Philippine waters, for only three species have been recorded here. These are *Puffinus leucomelas* Temminck, one specimen of which was collected by Hugh Cuming,[1] and another, by Paul Bartsch;[2] *Puffinus chlororhynchus* Gould, collected by Dean C. Worcester off the Zambales coast in 1910;[3] and *Oceanodroma* species, collected by me near

[1] Salvin, Osbert, Catalogue of the Birds in the British Museum. London **25** (1896) 371. Mathews and Iredale, Ibis X **3** (1915) 592, fig. 9, *b* and *d*, make *Puffinus leucomelas* the type of a new genus, *Calonectris*. They also record two "adult breeding birds in good plumage" from Pescadores Islands, May, 1909.

[2] Mearns, E. A., Proc. U. S. Nat. Mus. **36** (1909) 464.

[3] McGregor, R. C., Philip. Journ. Sci. § D **6** (1911) 183.

Mariveles during a severe typhoon.[4] The last specimen lacks the tail, and the species has not been determined. It is possible that both petrels and shearwaters nest on some of the many, small, uninhabited islands of the Archipelago. The gannets and the man-of-war birds have been rarely collected in Philippine waters, yet they are abundant on their breeding grounds, the small islands of Sulu Sea.[5] Gannets are believed to nest also on Didicas Rocks, north of Luzon.[6] During typhoon weather man-of-war birds are seen near Manila, and there is a record of *Fregata ariel* (Gould) having been collected on the northern coast of Luzon.[7]

Larus ridibundus Linnæus, a small species of gull, is fairly common in Manila Bay, but the genus is poorly represented in Philippine waters. The only other gull recorded is *Larus vegæ* (Palmen). However, there are several species of terns. *Hydrochelidon leucoptera* (Temminck) is rare, and *H. hybrida* (Pallas) is fairly abundant. *Anous stolidus* (Linnæus) has been collected in Sulu Sea, and *Micranous worcesteri* McGregor, an endemic species, breeds in abundance on Cavilli Island, in Sulu Sea.[8] Seven species of *Sterna* have been recorded from various parts of the Islands. *Sterna boreotis* Bangs is a large and abundant species; the others are small and of irregular distribution and occurrence, and very little is known about them. With the exception of *Micranous worcesteri,* all of these terns are of rather wide distribution in the world. Not much effort has been made to collect them, and the Philippine records are very sporadic. For example, *Sterna sinensis* (Gmelin), which ranges from the Chinese and Indian seas to Australia, has been recorded in the Philippine Islands only from widely separated islands—Mindanao, Mindoro, Palawan, and Polillo. Siquijor was for a long time the only Philippine locality for *Sterna fuscata* Linnæus, but this species is now known to breed on Maeander Reef.[9] Panay is the type locality of *Sterna anætheta* Scopoli; although this species is well known in many parts of the world, the records of it as a Philippine bird are surprisingly few. *Sterna gracilis*

[4] Idem, Bull. Philip. Mus. 4 (1904) 12.

[5] Worcester, D. C., Philip. Journ. Sci. § D 6 (1911) 167.

[6] Ibid. § A 2 (1907) 275.

[7] Grant, W. R. O., Ibis VII 2 (1896) 128.

[8] McGregor, R. C., Philip. Journ. Sci. § D 6 (1911) 184. Mathews places this species in the genus *Megalopterus;* see also Ridgway, Birds of North and Middle America 8 (1919) 553.

[9] McGregor, R. C., Philip. Journ. Sci. § D 13 (1918) 4.

Gould [10] has been only recently credited to the Philippines. The cormorants, the pelicans, and the grebes are represented by a single species each—even these are seldom found about salt water.

The foregoing include all of the Philippine sea birds. Puffins, guillemots, sea ducks, and auklets, characteristic of northern seas, are altogether lacking here. By describing this feature of the Philippine ornis first there is danger of giving it too much emphasis, but this scarcity of sea birds is sure to impress anyone that is familiar with the many sea birds of Asia or of the Pacific coast of North America.

TOPOGRAPHIC FEATURES OF THE MANILA AREA

Guarding the entrance to Manila Bay are several rocky islands—Monja, Corregidor, Caballo, Fraile—the largest and highest of which is Corregidor. To the northwest of the entrance are the forested Mariveles Mountains, of Bataan Province, with elevations of 1,200 to 1,400 meters; [11] to the southeast are the lower areas of Cavite and Batangas Provinces.

Manila lies northeast of Corregidor Island, nearly opposite the entrance to Manila Bay, at the mouth of Pasig River. From the water the city usually appears to be enveloped in a smoky haze, and the monotony of the low land immediately surrounding the town is broken only by the dim outlines of the distant mountains of Laguna, Rizal, and Pampanga Provinces. At one time most of the land on which Manila is situated must have supported nipa and mangroves and have been cut by numerous sluggish streams. The swamps have been gradually filled, so that scattered unfilled areas and the numerous tortuous esteros, or tidal creeks, are the only visible remains of the old swamps. The esteros are tributary to Pasig River, which is the outlet of Lake Bay and flows through Manila.

North and northwest of Manila the area near the bay shore in Bulacan and Pampanga Provinces is a vast swamp cut by esteros, an area similar to what Manila must have been before there was a city. Many of these streams are outlets for the Pampanga and other rivers, which drain an immense area of low, flat land north and northwest of Manila. The shallow water of Manila Bay off shore from this swampy area covers a deposit of deep black mud. As the shore enters Bataan

[10] Ibid. 3.

[11] See Whitford, H. N., Philip. Journ. Sci. 1 (1906) 376 and map.

Province, it turns sharply to the south, the land becomes more elevated, with alternate stretches of sand beach and rocky shore and the water near the land is deeper. South of Manila the coast extends in a gentle curve to Cavite and Cañacao. In this direction a fine sand beach extends from Pasay to Parañaque. Inland, a few kilometers southeast of Manila, the land has a gentle slope to the slightly elevated area that overlooks Lake Bay. The military reservation of Fort William McKinley is situated on this high ground.

CONSPICUOUS BIRDS OF MANILA

As the ship slowly enters the fine artificial basin that is Manila harbor, it is usually attended by a dozen or more scavenger hawks—*Haliastur intermedius* Gurney. The adult is a handsome bird, having the head and lower parts white and the rest of the plumage rich chestnut, but immature individuals are very commonplace in appearance. This species is especially abundant about shipping, both in bays and rivers, and feeds on scraps from ships' galleys and on other garbage. Occasionally individuals or small flocks of *Sterna boreotis*, *Hydrochelidon hybrida*, and *Larus ridibundus* may be seen in the harbor, but they are seldom abundant.

The first land bird to greet the visitor to Manila will doubtless be a fringillid, *Passer montanus* (Linnæus). This species is a native of Europe that is now well established in Manila and in many of the towns along the railroads or that are reached by water transportation. It is found in Dagupan, north of Manila, on the railroad and probably farther north and has reached many of the towns on Lake Bay. Outside of Luzon the mountain sparrow has extended its range to Cebu. This sparrow may be seen in small flocks along wagon roads and railroads and in old fields at some distance from houses. At first sight the mountain sparrow is easily mistaken for the European house sparrow, *Passer domesticus* (Linnæus), but the two species are sufficiently distinct. The former does not seem to increase with the rapidity of its less favorably known cousin and is not so great a pest.

STARLINGS AND LOCUSTS

The next bird that will be noted even by those who are not devoted to ornithology is a slate-gray starling, *Æthiopsar cristatellus* (Linnæus), about the size of an American robin. When this bird flies, a white band across the primary quills is conspicuously displayed. The feathers of the frons are long and erect or strongly antrorse, giving the head a curious profile view. The larger tail feathers are tipped with white. For several years there was a roost of these starlings in the trees in front of the Luneta police station, on Bagumbayan Drive, where their chatter was very noticeable at dusk. A closely related species, *Acridotheres tristis* (Linnæus), was introduced into Hawaii, where it is well established; I found it extremely abundant on Maui Island in 1900.[12] Both of these species are natives of southern Asia.

Æthiopsar cristatellus appears to have been introduced by the Spanish Government about 1850 with the hope that it would reduce the number of locusts, which were and still are a very serious pest to the agriculturist.

A quotation in Blair and Robertson [13] indicates that at least three attempts, 1849 to 1852, were made to introduce and establish a species of *martín* (probably one of the starlings) in the Philippines. Foreman [14] says:

> In 1851 the Government imported some MARTINS from China with the hope of exterminating the locusts. When the birds arrived in the port of Manila they were right royally received by a body of troops. A band of music accompanied them with great ceremony to Santa Mesa, where they were set at liberty, and the public were forbidden to destroy them under severe penalties.

Martín, as a Spanish word, is correctly applied to birds called starlings in English and is not equivalent to "martin" (species of Hirundinidæ). I have been under the impression that the bird introduced into the Philippines received its local name from Juan Antonio Martinez, governor from 1822 to 1825, but this governor left the Philippines twenty-five years before the arrival of *pájaros martines*. Casto de Elera[15] gives the name *martín langostero* for *Acridotheres cristatellus*. In Manila the common name for this species seems to be martines, not martinez as recorded by me.[16] As the Tagalog language makes no distinction in form to indicate number in nouns, the Spanish *pájaros martines* would readily become "martines," singular and plural.

Probably this starling does eat some locusts, but it has not

[12] Condor 4 (1902) 60.

[13] The Philippine Islands 1493–1898. The Arthur H. Clark Company, Cleveland 51 (1907) 127.

[14] The Philippine Islands ed. 3. Charles Scribner's Sons, New York (1906) 341.

[15] Fauna de Filipinas. Imprenta del Colegio de Santo Tomás, Manila 1 (1895) 199.

[16] A Manual of Philippine Birds. Bureau of Science, Manila (1909) 717.

increased in numbers rapidly enough to be of marked value in combating the locust pest. Like the mountain sparrow the starling has spread to towns in the vicinity of Manila; it is found in some of the towns about Lake Bay, and it was noted at Tagudin, Ilocos Sur, in 1909;[17] but while the former species is also established in the city of Cebu, the latter has been recorded only on Luzon.

The damage done by locusts constitutes one of the most serious problems of the agriculturist in the Philippine Islands.[18] The presence of these insects may be unsuspected until a few appear and alight. These may be so few, perhaps from three to five individuals to a square meter, as to cause little damage and comment. They may remain to feed, but often they move on in a few hours. Then there may appear a thicker flock so that ten, fifteen, or twenty are flushed at each step. As they become more numerous the rushing of their wings has an ominous sound, they obscure the sun, and bright green trees turn brown as the myriads settle to feed; corn, rice, and coconut leaves are stripped to the midrib. They settle on bamboos in such numbers that their weight causes even the largest of these trees to bend so that the tips of the stems nearly touch the ground. After the locusts have left, the ground beneath a clump of bamboo is littered with excreta and shredded leaves, as if twenty pounds of dust shot had been fired into the tops of the trees from the horn of a phonograph. They will eat even the dry nipa leaves on the roofs of houses. In a few hours or a day the main flock moves on, and at the end of two days there is usually none left.

The attempt to reduce the number of locusts by killing the adults is much like trying to restrain the tide with a broom. When the flock of locusts attacks a crop, there is comparatively little value in anything that can be done against them. Millions are caught in large scoop nets; these are killed in boiling water, and hundreds of bushels are sold for food in the Manila markets. Several species of birds eat locusts, and at times a curious mixed company of rollers, hawks, cuckoos, and other species can be seen in the air and on the ground eating them to repletion. Although birds eat many of the adult locusts, ten times as many birds would have no perceptible effect upon the flocks. Birds probably eat many locusts in the young stages and may thus

[17] Philip. Journ. Sci. § D 5 (1910) 219.

[18] See Jones, C. R., and Mackie, D. B., Philip. Agr. Rev. 6 (1913) 5–22; also Mackie, D. B., ibid. 538.

prevent more frequent flights that might destroy everything green.[19]

When the locusts have been cooked, they are dried, packed in sacks or baskets, and saved for food. The wings, the legs, and the dorsal shield of the thorax are removed; and the heads and bodies are fried. I have eaten locusts but cannot say that I care for them. They seem to have little flavor except that of the added salt, pepper, and vinegar, while the chitinous substance in the body covering is disagreeable. It is much the same as eating shrimps without removing the shells. The females are said to be of especially fine flavor when the bodies are distended with eggs. Boiled and partly dried locusts are sold in the Manila markets whenever they can be caught nearby.

Experiments in the destruction of this pest with bacterial disease of locusts have been made, but the results were not very satisfactory.[20] Recently the use of poisonous gas after European war methods has been suggested, but the technic does not seem to have been perfected; and I have not learned whether

[19] Some idea of the numbers of the locusts can be gained from the following from Jones and Mackie, op. cit.:

Using large circular hand nets in Cebu "in one hour three men using these nets captured 12 cavans [1 cavan, or caban, equals 75 liters] of insects; also at Mandaue, Cebu, sixteen nets caught 57 cavans of voladores [fliers, that is, winged locusts] in five hours." [p. 14.]

"At Carcar, Cebu, eleven persons engaged in digging out egg clusters averaged about 125 liters (about six kerosene cans full) of egg clusters per day." [p. 12.]

"It is estimated that the pit method accomplished the destruction between June and October of upwards of 8,000 cavans of hoppers in Bohol, while within a very short space of time some 20,000 cavans were reported to have been destroyed in Iloilo, and the total amount for the Province of Cebu may be estimated anywhere between 10,000 and 25,000 cavans." [p. 14.]

"Wild birds, however, are of more importance than is generally believed for they, from the very first appearance of the young locusts as they issue from the ground, wage a continuous warfare upon the swarm."

These authors (p. 19) consider the following to be "the most important locust destroyers" among Philippine birds:

Otomela lucionensis (Linnæus).
Bubulcus coromandus (Boddaert).
Halcyon gularis (Kuhl).
Halcyon chloris (Boddaert).
Alcedo bengalensis Gmelin.
Numenius variegatus (Scopoli).
Numenius arquatus (Linnæus).
Numenius cyanopus Vieillot.
Charadrius fulvus Gmelin.
Excalfactoria lineata (Scopoli).
Turnix fasciata (Temminck).
Gallus gallus (Linnæus).
Eurystomus orientalis (Linnæus).
Merops americanus P. L. S. Müller.
Merops philippinus Linnæus.

[20] See Barber, M. A., and Jones, C. R., Philip. Journ. Sci. § B 10 (1915) 163–176.

this was proposed seriously or merely in fun. It is probable that the cost would be out of all proportion to the benefits.

OTHER LAND BIRDS FOUND IN MANILA

The mountain sparrow and the martin langostero are the only species of birds that have adapted themselves to life in the busy parts of the town and that can be found there in abundance; even if we extend our observations to include the entire city, surprisingly few other birds can be seen. Nearly all of the birds to be found in or near Manila are migratory species or range throughout the Archipelago. As I shall point out in more detail, most of the endemic species of birds live only in the virgin forest and disappear with it. A very few of these species have become adapted to life in the cultivated areas and in the second-growth forests.

Many of the streets of Manila are shaded by large trees, the most abundant being several kinds of palms and various species of Leguminosæ with beautiful and conspicuous blossoms. Among the latter are the royal poinciana, *Delonix regia* (Bojer) Rafinesque, with gorgeous red and yellow flowers; the rain tree, *Samanea saman* (Jacquemont) Merrill, with rather small pink flowers; *Cassia siamea* Lamarck and *Peltophorum inerme* Naves, both with large showy yellow flowers; and the dap-dap, *Erythrina indica* Lamarck, with large red flowers.[21] The old botanic garden contains examples of many species of shrubs and trees, and there are private and commercial gardens that contain interesting collections of plants. The Cementerio del Norte, the largest burying ground of the city, is a beautiful example of what can be done in gardening on a large scale.[22] Very few of these cultivated plants are native species, and very few native birds take advantage of the planted vegetation.

A common bulbul, *Pycnonotus goiavier* (Scopoli); a migratory shrike, *Otomela lucionensis* (Linnæus); and a small, inconspicuous warbler, *Acanthopneuste borealis* (Blasius), occasionally visit the trees in my yard; and these three species are fairly common in Manila. The rufous-bellied cuckoo, *Cacomantis merulinus* (Scopoli), is often seen and heard in Manila, where its curious querulous call has earned for the bird the Tagalog name *masakit*. A shy thrush, the Siberian rubythroat, *Calliope calliope* (Pallas), occasionally sings early in the morning and at dusk. Three species of kingfishers—*Halcyon gularis*, *H. chloris*,

[21] See Merrill, E. D., Qr. Bull. Philip. Bur. Public Works 2[1] (1913) 34–41.

[22] See Merrill, E. D., Catalogue of the Plants Cultivated in the City Nursery at Cementerio del Norte. Manila, Bureau of Printing (1910) 40 pp. [Published by the city of Manila.]

and *Alcedo bengalensis*—are fairly common about Manila. The second and the third fish in small tidal streams within the city and often rest in convenient clumps of bamboo. I have found *Alcedo bengalensis* fishing in a small ditch, near the Walled City; and a specimen of *Halcyon chloris* can often be seen on Bagumbayan Drive, near the botanic garden. A grass warbler, *Cisticola exilis* (Vigors and Horsfield), sits on a telegraph wire, and a tailorbird, *Orthotomus chloronotus* Grant, sings in a bamboo thicket a few squares from the Bureau of Science. A small hawk, *Falco severus* Horsfield, has long made its headquarters on the roof of the Bureau of Science building. Two small swifts, *Tachornis pallidior* McGregor and a species of *Collocalia*, frequently fly over various parts of the city. Swallows, *Hirundo javanica* Sparrman and *H. gutturalis* Scopoli, can be seen over Pasig River in the busiest part of the city; and a large flock of these swallows regularly gathers the adults of the tobacco beetle, *Lasioderma serricorne* Fabricius,[23] as they emerge from a tobacco warehouse. Two species of doves, *Streptopelia dussumieri* (Temminck) and *Œnopopelia humilis* (Temminck), can be found in some of the few clumps of bamboo that remain about the edges of town.

Many of the birds mentioned in the last paragraph are not dependent upon any particular type of vegetation and are found feeding about streams, grasslands, second-growth thickets, and forests. The tailorbirds do not adapt themselves to planted vegetation in cities, but vanish with the clumps of bamboo and other wild thickets. The three kingfishers mentioned take kindly to man's alteration of the vegetation, and all of them are among the commonest species of birds to be noted on nearly every island. *Alcedo bengalensis* often feeds along the beach at low tide, and the two larger species are frequenters of coconut groves. I have recorded the interesting case of *Halcyon chloris* killing a half-grown chicken.[24] It sometimes happens that examples of these three kingfishers are within sight at one time, and they are conspicuous elements of the ornis.

Halcyon chloris is the noisest of these and its harsh, somewhat metallic call, "kak kak kak, kak kak," can be heard in the early morning, at midday, and late at night.

SHORE BIRDS OF MANILA

No city as large as Manila will offer many inducements to shore birds, but there are some low unfilled spots and natural

[23] For the life history of this beetle see Jones, C. R., Philip. Journ. Sci. § D 8 (1913) 1.

[24] Philip. Journ. Sci. § A 2 (1907) 346.

tidal creeks that are not altogether deserted. The common sandpiper, *Actitis hypoleucos* (Linnæus), clings to his old hunting grounds along the shores of an estero in Malate, and I can often see his teetering body from my window. Curlews, *Numenius variegatus* (Scopoli), stop each year on some marshy tideland that is now surrounded by houses. A few years ago we netted rails in a marshy area that is now filled and forms a part of Taft Avenue and a part of the Bureau of Science lawn. One day my cat brought into the house a specimen of the banded crake, *Hypotænidia torquata* (Linnæus). Small plovers can still be found within the city limits on Pasay Beach.

SHORE BIRDS OF THE PAMPANGA DELTA

The area now occupied by Manila was formerly inhabited by swamp-loving species and was visited by migratory shore birds. Nearly all of these have been driven out by the filling of their marshy haunts, and no other species have taken their places. However, within a few kilometers of Manila can be found two groups of birds, the members of which are characteristic of the open lowland of nearly all the islands. One of these groups includes the shore birds and the waders, the other comprises the birds of grasslands and second-growth thickets.

At the head of Manila Bay on the beach and about the openings of the delta of Pampanga River, already mentioned, there are wide flats, and beyond the flats is much shallow water. This is a way station of vast flocks of plovers, sandpipers, snipe, curlews, and godwits. I have never seen anywhere else such clouds of shore birds. I have published records of some of the rarer species,[25] and doubtless others will be added from time to time. The following is a nearly complete list of the shore birds that have been collected in the vicinity of Obando, Bulacan Province, Luzon, a few kilometers from Manila:

Arenaria interpres (Linnæus).
Ochthodromus geoffroyi (Wagler).
Ægialitis dubia (Scopoli).
Numenius arquatus (Linnæus).
Numenius cyanopus Vieillot.
Numenius variegatus (Scopoli).
Limosa baueri Naumann.
Limosa limosa (Linnæus).
Macrorhamphus semipalmatus (Jerdon).
Totanus eurhinus Oberholser.
Totanus stagnatilis Bechstein.
Actitis hypoleucos (Linnæus).
Terekia cinerea (Güldenstädt).
Glottis nebularius (Gunnerus).
Rhyacophilus glareola (Linnæus).
Pisobia ruficollis (Pallas).
Pisobia subminuta (Middendorff).
Heteropygia acuminata (Horsfield).
Erolia ferruginea (Brunnich).
Canutus rogersi Mathews.
Canutus tenuirostris (Horsfield).
Limicola platyrhyncha (Temminck).

[25] Philip. Journ. Sci. § D **11** (1916) 269–277, 2 text figs.; **13** 1–19, 3 pls., 10 text figs.

Besides the preceding species, which are found principally along the mud flats, several species of herons, rails, ducks, etc., inhabit the tidal streams and the marshland.

Snipe are abundant in rice fields during the fall and afford excellent sport. The most abundant species is *Gallinago megala* Swinhoe, while about one in fifty will be either of the closely related species *G. gallinago* (Linnæus) and *G. stenura* (Bonaparte). The curious painted snipe, *Rostratula capensis* (Linnæus), appears to be a resident species; it is slow and heavy in flight and somewhat rare.

Nearly all of these species of water birds have been recorded from one or more of the other large islands, and they may be expected to occur on any island whenever and wherever the time and the conditions are favorable. They are birds of passage, some of them of cosmopolitan range, others with a wide range in the Eastern Hemisphere. They are interesting but are not characteristic elements of the fauna and so indicate nothing as to the relation of this ornis to others.

BIRDS OF THICKETS AND GRASSLANDS

The open grasslands that have replaced the original forest support plant species for the most part of wide distribution. These areas are inhabited by birds of comparatively wide distribution, at least in the Philippine Islands.

In grassland such as exists in the area southeast of Manila and near Fort William McKinley one of the most characteristic birds is *Pratincola caprata* (Linnæus). This species calls to mind the American lark bunting, *Calamospiza melanocorys* Stejneger, in the black and white plumage of the male, in its haunts and habits, and in the fact that the sexes are very differently colored. Other species characteristic of grasslands are: *Cisticola exilis* (Vigors and Horsfield), a bird about the size of a bush tit and with a tail built on the same plan; *Alauda wattersi* Swinhoe, an oriental subspecies (?) of the skylark; *Anthus rufulus* Vieillot, somewhat similar to the North American *Anthus rubescens* (Tunstall); *Mirafra philippinensis* Ramsay, a thick-billed lark; *Megalurus palustris* Horsfield, a long-tailed, white, gray, and brown warbler the size of a chat; *Megalurus tweeddalei* McGregor, a smaller warbler; *Excalfactoria lineata* Scopoli, a small quaillike bird, the male of which has black and white markings on the head and the throat that are curiously suggestive of *Lophortyx californica* (Shaw); *Caprimulgus manillensis* Walden, a beautiful nightjar; *Tachornis pallidior* McGregor and species of *Collocalia,* small swifts that usually hunt over open land;

Munia jagori Martens, a weaver finch that often congregates in flocks of from two to three hundred individuals, although much smaller flocks are commoner. *Uroloncha everetti* (Tweeddale) is a less-abundant weaver finch.

One of the most interesting birds found in thickets and tall grass is *Centropus viridis* (Scopoli), a large, long-tailed cuckoo, entirely different from the small North American cuckoos and more like the roadrunner, *Geococcyx californianus* (Lesson). Its length is nearly 40 centimeters, of which 25 centimeters are appropriated for the wide wedge-shaped tail, the feathers of which are 3.5 centimeters wide. The entire plumage is lax and slightly harsh, thus being very suggestive of the roadrunner.

The grass owl, *Tyto longimembris* (Jerdon), which is very similar to the North American barn owl, is at home in open grassy country and is fairly abundant in the area under consideration. A species of Chinese quail has been introduced and seems to thrive in this area.

In bamboos and second-growth thickets that may grow in scattered clumps in the grassland, especially near streams, are found other species of wide distribution. Three species of doves, already mentioned, feed in fields and along roads and often rest in bamboos; a migratory green dove, *Chalcophaps indica* (Linnæus), feeds on the ground in thickets, flies near the ground, and avoids the open; *Copsychus mindanensis* Boddaert, a conspicuously marked, black and white, thrushlike bird with a pleasing hearty song, is found in bamboo thickets.

Another common black and white bird is *Rhipidura nigritorquis* Vigors; this creature appears to be very well pleased with itself for it seems to enjoy nothing better than to twist and turn, spread its long and strongly graduated, white-tipped tail, expand its wings, twitch its tail up and down, then flit to another twig and repeat the series. It has a harsh rasping call not at all consistent with its conceited actions, but it also executes a simple song of a few notes. This flycatcher is widely distributed in the Archipelago, having been noted on thirty-two islands, but it does not seem to occur north of Luzon; it is characteristic of lowland second-growth thickets and small forest and is quite at home in the mangroves.

Another equally common flycatcher, characteristic of the second-growth forest and of thickets bordering streams, is a beautiful blue species, *Hypothymis occipitalis* (Vigors); on the occiput there is a velvety black patch, and across the forebreast there is a narrow black crescent; the short feathers immediately posterior of the nostrils and in the rami of the lower jaw are black; most of the head is smalt blue, slightly darker and with a faint violet cast on the throat and breast, fading gradually to white on abdomen, flanks, and under tail coverts; the wings and upper parts are darker to about azurite blue; even the bill, eyelids, legs, and feet are blue. This flycatcher sits very quietly on a twig and often is not noticed until it moves to another perch. Like *Rhipidura nigritorquis* this species is found in many parts of the Archipelago.

Some of the other land birds that are more or less abundant in the vicinity of Manila, as well as throughout the Islands, and that inhabit open grassland, thickets, or second growth are:

Osmotreron axillaris (Bonaparte).
Osmotreron vernans (Linnæus).
Circus spilonotus Kaup.
Circus melanoleucos (Pennant).
Butastur indicus (Gmelin).
Elanus hypoleucus Gould.
Ninox japonica (Temminck and Schlegel).
Tyto longimembris (Jerdon).
Eurystomus orientalis (Linnæus).
Merops americanus P. L. S. Müller.
Merops philippinus Linnæus.
Cacomantis merulinus (Scopoli).
Eudynamys mindanensis (Linnæus).
Lalage niger (Forster).
Pycnonotus goiavier (Scopoli).
Petrophila manillensis (J. R. Forster).
Artamus leucorynchus (Linnæus).
Motacilla melanope Pallas.
Budytes leucostriatus Homeyer.
Emberiza sulphurata Temminck and Schlegel.
Padda oryzivora (Linnæus).
Oriolus acrorhynchus Vigors.
Lamprocorax panayensis (Scopoli).
Sarcops calvus (Linnæus).

The species enumerated so far are nearly all that can be found within several kilometers of Manila; there are doubtless a few more, but no effort has been made to record all of the species. Most of them are of wide distribution, at least within the Philippines; and are to be found wherever the vegetation is similar to that about Manila.

THE INTRODUCED ELEMENT OF THE PHILIPPINE FLORA [26]

In order to understand the distribution of the plants and the animals in the Philippine Islands and to search for and to collect specimens of the endemic species, it is necessary to realize that the areas now under cultivation or overgrown with grass and thickets were originally covered with forest. The casual visitor to the Philippines, even though he makes a fairly extended tour of the Islands, gets no idea of the forest. He sees vast areas covered with grass; fields of cultivated rice, sugar cane, corn,

[26] Prof. E. D. Merrill and Dr. W. H. Brown have read my entire discussion of the Philippine flora and have made welcome corrections and suggestions; as a result I believe that this part of the paper is in reasonable agreement with our present knowledge of the Philippine vegetation.

and tobacco, interspersed with various trees and shrubs; long, irregular lines of bamboo; hedges of madre cacao; many groves of coconut trees; and hillside and valley planted to bananas and abacá. Often a view across country suggests a distant forest, but on closer inspection the supposed forest proves to be merely planted fruit trees, bamboos, etc., scattered among cultivated fields. If his curiosity leads the traveler to a personal investigation and closer view of the jungle near some of the smaller towns, he finds that he must keep to the beaten path. On each side of the trail the tangle of coarse grasses, tough vines, and stiff shrubs effectually bars progress. Even with the help of a bolo, cutting a new trail in the average jungle is slow work.

There are real forests within easy reach from Manila, but comparatively few persons know where to look for them. The casual visitor then leaves the Islands with no adequate idea of their endemic vegetation. What is true here is doubtless true of other tropical countries visited by travelers that are not botanists, and thus has arisen the more or less prevalent, popular conception that the tropical vegetation is typically a jungle.

Whitford [27] says:

> In the more thickly settled portions of the Islands, and along well-traveled trails, practically all the original forests have disappeared, giving place to grass or second-growth forests. The second-growth forests are seen by the average traveler, and have conveyed the wholly wrong impression that the forests of the Philippines, and, it is believed, of the Tropics in general, are a densely overgrown mass of impenetrable jungle.

Some visitors to the Islands have been interested in the many curious plants that can be seen even about Manila, while others are enthusiastic in their praises of Philippine fruits; yet a large percentage of the species of plants found in and about Manila have been introduced. Few species yielding edible fruit are natives of the Philippine Islands, and not one is found among the more commonly cultivated fruit trees.

Of the 1,007 species of plants recorded by Merrill [28] for the vicinity of Manila, only 124 are endemic; 550 are indigenous—that is, native to the Archipelago or introduced by natural agencies; while 457 have been purposely or inadvertently introduced by man. Of the introduced species more than half are now spontaneous and about 225 are rarely found except as cultivated plants.

If we exclude the abacá plant (*Musa textilis* Née) and the various trees yielding timbers, gums, and resins, a few palms, some bamboos, the rattans,

[27] Bull. Philip. Bur. Forestry 10^1 (1911) 15.
[28] Philip. Journ. Sci. § C 7 (1912) 152.

etc., it will be found that practically all the species now found in the Archipelago that are of the greatest importance in the economy of the native, whether for food, for condiments, for clothing, for dyes, for ornamental purposes, and very many for medicinal purposes, have originated outside of the Philippines, and have purposely been introduced at one time or another. Not a single important food plant or fruit tree has originated in the Archipelago, but all have been introduced.[29]

In order to emphasize the statements in the preceding paragraph I have selected the names of one hundred well-known species from Merrill's Flora of Manila,[30] not one of which is a native of the Islands. All of these are useful in one way or another and have been purposely introduced.

GRAMINEÆ

Zea mays L.; corn, maize, mais. Introduced by the Spaniards at an early date; a native of tropical America; extensively cultivated for food.

Saccharum officinarum L.; sugar cane, caña dulce, tuba. Probably a native of tropical Asia; introduction into the Philippines prehistoric; a source of sugar.

Andropogon zizanioides Urb.; vetiver, moras or raiz de mora. A native of India, widely distributed in the Philippines and certainly introduced; its aromatic roots yield an essential oil.

Oryza sativa L.; rice, arroz, palay. A native of tropical Asia; introduction into the Philippines prehistoric; cultivated throughout the Philippines for the grain and the straw. There are many varieties cultivated in the Islands. This species is nowhere wild, but there are two or three wild species of the genus *Oryza* in the Philippines.

Bambusa vulgaris Schrad.; bamboo, cauayan quiling. Widely distributed in the Philippines; probably not a native, but of prehistoric introduction; used for general construction purposes.

Bambusa blumeana Schultes f.; "true bamboo," cauayan totoo. Common throughout the Islands; its introduction prehistoric, a native of Malay Peninsula and Archipelago; the bamboo most used for building material.

PALMÆ

Cocos nucifera L.; coconut, coco, niog. Cultivated throughout the Islands at suitable elevations. The original home of the coco palm is not definitely known, but it is certainly not a native of the Philippine Islands.[31] Its introduction was prehistoric. This palm is a source of food, drink, oil, thatch, and firewood.

Areca catechu L.; betel-nut palm, bunga. Cultivated, of prehistoric introduction; probably a native of India. The nut is chewed with lime and leaves of *Piper betle* as a stimulant.

[29] Ibid. 169.

[30] A Flora of Manila. Bureau of Science, Manila (1912).

[31] See Cook, O. F., Contr. U. S. Nat. Herb. 7 (1901) 298 and 14 (1910) 271, favoring the American origin of the coco. Beccari, O., Philip. Journ. Sci. § C 12 (1917) 27, opposes Cook's theories.

ARACEÆ

Acorus calamus L.; sweet flag, acoro, lubigan. Certainly introduced here; medicinal.

Colocasia esculentum Schott; taro, gabi. Probably a native of India, now cultivated in all tropical countries; cultivated for food throughout the Islands.

BROMELIACEÆ

Ananas comosus Merr.; pineapple, piña. A native of tropical America, introduced here by the Spaniards; cultivated for food and fiber.

Asparagus officinalis L.; asparagus, espárrago. A native of Europe, cultivated for ornamental purposes.

Allium cepa L.; onion, cebolla, sebuyas. A native of Europe; cultivated in Manila by Chinese market gardeners.

AMARYLLIDACEÆ

Agave cantala Roxb.; sisal hemp, century plant, maguey. A native of tropical America; cultivated in the Philippines as an ornamental and for its fiber.

Polianthes tuberosa L.; tuberose, azucena. A Mexican genus and species; cultivated for the fragrant flowers.

Crinum zeylanicum L.; lily, lirio. A native of tropical Asia and Africa; an ornamental.

DIOSCOREACEÆ

Dioscorea alata L.; yam, ubi. Found from India to Malaya; throughout the Islands, but certainly not indigenous; cultivated for its edible tubers.

MUSACEÆ

Musa paradisica L.; banana, platano, saguing. Cultivated throughout the Philippines, but its introduction probably prehistoric. The bananas yield fruit throughout the year, which can be found in most parts of the Islands. The leaves are used to a considerable extent for wrapping food, especially cooked rice, when it is necessary to carry a lunch. There are many varieties of bananas, distinguished chiefly by the size, shape, color, and flavor of their fruits. Blanco said that there were fifty-seven varieties known in the Philippines. Some of the commonest varieties of bananas sold in Manila are the tundan, the gloria, the sabá, the lacatan, the morado, and the cariñosa.[32] *Musa textilis* Née, the source of the valuable fiber known as abacá, or Manila hemp, is an endemic species.

CANNACEÆ

Canna indica L.; canna, ticas ticas. A native of tropical America; many varieties are grown in the Philippines as ornamental plants.

[32] Teodoro, N. G., Philip. Journ. Sci. § C 10 (1915) 379–418, describes the commoner species and varieties of bananas growing in the Philippines. Fawcett, The Banana, its Cultivation Distribution and Commercial Uses. London, Duckworth and Co. (1913), enumerates 66 species of *Musa*, but there are many more kinds if varieties and cultural forms be considered.

MARANTACEÆ

Maranta arundinacea L.; arrowroot, arurú. Genus and species of tropical America; introduced in the Philippines at an early date and cultivated to a small extent; a source of food.

PIPERACEÆ

Piper betle L.; betel pepper, icmo. Common in cultivation and wild throughout the Philippines, probably introduced; the leaves are chewed with the fruit of *Areca catechu* and lime.

MORACEÆ

Ficus elastica Roxb.; fig, india-rubber tree, banyan. Introduced from India; a shade tree.

Artocarpus communis Forst.; bread fruit, rimas, camansi. Several varieties of this species in Malaya and Polynesia, not indigenous to the Philippines; cultivated for the fruit, which is eaten.

Artocarpus integrifolia L. f.; jack fruit, nanca. India to Malaya, certainly introduced in the Philippines; the fruit is eaten raw and as a preserve.

NYCTAGINACEÆ

Bougainvillea spectabilis Willd. A showy ornamental vine, native of Brazil.

MAGNOLIACEÆ

Michelia champaca L.; champaca. Introduced from India or Malaya, not spontaneous; a small tree, valued because of its fragrant flowers, which are a source of perfume.

ANNONACEÆ

Annona muricata L., soursop, guaiabano; *A. reticulata* L., custard apple, anonas; *A. squamosa* L., sugar apple, ates. These three species are natives of tropical America; they were introduced into the Philippines and are now widely cultivated for their edible fruits.

LAURACEÆ

Persea americana Mill.; alligator pear, avocado. A native of tropical America from whence it was introduced by the Spaniards before 1700. In 1903 it was again introduced, from Honolulu, Hawaii. It is highly prized for its fruit.

LEGUMINOSÆ

Samanea saman Merr.; acacia, rain-tree. A native of the West Indies; a very common shade tree.

Pithecolobium dulce Benth.; camonsil, camanchiles. A native of tropical America, now thoroughly naturalized in the Philippines; a common source of tan bark; the fleshy arils are eaten.

Acacia farnesiana Willd.; aroma. Probably a native of tropical America; abundant in waste places and thoroughly naturalized; in many places one of the commonest shrubs invading grasslands.

Leucaena glauca Benth.; ipil-ipil, malaganit. A native of tropical America; thoroughly naturalized; a source of firewood in the Philippines.

Mimosa pudica L.; sensitive plant, macahia. A native of tropical America, now a widely distributed weed of all tropical countries.

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Caesalpinia sappan L.; sappang. India and Malaya, probably introduced in the Philippines; a source of dyewood.

Delonix regia Raf.; fire tree, poinciana, caballero, arbol del fuego. A native of Madagascar and tropical Africa, cultivated as an ornamental tree in the large towns of the Archipelago; probably introduced about the middle of the nineteenth century.

Tamarindus indica L.; tamarind, sampaloc. Commonly cultivated for its edible fruit; its introduction prehistoric; probably a native of tropical Africa.

Arachis hypogaea L.; peanut, mani. A native of tropical America, now cultivated in the Philippines; the source of the well-known peanut.

Indigofera suffruticosa Mill. and *I. tinctoria* L.; indigo, tayom. Both species are natives of tropical America and were formerly extensively cultivated in the Philippines as a source of indigo.

Gliricidia sepium Steud.; madre cacao. A native of Mexico, introduced at an early date and now thoroughly naturalized in the Philippines; much used in hedges and for fence posts.

Sesbania grandiflora Pers.; caturay. Certainly not indigenous, but its introduction prehistoric; valued for its resin and edible flowers.

Phaseolus lunatus L.; lima bean, patani. A native of tropical America; cultivated for its edible beans.

Vigna sesquipedalis L.; cowpea, sitao. Probably a native of China; cultivated for its edible pods and beans.

Phaseolus radiatus L.; green gram, mungos. A native of the Old World; introduced here and cultivated as a source of food.

OXALIDACEÆ

Averrhoa bilimbi L., camias; *A. carambola* L., balimbing. Both are natives of tropical America; cultivated for their acid edible fruits.

RUTACEÆ

Citrus maxima Merr.; pomelo, lucban, suha. A native of Malaya and Polynesia; cultivated throughout the Philippines for its fruit.

Citrus aurantium L., cahel; and *C. nobilis* Lour., naranjita. Extensively cultivated for their valuable fruits; probably introduced.

Citrus aurantifolia Swingle; limon, dayap. India and Malaya; undoubtedly of prehistoric introduction in the Philippines, where it is cultivated for its fruit.

MELIACEÆ

Sandoricum koetjape Merr.; santol. India to Malaya, undoubtedly introduced in the Philippines; cultivated for its edible fruit, and also naturalized in some regions.

Aglaia odorata Lour.; cinamomo de China. A small tree, commonly cultivated for its fragrant flowers; a native of southeastern Asia.

EUPHORBIACEÆ

Euphorbia tirucalli L.; consuelda. A leafless ornamental shrub or small tree, with green branches; a native of Africa.

Euphorbia heterophylla L.; painted leaf. An herb; native of temperate and tropical America; grown for ornamental purposes.

Euphorbia pulcherrima Willd.; pascuas, poinsettia. A native of tropical America; grown for ornamental purposes.

Jatropha curcas L.; physic nut, tuba. A native of tropical America; thoroughly naturalized in the Philippines; common in hedges.

Codiaeum variegatum Blume; croton, San Francisco, buenavista. Probably a native of the Moluccas; commonly cultivated as an ornamental foliage plant.

Acalypha hispida Burm. An introduced ornamental shrub; probably a native of Malaya or Polynesia.

Acalypha wilkesiana Muell.-Arg. A native of Fiji Islands; an ornamental shrub with variously colored leaves.

Ricinus communis L.; castor-oil plant, tañgan-tañgan. Probably a native of tropical Africa and of prehistoric introduction into the Philippines; the seeds are used as a medicine; the source of castor oil.

Manihot utilissima Pohl; tapioca plant, cassava, camoting cahoy. A native of tropical America; the roots are used for food.

ANACARDIACEÆ

Anacardium occidentale L.; cashew nut, casoy. Introduced from tropical America at an early date; cultivated for its edible fruit.

Mangifera indica L.; mango, manga. A native of India or Malaya; cultivated throughout the Tropics for its splendid fruit.

Spondias purpurea L.; ciruela. A native of tropical America; introduced into the Philippines at an early date; valued here for its plumlike fruit.

BALSAMINACEÆ

Impatiens balsamina L.; balsam, balsamina, camantigui. A native of British India; cultivated for medicinal and ornamental purposes.

MALVACEÆ

Hibiscus sabdariffa L.; roselle. A native of India; recently introduced in the vicinity of Manila and cultivated for its edible fruit.

Hibiscus rosa-sinensis L.; probably a native of southeastern Asia; *H. mutabilis* L., a native of China; and others are commonly cultivated as ornamentals and for hedges.

Gossypium brasiliense Macf.; cotton, algodon, bulac castila. A native of Brazil; cultivated as an ornamental in Manila and for the fiber in the provinces.

BOMBACACEÆ

Ceiba pentandra Gaertn.; silk-cotton tree, kapok. Probably a native of tropical America; the short silky fiber is used for pillows and mattresses.

STERCULIACEÆ

Theobroma cacao L.; chocolate, cacao. A native of tropical America; introduced by the Spaniards at an early date and now cultivated in many parts of the Philippines; the source of chocolate.

BIXACEÆ

Bixa orellana L.; anatto, achuete. A native of tropical America; cultivated throughout the Philippines; the seeds yield anatto dye.

CARICACEÆ

Carica papaya L.; papaya. Introduced from Mexico by the Spaniards at an early date; common in cultivation and frequently spontaneous; edible fruit.

PUNICACEÆ

Punica granatum L.; pomegranate, granada. Introduced by the Spaniards at an early date and cultivated as an ornamental shrub; a native of eastern subtropical Asia.

MYRTACEÆ

Eucalyptus tereticornis Sm.; blue gum. A native of Australia; occasionally cultivated in Manila as a shade tree.

Psidium guajava L.; guava, guayaba, bayabas. A native of Mexico; now thoroughly naturalized in the Philippines; it produces excellent firewood and an edible fruit.

ARALIACEÆ

Nothopanax fruticosum Miq.; papua. Probably of prehistoric introduction here; a native of Malaya or Polynesia; cultivated as an ornamental shrub.

SAPOTACEÆ

Achras sapota L.; chico. Introduced from Mexico by the Spaniards at an early date; now found in all parts of the Archipelago; cultivated for its edible fruit.

OLEACEÆ

Jasminum sambac Ait.; jasmine, sampaguita. A native of India; now cultivated in many tropical countries; valued for its fragrant white flowers.

CONVOLVULACEÆ

Ipomoea cairica Sweet, a native of northern Africa, very commonly cultivated as an ornamental for covering walls, porches, etc., also spontaneous; *I. nil* Roth, a native of tropical America; *I. pes-tigridis* L., a native of tropical Africa and Asia; *I. purpurea* L., morning glory, a native of tropical America; *I. triloba* L., introduced from tropical America; *I. batatas* Poir, sweet potato, camote, a native of tropical America.

LABIATÆ

Rosmarinus officinalis L.; rosemary, romero. Introduced from Spain; a source of medicine.

Mentha arvensis L.; mint, yerba buena. Introduced from Europe; cultivated for its aromatic leaves.

SOLANACEÆ

Datura alba Nees; talong punay. India to China and Malaya; widely distributed and spontaneous in the Philippines, where it undoubtedly has been introduced; used in medicine.

Cestrum nocturnum L.; dama de noche. A native of tropical America; introduced here at an early date; cultivated for its fragrant flowers.

Nicotiana tabacum L.; tobacco, tabaco. A native of tropical America; introduced here at an early date and now extensively cultivated; the source of tobacco.

Lycopersicum esculentum Mill.; tomato, tomate, camatis. A native of tropical America; spontaneous and cultivated in the Philippines; valued for the edible fruit.

Capsicum frutescens L.; Chile pepper, Chile, pasites, sili. A native of tropical America; now wild and cultivated in all parts of the Philippines; the fruit is used as a condiment.

RUBIACEÆ

Coffea arabica L.; coffee, café. A native of southwestern Asia; now cultivated in most tropical countries as a source of the coffee bean.

Ixora finlaysoniana Wall., probably a native of Siam; *I. coccinea* L., a native of India; *I. chinensis* Lam., a native of tropical Asia. Ornamental shrubs.

CUCURBITACEÆ

Cucurbita maxima Duchesne; squash, calabaza. Probably a native of tropical America; cultivated for its edible fruit.

Luffa cylindrica Roem.; sponge gourd, patola. Native country uncertain; cultivated for its edible fruit.

Citrullus vulgaris Schrad.; watermelon, sandia, pacuan. A native of tropical Africa; a vine, cultivated for its edible fruit.

Cucumis melo L.; melón. A native of tropical Asia or Africa; a vine, cultivated for its edible fruit.

COMPOSITÆ

Artemisia vulgaris L.; camaria, damong maria. A native of Europe and Asia, introduced from Europe for medicinal use.

In addition to the preceding introduced plants, most of which are of much or considerable economic value, there are numerous grasses, herbs, and shrubs that have been introduced inadvertently and now persist as weeds. I shall not enumerate any of these. It must be clear that the plants found in the vicinity of Manila are far from being typical of the endemic flora.

DESTRUCTION OF THE INDIGENOUS FOREST

Dr. H. N. Whitford, formerly forester in the Philippine Bureau of Forestry, was much interested in the types of forest vegetation and in 1906 wrote a paper on this subject. Five years later he published the results of his investigation of the entire Archipelago or so much of it as had been examined from the forester's viewpoint.

Mr. E. D. Merrill, botanist of the Philippine Bureau of Science, has traveled over a large part of the Archipelago and has studied Philippine plants as a botanist since 1902.

The opinions of these two authors with regard to Philippine forests are entitled to respectful consideration, and indeed it seems unlikely that anyone who has considered the subject in the light of field experience will question the conclusions in the following quotations:

Whitford [33] says:

> There is little question that practically the entire land area of the Philippines, from sea level to the highest mountains, was originally covered with unbroken forest growth of some kind.

Merrill [34] says:

> It is practically certain that before the advent of man in the Philippines, the entire country was covered with unbroken forest, of one kind or another, from sea-level to the tops of the highest mountains, except, perhaps, where the vegetation had been temporarily destroyed by natural causes, such as volcanic eruptions. Such types of vegetation as the extensive grass-covered hills, mountain sides, and plains, and the open cultivated areas, now such prominent features in the landscape, did not originally exist, so that the whole aspect of many localities must have been quite different from what it is to-day and from what has been its condition within historic times. When we consider that about two-thirds of the entire land surface of the Archipelago consists of cultivated areas, open grass lands, thickets, and second-growth forests, and that all these types of vegetation are due directly or indirectly to the presence of man, some idea can be obtained of the profound changes that have been wrought in the vegetation of the country in past centuries.

The earliest inhabitants—presumably the Negritos [35]—were not skilled in any kind of agriculture and were not numerous enough to have been an important factor in the extermination of the coastal and other lowland forest. With the increase in population by the advent of the tribes that are now the Christian Filipinos, the cultivation of rice was introduced or, at any rate, much extended in the lowlands. This necessitated the clearing of large areas of level or nearly level land. If the population of an island increased, the area of cleared land was increased, until in some of the islands there was no new level land to be brought under wet-rice culture. In such cases some of the surplus population migrated to other islands or pushed into the hills and raised upland rice, which matures without irrigation and, therefore, can be grown on steep slopes. Even rice that requires much irrigation can be grown on steep mountain sides where level areas are made by means of retaining walls, as in many parts of Mountain Province, Luzon.[36] This method of cultivation is not practiced in the lowlands. All of this clearing means the destruction of forest; and other uses for wood, such

[33] Bull. P. I. Bur. Forestry 10 [1] (1911) 12.

[34] Philip. Journ. Sci. § C 7 (1912) 149.

[35] See Reed, Wm. A., Negritos of Zambales, Ethnol. Surv. Publ. 2 [1] (1905) 1–83, 62 pls., 2 figs.

[36] See Jenks, A. E., The Bontoc Igorot, Ethnol. Surv. Publ. 1 (1905) 266 pp., 145 pls., 9 text figs.; and Worcester, D. C., The non-Christian tribes of northern Luzon, Philip. Journ. Sci. 1 (1906) 791–876, 47 pls.

as cooking and house and boat construction, play their parts in thinning the forest near large towns.

A method of agriculture common to various tropical countries is also practiced in the Philippines, where it is known as the caiñgin system. The caiñgin is merely a clearing in the forest, and if this were continuously cultivated no harm would result.[37] The caiñgin is seldom thoroughly cleared; the smaller trees are cut and when dry are burned. Nearly all of the large trees in the field are killed in this process. A crop of corn, rice, sweet potatoes, or yams is now planted. For a few seasons good crops can be taken off a caiñgin without much labor, but grass soon becomes so well established that the farmer finds it easier to make a new caiñgin than to struggle with the grass.

In the part of the Archipelago having distinct wet and dry seasons, that is, the western half, grass areas tend to remain in grass. The grass is frequently burned during the dry season, either by accident or intention, and this kills any forest-tree seedlings that have entered the grass, while the deep-seated perennial rhizomes of the grasses are uninjured. After the first rain the grass soon produces a luxuriant growth. On the eastern side of the Islands there is a nearly continuous wet season. Here the more uniformly moist condition prevents grass fires and the grassland is soon invaded by tree species and gradually returns to forest.[38]

If the population of a thickly inhabited island decreases, which has undoubtedly happened as the result of war or epidemic disease, some of the rice fields will be abandoned. These, even when bordering forest, do not grow up to the old forest species of trees, but first with a rank grass and later with species of shrubs and second-growth trees. If this be in the region of marked wet and dry seasons, it will be very difficult for the forest species to regain a foothold in an area from which they have been removed.[39]

[37] See Merrill, E. D., Philip. Journ. Sci. § C 7 (1912) 149.

[38] With regard to the soils and the climate of the Philippines see Cox, A. J., Philip. Journ. Sci. § A 6 (1911) 279–330; also Brown, W. H., and Matthews, D. M., ibid. § A 9 (1914) 417.

[39] With regard to revegetation in the Philippines see: Gates, F. C., The pioneer vegetation of Taal Volcano, Philip. Journ. Sci. § C 9 (1914) 391–434, 8 pls.; Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, ibid. § A 9 (1914) 413–562, 13 pls., 1 map, 12 figs.; Merrill, E. D., Brown, W. H., and Yates, H. S., The revegetation of Volcano Island, Luzon, Philippine Islands, since the eruption of Taal Volcano in 1911, ibid. § C 12 (1917) 177–248, 16 pls., 2 figs.

In some localities the clearing of land for planting coconuts, bananas, abacá, corn, and rice is an important factor in the destruction of the original vegetation. It is probable that the destruction of the original forest to make room for commercial plantations is in progress, more or less, over the entire Eastern Tropics. In this connection Merrill says:[40]

It is only necessary to examine most parts of Java below an altitude of 4,000 feet, such islands as Singapore, immense areas in the Malay Peninsula, and the settled areas generally in the whole Malayan region in order to gain some appreciation of the disastrous effects of man's activities on the floras of these regions. It is a well-known fact that where the virgin, or primary, forest is once destroyed in the Eastern Tropics, the areas practically never revert to the original type of vegetation, at least in any reasonable amount of time. If the cleared lands are abandoned, as they frequently are by the primitive native agriculturist, they are quickly occupied by grass formations, usually lalang (*Imperata*), bamboo formations, or complex second-growth forests in constituent species entirely different from the primary, or virgin, type. The pressure on the primary forest is rapidly increasing in many parts of Malaya, not only by the increase in the native Malay population, and the resultant demand for more agricultural lands, but also in the demands of modern industries for increased production in such commodities as rubber and copra and for other tropical products such as sugar, tobacco, fibers, coffee, tea, and other staples. Since the beginning of the present century immense areas in the Malay Peninsula, in Sumatra, in the Philippines, and doubtless in Borneo and in other parts of Malaya have been denuded of their original vegetation to provide place for modern plantations, and it is safe to assume that most such areas will never again be occupied by primary forests. The shade plants and enormous trees characteristic of the primary forest cannot persist under the conditions demanded by modern agriculture, and they cannot exist in the second-growth forests, grasslands, and bamboo thickets that rapidly encroach on cleared areas that are abandoned. Perhaps without realizing the fact we are witnessing in our own generation the rapid extermination of some of the noblest types of tropical vegetation, and all botanists should be interested in preserving at least herbarium records while such records are to be secured. The present century will certainly witness an enormous extension of the agricultural areas in Malaya, for modern science has rendered our "conquest of the Tropics" a comparatively simple matter; and any general extension of agricultural areas will to a large degree be at the expense of regions now covered with forests of one type or another.

Shelford [41] notes that—

* * * even in Sarawak, that peaceful backwater of civilization, there have been notable alterations in the land fauna in the neighborhood

[40] Merrill, E. D., A bibliographic enumeration of Bornean plants. Introduction. MS.

[41] Shelford, R. W. C., A naturalist in Borneo. E. P. Dutton and Co., New York (1917) 294.

of towns and of Government stations within the last twenty-five years, whilst the natives themselves, by their extravagant system of cultivation, whereby tracts of jungle are annually destroyed, must be responsible in the long run for the extermination of many species.

TYPES OF PHILIPPINE FORESTS

Vegetation is such an important factor in the distribution of birds that it is necessary to consider in some detail the various types of Philippine forest. Most of my information concerning forests is condensed from Whitford [42] wherever it is not quoted exactly from him or from other authors. As already stated it is believed that practically the entire area of the Islands was at one time covered with forest. The extent of the change brought about by man is shown by estimates of the Philippine Bureau of Forestry, given here as Table 1.

TABLE 1.—*Areas of various types of vegetation in the Philippine Islands.*

	Square miles.	Per cent.
Virgin forest	40,000	$33\frac{1}{3}$
Second-growth forest	20,000	$16\frac{2}{3}$
Grassland	48,000	40
Cultivated land	12,000	10
Total	120,000	100

Whitford says:

Put in another way, the land area of the Philippines is about equal to that of the State of New Mexico, while the virgin forest is approximately equal to the entire area of the State of Kentucky. [p. 13.]

George P. Ahern, for many years director of the Philippine Bureau of Forestry, was enthusiastic over the variety of tree species in the native forest. In one of the Government publications he says:[43]

One can not realize the richness of the tree flora of the Philippine Islands until he is told that there have already been found over two thousand kinds in the Philippine Islands. This means more to the average person when it is known that this is probably three times as many varieties as have been found in the United States. When all is known concerning the tree flora of the Philippines it is probable that this number will reach three thousand. Of course it must be stated that all of these are not used commercially.

According to Whitford [44] there are one hundred six species of Philippine trees the lumber from which finds a place of some

[42] The forests of the Philippines, Bull. P. I. Bur. Forestry 10[1] (1911) 94 pp., 24 pls.

[43] A few pertinent facts concerning the Philippine forests, P. I. Bur. Forestry Circular 3 (1908) 9.

[44] Bull. P. I. Bur. Forestry 10[1] (1911) 9, 10.

prominence in the markets, but the number of species that are of no value for lumber is so much greater that the timber trees seem few in comparison. On any given tract the merchantable kinds of trees are not likely to exceed twenty. While a tract may contain two hundred tree species, nine-tenths of them will be of species that never reach a size suitable for lumber. Whitford says that "the largest tree measured to date shows 61 meters (200 feet). Very few species will reach a diameter of more than 180 centimeters (6 feet), measured above the root buttresses."

The species of trees in the Philippines and in the Tropics in general are very different from those of temperate-zone forests. Conifers appear only with elevation. In the Philippines the pine type of vegetation is estimated to be only 5 per cent of the total forested area; it is confined to parts of Luzon and of Mindoro.

A very large area of the forests, about 75 per cent, is characterized by various species of dipterocarps. The trees of this family yield a great variety of commercial wood suitable for many purposes. Whitford says:

> Throughout the work [Whitford's book] emphasis has been laid on the importance of the dipterocarp family; for in spite of the richness of the Philippines in fine furniture wood, the real wealth of their forests consists of construction timbers, such as are represented by the lauans, apitongs, and yacals—all belonging to the dipterocarp family.[45] It is estimated that the dipterocarps include about 144 out of a total of the 200 billion board feet of standing timber in the Islands. Not only is the total amount great, but the members of this family occur in stands sufficiently heavy to be exploited by the use of machinery. The predominance of this family needs emphasis because it is the general belief that the Philippines and the Tropics in general produce only wood of the mahogany and teak grades. [p. 9.]

Whitford recognizes six major types of forest, each of which is characterized by certain tree species. In abstracting the characters of these types as given by Whitford I have omitted much of the detail and have treated his five dipterocarp types as one. I have also arranged the types in what seems a logical order, beginning with the mangrove and ending with the mossy forest. Each of the six types is characterized by certain conspicuous species of plants. There are forests that do not have the characters of any one type, but in general these divisions

[45] See Foxworthy, F. W., Philip. Journ. Sci. § C 6 (1911) 231–287, pls. 34–44, and 13 (1918) 163–197, for the classification of Philippine dipterocarps.

can be distinguished; namely, mangrove, beach, dipterocarp, molave, pine, and mossy forest.

The mangrove forest is distinct; it is important as a source of firewood and tanbark and is interesting because of its plants, but it harbors few birds. The beach forest has been largely destroyed and is of little interest for its birds. The dipterocarp forest covers the largest area and is the most important as a source of lumber; all of its birds and plants are of much interest. Much of the molave forest has been destroyed; zoölogically it scarcely differs from the dipterocarp forest. The pine forest is found in restricted areas in Luzon and Mindoro. The mossy forest is found on several islands at high altitudes; its trees are almost worthless for lumber. The species of plants and animals of the pine forest and the mossy forest are much fewer than those of the dipterocarp forest, but they are of very great interest to the naturalist.

MANGROVE TYPE OF FOREST

The mangrove type is literally a forest in the sea. Where conditions are favorable it occupies beaches washed by the tides. It is especially well developed on mud flats at the mouths of rivers that enter the sea at the heads of protected bays. Wherever wave action allows a fairly stable shore line, trees of this type are present. They occur on the quieter portions of coral reefs and may be the only indication of slightly submerged reefs; in such cases what appear at a distance to be forested islands are found to have no land exposed except perhaps at the lowest tides. Most of the trees in mangrove forests belong to the family Rhizophoraceæ and include the following species:

Rhizophora mucronata Lam.
Rhizophora conjugata Linn.
Bruguiera gymnorhiza Lam.
Bruguiera eriopetala W. & A.
Bruguiera cylindrica (Linn.) Blume.
Bruguiera parviflora W. & A.
Ceriops tagal C. B. Rob.

Species of other families that are characteristic of the mangrove type of vegetation include:

Sonneratia pagatpat Blanco.
Avicennia officinalis Linn.
Lumnitzera littorea (Jack.) Voigt.
Xylocarpus moluccensis (Lam.) M. Roem.
Xylocarpus granatum Koen.
Excoecaria agallocha Linn.
Heritiera littoralis Dry.

Although this type of forest, from the nature of its habitat, is free from undergrowth it is difficult to make one's way through a typical stand because of the complex and tangled system of stilt roots of the species of *Rhizophora*, the dominant species in these swamps, and also because of the soft mud forming the substratum. At the upper limits of the mangrove there may be a fringe of the nipa palm, *Nipa fruticans* Wurmb, and this palm is inclined to form extensive thickets on low land along streams where the water is only slightly brackish.[46]

BIRDS OF THE MANGROVE FOREST

Few if any species of birds are characteristic of the mangrove forest. I have spent much time among these curious trees in fruitless efforts to discover something startling in birds, but nothing was ever found that could not have been collected elsewhere. Several species of kingfishers, the ever-present fly-catcher *Rhipidura nigritorquis* Vigors, the little migratory warbler *Acanthopneuste borealis* (Blasius), and the migratory starling *Sturnia philippensis* (Forster) are among the land birds that can be found in mangroves. The curious little muscicapine species *Gerygone simplex* Cabanis seems to have a predilection for rhizophoraceous trees, but I have found it in other stations as well; for example, in bamboo thickets on the borders of Lake Bay. Near Puerto Princesa, Palawan, I collected specimens of the exquisite, endemic sunbird *Æthopyga shelleyi* Sharpe in mangroves, but they were attracted there by the flowers and are not ordinarily found in this type of forest.

BEACH TYPE OF FOREST

Sandy beaches above the limits of high tide usually have been cleared and are occupied by towns or are planted to coconuts. Where this has not occurred there is a distinct type of forest in which the following trees are found:

Terminalia catappa Linn.	*Thespesia populnea* Corr.
Erythrina indica Lam.	*Heritiera littoralis* Dry.
Barringtonia speciosa Forst.	*Calophyllum inophyllum* Linn.
Hibiscus tiliaceus Linn.	*Casuarina equisetifolia* Linn.
Pongamia pinnata Merr.	*Pemphis acidula* Forst.

Some of these species, for example, the *Barringtonia* and the *Casuarina*, may occur in more or less extensive pure stands as a result of favorable soil and other conditions, while some of the more valuable timber trees of other types, such as ipil, narra, and bansalaguin, may be mixed in the beach type.

BIRDS OF THE BEACH FOREST

In most islands much of the beach type of forest has been cleared away, and coconut groves are more or less mixed with

[46] See also Brown, W. H., and Fischer, A. F., Bull. P. I. Bur. Forestry 17 (1918). [Published in 1919.]

what remains. It is difficult to determine if there is any endemic species of bird that is confined to the beach type; probably there is none. I believe that the tabon, *Megapodius cumingi* Dillwyn, which is nearly endemic, is perhaps confined to the beach forest under normal conditions. The following are more or less characteristic of the beach forest, although none of them is confined to it:

Gallus gallus (Linnæus).
Lalage niger (Forster).
Oriolus acrorhynchus Vigors.
Hypothymis occipitalis (Vigors).
Cyornis philippinensis Sharpe.
Copsychus mindanensis (Boddaert).
Lamprocorax panayensis (Scopoli).
Sarcops calvus (Linnæus).
Corvus philippinus Bonaparte.

Various species of *Otus, Loriculus, Caprimulgus, Iole, Macronous, Orthotomus, Zosterops, Æthopyga, Leptocoma, Cyrtostomus,* and *Anthreptes* are also found in the beach forest.

DIPTEROCARP TYPE OF FOREST

The dipterocarps are the most important trees of the Philippine forests. They comprise seventy species in nine genera;[47] and, while some of the species are so rare as to be inconspicuous as individual trees and negligible for commercial purposes, trees of many of the species are numerous enough to be very important. The genera are *Isoptera, Balanocarpus, Dipterocarpus, Anisoptera, Parashorea, Pentacme, Shorea, Hopea,* and *Vatica.* The lumber from different species is adapted to different uses and is marketed under many trade names.

Whitford divides the dipterocarp forests into five types, each of which is characterized by certain dominant dipterocarps and by species of other families. It is not necessary to consider each of these types here. The dipterocarp types cover 75 per cent of the virgin forest of the Philippine Islands or about 30,000 square miles and contain 95 per cent of the standing timber. They are found on all kinds of topography from immediately behind the beach type to 800 meters' altitude on the slopes of the largest mountains.

Practically all the species of the dipterocarps are large trees, reaching heights of 40 to 50 meters and diameters of 100 to 150 centimeters or more, and it is not rare to find even these dimensions exceeded. They have straight, regular boles, resembling in size and shape the *Liriodendron tulipiferum* (yellow poplar or tulip tree) of the United States. Some species of other families have a size and form similar to and [are]

[47] See Foxworthy, F. W., Philip. Journ. Sci. § C 13 (1918) 163–200, 2 pls.; and Brandis, D., Journ. Linn. Soc. Bot. 31 (1895) 1–148, on the dipterocarps of India.

codominant with the dipterocarps, but by far a greater majority are subdominant species, some of which have ill-formed boles, much smaller in diameter and length. Underneath the dominant and subdominant species are a large number of undergrowth tree species which do not attain more than 10 centimeters in diameter when mature, and a height of 10 meters or less. From a botanical point of view, these add greatly to the complexity of the forests, but for commercial considerations they should be called undergrowth trees. Within the forests there are comparatively few shrubs, or bushes, and herbs.

All the types of dipterocarp forests contain climbing palms (rattans), but the number and size of other large vines (lianas) seem to diminish with the prominence of the dipterocarps. Artificial and natural openings in the forests are often covered with a jungle of climbing bamboos and other large lianas, and the edges of the forests especially along streams, present breast-works of twisted vines which are very difficult to penetrate; but as soon as the interior is reached it is easy to pass through the forest with only the occasional use of a bolo (machete).[48]

Dipterocarp forests are best developed on well-watered plains or on the lower slopes of large mountains. Here the soil is usually a deep loamy clay of volcanic origin; passing to drier soils of calcareous origin the dipterocarp species give way and the forest becomes more open, usually dominated by such species as molave, *Vitex parviflora* Jussieu. As higher elevations are reached the trees become smaller and the dipterocarps less numerous. At 800 meters or less this type gives way to one in which miscellaneous trees—*Quercus* and other genera—are more prominent.[49]

Brown[50] has written a careful description of the forests of Mount Maquiling, Laguna Province, Luzon, in which is included a vast amount of detailed and exact information. The volume and the composition of the forest at different altitudes are given with great care, and the book is a unique study of tropical vegetation.

MOLAVE TYPE OF FOREST

Molave, *Vitex parviflora* Jussieu, is fairly well distributed throughout the forest that is designated the molave type. It is found typically on low limestone hills, which are usually composed of crystalline coral limestone with a honeycomb structure. These rocks are generally covered by shallow or scanty soil. The habitat is very dry. A large part of the molave type has

[48] Whitford, H. N., Bull. P. I. Bur. Forestry 10[1] (1911) 18.

[49] See Brown, W. H., and Matthews, D. M., Philip. Journ. Sci. § A 9 (1914) 416.

[50] Vegetation of Philippine Mountains. Bureau of Science, Manila (1919) 434 pp., 41 pls.

been destroyed. In its virgin state it is open, with its large trees few and far apart; the intervening spaces are filled with small trees or by a jungle of sprawling, climbing, and small erect bamboos. In some expressions of this type the dominant trees include:

Vitex parviflora Juss.	*Albizzia acle* Merr.
Tarrietia sylvatica Merr.	*Wallaceodendron celebicum* Koord.
Sindora supa Merr.	*Zizyphus zonulata* Blanco.
Kingiodendron alternifolium Merr.	*Pterocarpus echinatus* Pers.
Intsia bijuga O. Ktz.	*Aglaia clarkii* Merr.

Among the smaller species there may be:

Maba buxifolia Pers.	*Cassia javanica* Linn.
Diospyros discolor Willd.	*Pterospermum* spp.
Taxotrophis ilicifolia Vid.	*Mallotus floribundus* Muell.-Arg.

WALLACE ON THE TROPICAL FOREST

The lowland tropical forest was described in popular language years ago by Wallace. He says (pp. 240–244):[51]

It is not easy to fix upon the most distinctive features of these virgin forests, which nevertheless impress themselves upon the beholder as something quite unlike those of temperate lands, and as possessing a grandeur and sublimity altogether their own. * * *

The observer new to the scene would perhaps be first struck by the varied yet symmetrical trunks, which rise up with perfect straightness to a great height without a branch, and which, being placed at a considerable average distance apart, give an impression similar to that produced by the columns of some enormous building. Overhead, at a height, perhaps, of a hundred and fifty feet, is an almost unbroken canopy of foliage formed by the meeting together of these great trees and their interlacing branches; and this canopy is usually so dense that but an indistinct glimmer of the sky is to be seen, and even the intense tropical sunlight only penetrates to the ground subdued and broken up into scattered fragments. There is a weird gloom and a solemn silence, which combine to produce a sense of the vast—the primeval—almost of the infinite. It is a world in which man seems an intruder, and where he feels overwhelmed by the contemplation of the ever-acting forces which, from the simple elements of the atmosphere, build up the great mass of vegetation which overshadows and almost seems to oppress the earth.

Passing from the general impression to the elements of which the scene is composed, the observer is struck by the great diversity of details amid the general uniformity. Instead of endless repetitions of the same forms of trunk such as are to be seen in our pine, or oak, or beechwoods, the eye wanders from one tree to another and rarely detects two together of the species. All are tall and upright columns, but they differ from each other more than do the columns of Gothic, Greek, and Egyptian

[51] Wallace, A. R., Natural Selection and Tropical Nature. Essays on descriptive and theoretical biology, new edition, with corrections and additions. Macmillan and Co., London and New York (1895).

temples. Some are almost cylindrical, rising up out of the ground as if their bases were concealed by accumulations of the soil; some get much thicker near the ground like our spreading oaks; others again, and these are very characteristic, send out towards the base flat and wing-like projections. These projections are thin slabs radiating from the main trunk, from which they stand out like the buttresses of a Gothic cathedral. They rise to various heights on the tree, from five or six to twenty or thirty feet; they often divide as they approach the ground, and sometimes twist and curve along the surface for a considerable distance, forming elevated and greatly compressed roots. These buttresses are sometimes so large that the spaces between them if roofed over would form huts capable of containing several persons. Their use is evidently to give the tree an extended base, and so assist the subterranean roots in maintaining in an erect position so lofty a column crowned by a broad and massive head of branches and foliage. Aërial-rooted forest trees * * * and the equally remarkable fig-trees of various species, whose trunks are formed by a miniature forest of aërial roots, sometimes separate, sometimes matted together, are characteristic of the Eastern tropics, * * *. The leaves of the Asiatic caoutchouc tree (Ficus elastica), so often cultivated in houses, is a type of this class (trees with large, thick, and glossy leaves), which has a very fine effect among the more ordinary-looking foliage. Contrasted with this is the fine pinnate foliage of some of the largest forest trees, which, seen far aloft against the sky, looks as delicate as that of the sensitive Mimosa. The great trees we have hitherto been describing form, however, but a portion of the forest. Beneath their lofty canopy there often exists a second forest of moderate-sized trees, whose crowns, perhaps forty or fifty feet high, do not touch the lowermost branches of those above them. * * * Yet beneath this second set of medium-sized forest trees there is often a third undergrowth of small trees, from six to ten feet high, of dwarf palms, of tree-ferns, and of gigantic herbaceous ferns. Yet lower, on the surface of the ground itself, we find much variety. More frequently it is covered with a dense carpet of selaginella or other lycopodiaceae, and these sometimes give place to a variety of herbaceous plants, sometimes with pretty, but rarely with very conspicuous flowers.

BIRDS OF THE LOWLAND FORESTS

In the lowlands of any island it is the old uncut forest, more or less similar in character to the tropical forests described by Wallace or the dipterocarp and molave forests described by Whitford and by Brown, that will harbor the endemic species of birds if there be any. Unless it is desired to accumulate a series of specimens of widely distributed species, it is almost a total waste of time to collect in grassland or second-growth thickets.

In investigating the avifauna of an island that is ornithologically unknown, the main effort should be expended in reaching primary, uncut forest [52]—on level ground, if possible, and as

[52] By primary forest I mean the original natural forest of the lowland in distinction from grassland, second-growth thickets, coconut trees and other planted vegetation, the beach type, and the mangrove forest.

clear of undergrowth as may be—but, hilly or level, the primary forest is almost the only vegetation that will yield local endemic species. Coconut groves must not be overlooked, and some valuable specimens can be found in the beach forest. The parrakeets of the genus *Loriculus* and all or most of the sunbirds feed among the blossoms of the coconut palm, and such forest birds as the small orioles and the fairy bluebirds often feed in small second-growth trees when conditions suit them; but these birds are at home in the primary forest and are attracted to other types of vegetation by abundance of food.

In order to reach primary forest it is usually necessary to pass through areas of grassland, cultivated fields, and thickets. Unless a trail can be utilized, there is often much difficulty in entering the forest, for the borders are usually a thick tangle of grasses, vines, and shrubs.

When the primary forest has been cleared from the level parts of an island, it becomes necessary to search for birds among the trees on more or less steep mountain sides. In such situations there seem to be fewer birds than in forests on level ground, and the difficulty of collecting is increased; this results partly from the less ease with which one can walk and partly from the fact that birds, if killed in trees on hillsides, usually fall much farther from the shooter than they do when killed in trees on level ground and consequently are more frequently lost. So far as I can judge there is little if any difference in the species of birds of the dipterocarp forest, the molave type, and Brown's midmountain forest. The last sort of forest is composed of lower, smaller trees and seems to have fewer species of birds, but these birds are species that are also found in the dipterocarp forest.

Within many forests the ground is nearly clear of undergrowth so that one can wander at will, provided that care is taken to avoid the sharp hooks on the long flagellæ terminating the feathery fronds of rattan palms. If the ground is level, it is an easy matter to become confused as to directions. The light filters through many layers of leafy branches, and the air is damp and cool. No hat is needed even when the heat is dizzying in the open. Much of the time such a forest is absolutely silent. Although the monsoon may be blowing a gale, its effect ceases at the border of the forest. Occasionally a troop of monkeys will suddenly chatter and make a great commotion leaping and crashing from one tree to another. A large cicada

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often makes a deafening sound. A woodpecker may make the woods ring with his harsh call or a large hornbill awaken the echoes with his loud weird "au, calau au au;" as he flaps slowly away, his wings produce a curious rustling sound.

Now a familiar bird note may come faintly from the high leafy branches as at a distance—"te-dee, dee dee dee." Wait, it is coming this way. There it is again, and it sounds like a chickadee. No wonder, either, for it really is a chickadee—a fine black and yellow chap, *Pardaliparus elegans* (Lesson) or a related species, that is not very much different from some of its American cousins. That long-tailed nervous thing with a harsh voice is a flycatcher, *Rhipidura cyaniceps* (Cassin); let it go, the branches overhead are full of birds. We are in the midst of one of the wandering bands that are characteristic of the forest. There is a fine male *Cyanomyias cœlestis* (Tweeddale)—a gem among flycatchers; one good specimen of that is worth a day's work. Look carefully for the small quiet ones. The rare species of *Zosterornis* go in these flocks. What is that you have picked out from the end of a high branch? A rare warbler? Yes, rare in North America. That is *Acanthopneuste borealis* (Blasius), one of the worst pests of the collector. It is an abundant migrant in the Philippine Islands, and because of its pale gray and greenish yellow colors it is difficult to identify as it flits among the leaves.

If you have had good luck you have been able to recover two or three good specimens from this flock, which has now passed on its way. Perhaps you have lost as many more, some having lodged in masses of epiphytic plants far from the ground, others being hopelessly buried in a rank growth of ferns. The last you hear of the flock are the calls of the chickadee and the nuthatch as they fade in the distance. The silence is now oppressive, for there is absolutely not a sound.

Where do these wandering bands come from and where do they go? What leads such a variety of kinds to travel together? Here are chickadees, nuthatches, flycatchers, thickheads, silver-eyes—birds of various families, but all insect-eaters. Do they secure any protection by traveling together? It is doubtful if they need it, for hawks cannot work to advantage among the branches of the forest trees. It is possible that these birds take pleasure in each other's company, but that is mere surmise. It seems more probable that several or many birds traveling through the tree tops disturb the insects upon which they feed, and so all of the members of the band are able to secure more food than if they moved about singly or in pairs.[53]

The following paragraph [54] is in agreement with this idea:

In tropical forests, where insects are everywhere abundant, the birds seemed to have realized the fact that to each is apportioned certain phases of insect life, and that by hunting in large flocks, instead of competition resulting between birds of different species, they play into each other's hands (or rather beaks). It is of such a flock that Hudson writes: "The larger creepers explore the trunks of big trees, others run over the branches and cling to the lesser twigs, so that every tree in their route, from its roots to the topmost foliage, is thoroughly examined, and every spider and caterpillar taken, while the winged insects, driven from their lurking-places, are seized where they settle, or caught flying by the tyrant-birds."

Swynnerton [55] has published an interesting paper on this phase of the bird life of southeast Africa in which he gives us many of his own observations. He quotes Bates [56] as saying that—

The simplest explanation appears to be this: that the birds associate in flocks from the instinct of self-preservation, and in order to be a less easy prey to hawks, snakes, and other enemies than they would be if feeding alone.

Marshall,[57] in a paper on the birds of Mashonaland, seems to agree with Bates. He says:

A fact which must impress every observer is the way in which one may often walk for several miles through likely-looking country and scarcely see a bird; then suddenly one comes upon a troop of them, composed of Drongos, Tits, small Shrikes, Flycatchers, Warblers, and Buntings, keeping more or less together in a limited area. Personally I have little doubt that this may be attributed to the large number of birds of prey which occur here; so that the smaller birds find it advisable to associate as a means of protection, the Drongos acting as a sort of body-guard. My view is supported by the fact that the phenomenon is observed principally in the open forest which characterizes the greater part of the country; while, wherever the bush is more dense and affords better cover, the small birds are more generally distributed.

Swynnerton says that he has seen birds attending a party of monkeys that was moving through the tree tops. He concludes his paper with the following paragraphs:

While, however, I feel that the mixed parties are primarily drives, and the Drongo from this standpoint mainly parasitic, it is, I think,

[53] It is perhaps worth while recording that I had written the above paragraph before I had seen any of the following notes by other authors on the same subject.

[54] Beebe, C. W., The Bird: its Form and Function. Henry Holt and Company, New York (1906) 150.

[55] Swynnerton, C. F. M., Mixed bird-parties, Ibis X 3 (1915) 346–354.

[56] The Naturalist on the Amazons 2 (1863) 334–336.

[57] Marshall, G. A. K., Ibis VII 4 (1900) 222.

likely that the great "mobbing" power afforded by numbers must be so great an advantage as to probably act as a contributing factor. I think, too, that the Drongo, with his boldness and readiness to attack, quite likely fully "pays for his keep."

The fact of systematic co-operative hunting on so large a scale suggests the views on mutual aid amongst animals that have been laid stress on by some Russian naturalists; yet is of *particular* interest as suggesting how keen selection must sometimes be and how baseless, probably, is the view that the more perfect defensive adaptions of insects constitute hypertely.

At another time a family of four or five fiery minivets (*Pericrocotus*) comes into sight. The adult male is brillant red or orange and black, the female and young are yellow and black. The minivets are rare and seem to care little for the company of other birds. The various species of forest orioles (*Oriolus*) and of fairy bluebirds (*Irena*) move about in pairs; they feed among the branches of the tallest trees, and their presence is usually revealed by their characteristic call notes some time before they can be seen.

Few of these forest-inhabiting species are even seen in the open. As Worcester [58] remarks, birds in the Tropics "may be born, grow old, and die within the limits of a single grove, and never suffer want of food or shelter." This seems to account for the fact that many species of birds are confined to single islands, in some cases to very small islands. The species having been developed in a thick forest, the individuals never leave it and have no chance or inclination to extend their range to other islands, however near. Furthermore, in the forest they are perfectly protected from being driven to sea or to other islands by winds, no matter how powerful.

There are many endemic species that are seldom found except when they are feeding at flowering or fruiting trees. Days or even weeks may be spent without an individual of these species being seen; but when a favorite tree is found in flower or fruit it is only necessary to wait nearby, where as many specimens as desired can be collected.

The species of *Dicæum, Prionochilus, Leptocoma, Cyrtostomus, Æthopyga, Iole,* and *Loriculus,* especially, can be obtained in quantities at trees in flower. One tree that is a particular favorite with many species of birds is the dap-dap, *Erythrina indica,* which has large scarlet flowers from January to April; as it usually casts most of its leaves during anthesis the flowers are rendered very conspicuous. Zimmer [59] gives a good picture

[58] Proc. U. S. Nat. Mus. **20** (1898) 581.

[59] Philip. Journ. Sci. § D **13** (1918) 350.

of such a tree at Brooke's Point, Palawan, in the following words:

> At times I have seen parrots, cockatoos, leafbirds, nuthatches, chickadees, woodpeckers, orioles, flowerpeckers, sunbirds of various kinds, spider-hunters, pigeons, and starlings, all in this tree at once, while in nearby foliage were cuckoos, fairy bluebirds, flycatchers, minivets, thrushes, tailorbirds, bulbuls, and the like. The clamor was indescribable, and the conglomeration of assorted colors exhibited by the assemblage and set off by the brilliant blossoms of the tree was most striking and yet harmonious.

Some species of *Ficus* are favorite feeding resorts for doves, parrots, flowerpeckers, sunbirds, etc. Sunbirds and the colasisis (*Loriculus*) are usually more or less abundant in coconut groves. I found *Æthopyga shelleyi* Sharpe in abundance on some flowering trees in a mangrove swamp near Puerto Princesa, Palawan. The imperial pigeons (*Muscadivores*) are very fond of the fruit of certain species of fig trees. In Biliran, a lone buri palm, standing near the beach, was loaded with fruit and was regularly visited by crows and imperial pigeons. Merrill's fruit pigeon, *Leucotreron* (*Neoleucotreron*) *merrilli* McGregor, was collected in Laguna Province only when it was feeding on the small fruits of *Symplocos ahernii* Brand. By waiting beneath these trees we could see the pigeons as they moved about in feeding; at other times it was impossible to detect them among the leaves. In Polillo a parrot (*Tanygnathus freeri* McGregor) fed on the fruit of *Artocarpus camansi* Blanco and of *Dillenia philippinensis* Rolfe. In the same island *Penelopides subnigra* McGregor was often found feeding on the fruit of *Dysoxylum altissimum* Merrill and of a species of *Ficus*.

The pittas are short-tailed, plump birds with bright-colored plumage. Their well-developed legs enable them to hop about beneath the forest undergrowth and in thickets where they sometimes make considerable noise in scratching among dry leaves. Nevertheless all of the pittas are shy birds, and although gorgeously colored they are among the birds requiring the greatest skill and patience on the part of the collector.

The puñaladas, or blood-breasted pigeons (*Phlegœnas* vel *Gallicolumba*), are usually seen walking quietly along a forest trail or hastening across a small opening, but they are very nervous and take flight at the least suspicious noise or movement and are by no means easy to get sight of.

Several types of kingfishers inhabit the forest. They are all beautifully colored, but they seem to have been influenced by their habitat for they are usually silent and retiring. It does not seem possible that they are related to the noisy, impudent, and conspicuous species of the open country.

The most gorgeous Philippine bird is the Palawan peacock pheasant, *Polyplectron napolionis* Lesson, yet it is seldom seen. Mr. Worcester has told me that he never saw an individual of this species in the field and that all of the specimens obtained by him were purchased from men who had snared them.

The male of the Philippine trogon, *Pyrotrogon ardens* (Temminck), is perhaps the most beautiful—certainly it is the most brilliantly colored—Philippine bird of medium size; but as it sits on a branch 10 to 15 meters from the ground, motionless in the mottled light and shadow, it is far from being conspicuous.

Of very rare Philippine birds perhaps the frogmouths (*Batrachostomus*) will ever remain the rarest. They superficially resemble the nightjars, especially in their soft mottled plumage and small feet; but the outermost pair of rectrices is only half as long as the middle pair, and the wings are shorter than in the Caprimulgidæ. The most conspicuous feature of *Batrachostomus* is its bill, which is enormous and has a peculiar sigmoid curve to the cutting edge that gives these birds a very grotesque expression, especially when seen in full-faced view. Undoubtedly they hunt at night and rest in deep shade during the day; I have seen only a few specimens, and these were obtained by the merest chances.

Two curious species of the endemic genus *Sarcophanops*, one of which inhabits Mindanao and Basilan, the other, Samar, are the only Philippine members of the order Eurylæmiformes. Little is known about the habits of these birds. They are usually found in small parties perching quietly among the branches of forest trees, and they display more curiousity than fear in the presence of man. The conspicuous characters of these birds are the broad bill, the bristles about the mouth, the ring of bare skin around the eye, the wedge-shaped tail, and the peculiar colors. In *Sarcophanops steeri* the bill, the fleshy wattle about the eye, and the feet are light blue; the iris is blue or green, depending upon the angle of the light. The chin, throat, and wings are black, the secondaries with a band of yellow and white near the middle; the top of the head is dark purple, separated from the brown back by a white collar; the rump and the tail are bright chestnut. The breast and the sides are lilac in the male and white in the female. The length is about 175 millimeters.

One of the largest eagles known,[60] *Pithecophaga jefferyi* Grant, inhabits the forests of Luzon, Samar, and Mindanao. It is

[60] See Shufeldt, R. W., Philip. Journ. Sci. 15 (1919) 31.

known to eat monkeys.[61] In contrast to this ponderous eagle is the butterfly falcon, *Microhierax erythrogenys* (Vigors), which is no larger than a large sparrow.

LOCAL ABUNDANCE OF CERTAIN SPECIES OF BIRDS

A curious condition is found in some small islands, where one or more local species may be common over the entire area of the island, even if there be but little forest. Thus, *Dicruropsis cuyensis* (McGregor) is found all over Cuyo, and *Zosterops richmondi* McGregor fairly swarms on Cagayancillo; but neither genus is represented on the other island. *Hypsipetes fugensis* Grant and *Leptocoma henkei* (Meyer) are extremely abundant on both Fuga and Calayan. The latter species is found in Luzon also, but is not nearly so abundant as it is in the small northern islands. *Hyloterpe fallax* McGregor is one of the most abundant species on Calayan. *Terpsiphone periopthalmica* (Grant) is confined to Batan and is fairly abundant in forest over most of that island; the type specimen of this species came from Malabon, near Manila, but it must have been a straggler.

DISCONTINUOUS DISTRIBUTION OF SPECIES

This superabundance of one or a few species on a small island where other species occur in no more than their normal numbers seems to indicate that there are unusually favorable conditions on these small islands for some species. Another curious condition is the absence of a species from an island on which it is reasonable to expect it to occur. Thus, *Corvus philippinus* Bonaparte, a large, conspicuous bird, which is abundant in most islands, does not occur on Camiguin Island, north of Luzon, although it is found in Calayan, Fuga, and Luzon. *Pycnonotus goiavier* (Scopoli), one of the commonest and most universally distributed among Philippine species does not occur on any of the islands north of Luzon. Somewhat allied to this condition is the discontinuous, or interrupted, distribution of a species. *Centropus carpenteri* Mearns, of Batan Island, is very slightly if at all different from *C. mindorensis* (Steere), of Mindoro; yet no species like either of these is found on any of the intermediate islands or on any other island. *Camiguinia helenæ* (Steere) is abundant on Camiguin, north of Luzon, but is unknown south of there until northern Mindanao is reached. Specimens from these two localities are indistinguishable. *Chloropsis flavipennis* (Tweeddale) is one of the characteristic birds of Cebu and appears also in northern Mindanao. The first

[61] See Clemens, J., Condor 9 (1907) 92.

record of *C. flavipennis* for Mindanao was based on a specimen supposed to have been secured there by Platen, but the locality seemed impossible and for a long time the record was considered to be a mistake. However, the Bureau of Science has a specimen that was undoubtedly killed in Mindanao,[62] and it cannot be distinguished from Cebu specimens.

There are many other interesting genera of birds to be found in the primary lowland forest, but there is no need to mention more of them here. The endemic Philippine land birds are enumerated in Table 2, and most of these are forest-inhabiting species.

Where the altitude becomes too great for the dipterocarp, the molave, and the midmountain forest, there succeeds a mossy forest. In parts of Luzon and in western Mindoro there is a pine forest below the mossy forest.

PINE TYPE OF FOREST

The pine type is distinctly characterized by open stands of *Pinus insularis* Endlicher in north-central Luzon, of *Pinus merkusii* Junghuhn and De Vriese in Mindoro, and of both species in Zambales Province, Luzon. The pine type is found in a mountainous habitat at elevations of from 500 to 1,500 meters, with straggling specimens up to 2,700 meters. No other tree of importance is found in the pine type.

MOSSY TYPE OF FOREST

The summits and sides of many high and rough mountains are covered with a thick growth of more or less dwarfed trees, which are characteristically decorated with luxuriant growth of mosses, liverworts, foliaceous lichens, orchids, and ferns. The strong winds of these regions cause the stunted growth of the trees, while the high humidity favors the development of the fantastic epiphytic plant species that are characteristic of the mossy forest. Among the characteristic tree species of the mossy forest are *Podocarpus imbricatus* Blume, *Drimys piperita* Hooker f., *Dacrydium elatum* Wallich, and species of *Vaccinium, Rhododendron,* and *Quercus.* High-altitude species of *Eurya, Symplocos, Eugenia,* and many other genera that are also represented in the lowland forests are noteworthy.

To the casual observer the most obvious botanic feature of the mossy forest is the great quantity of epiphytic lichens, mosses, liverworts, ferns, orchids, and epiphytic flowering plants of certain families, especially species of the Melastomataceæ,

[62] Philip. Journ. Sci. § A 4 (1909) 74.

which grow in profusion on every shrub and tree so that their stems and branches are entirely hidden. The tree species are fewer than those of the lower and more level forests. The trees of the mossy forest are small; for the most part their trunks and branches are slender and are so twisted and distorted as to be useless for commercial lumber. Many of the individual trees are so covered with moss that the branches and the smaller trunks appear to be two or three times their actual diameters. The forest is so crowded with inclined and twisted trunks, which are hidden beneath a dense growth of ferns and herbaceous plants, that walking is difficult. On the steeper slopes progress is slow and laborious and in places is dangerous if not nearly impossible. All of this vegetation is almost continuously saturated with moisture.

On the higher ridges and the summits of many peaks the vegetation is much dwarfed, tree species being reduced to mere shrubs. Mount Pulog is an exception to this rule, for above the mossy forest its summit protrudes entirely free of shrubs and trees, the only vegetation here being a thick carpet of small grasses, sedges, and herbs.

In the ascent of Mount Pulog four main types of vegetation are noted, the first three of which are characteristic of the entire Benguet-Lepanto region, the fourth being apparently entirely confined to Mount Pulog. The steep slopes leading up from the river are covered almost entirely with grass, although scattered broad-leaved shrubs and small trees are found in the gullies and stream depressions; this grass-covered area extends to an altitude of about 1,200 m. The second formation encountered is an open forest belt in which the pine (*Pinus insularis* Endl.) is the characteristic tree, which extends upward to an altitude of about 2,200 m. The third formation, the mossy forest, extends from the upper limits of the pine region to an altitude varying from 2,500 m to 2,600 m. The fourth formation, the open, grass-covered summit, extends from the upper limits of the mossy forest to the top of the mountain. Mount Pulog is apparently the only peak in the entire region that has an area of grass land succeeding the mossy forest; all the other peaks are forested to the summit.[63]

Brown's description of the changes in vegetation on Mount Maquiling can be appropriately included at this point. In his summary Brown says:[64]

The vegetation on Mount Maquiling shows a gradation from a tall forest at the base of the mountain to a dwarfed mossy one at the summit.

Between elevations of about 100 and 600 meters there is a tall diptero-

[63] Merrill, E. D., and Merritt, M. L., Philip. Journ. Sci. § C 5 (1910) 294.

[64] Vegetation of Philippine Mountains. Bureau of Science, Manila (1919) 414.

carp forest, a type of Schimper's tropical rain forest, characteristic of the lowlands in the Philippines and in many other parts of the Indo-Malayan region. This forest consists of three stories of trees, each composed of different species. The first, or tallest, story is dominated by members of the family Dipterocarpaceæ. At middle elevations the forest consists of two stories composed of different tree species. At the top of the mountain there is only one story of trees. These trees are dwarfed and very peculiarly shaped and are thickly covered with mosses and mosslike plants. Mossy forests are frequently found on high mountains in the Philippines and elsewhere in the tropics.

The ground covering in the dipterocarp forest is composed largely of tree seedlings and, at higher elevations, of herbaceous plants.

The epiphytes in the dipterocarp forest are largely phanerogams and are confined chiefly to the largest branches of the tallest trees. At middle elevations epiphytes are more numerous and cryptogams are more conspicuous. Mosses and liverworts may form a thin covering over a considerable portion of the trunks of trees. The greatest development of epiphytes is at the top of the mountain in the mossy forest; where the lower branches and the trunks of the trees are thickly covered with mosses and mosslike plants, in which grow a number of larger plants, including phanerogams. On the smaller branches epiphytes are also numerous, but less so than on the trunks.

BIRDS OF THE HIGHLANDS

Highlands is used here as a loose term to designate the mountainous regions above 1,200 meters' altitude. The land birds so far mentioned are found in cleared areas, in second growth, in grasslands, and in lowland forest. There remains to be said something of the change in the avian fauna with change in elevation. In northern Luzon there is a large area having a general elevation of from 1,200 to 1,600 meters and many parts are much higher than this. The highest point in Luzon is believed to be the summit of Mount Pulog, which is 2,880 meters (9,480 feet) in altitude.[65] The flora of most of this region is characterized by open, parklike forests of *Pinus insularis;* except as scattered individuals this species does not grow below about 1,200 meters. Above 2,200 meters, especially on ridges and the summits of peaks, the pine gives way to a mossy forest.

Several of the other large islands present almost the same changes in vegetation with increase in altitude as those described for northern Luzon, but only one other island of this Archipelago, Mindoro, yields trees of the genus *Pinus*.

Before John Whitehead made his first trip into Benguet Province, nothing was known of the highland fauna. It is true that

[65] See Merrill, E. D., and Merritt, M. L., Philip. Journ. Sci. § C **5** (1910) 290.

two of the most remarkable highland species, *Pitta kochi* Brüggemann and *Leucotreron marchei* (Oustalet), had been described from specimens labeled "Manilla," but no one seems to have suspected that these were representatives of a distinct highland fauna.[66]

Whitehead's first highland collection[67] was made in the vicinity of Trinidad, which marks about the lower limit of the pine forest in that region.

After the Benguet trip Whitehead visited other parts of northern Luzon and collected specimens of nearly every species of bird that is known from these highlands. In Isabela Province he discovered *Zosterornis striatus* Grant and *Oriolus isabellæ* Grant.[68]

On his next trip, although he was very weak and scarcely able to eat or to walk because of dysentery, Whitehead pushed to the elevated region known as Mount Data where he rediscovered the two magnificent species *Pitta kochi* Brüggemann and *Leucotreron marchei* (Oustalet). On this trip he added ten new species to the known fauna of the Philippines, and some of them are characteristic of the highlands. Nearly all of the species discovered by Whitehead in the highlands have been collected since by Worcester, Mearns, or McGregor.

Scops whiteheadi Grant, *Pitta kochi* Brüggemann, and *Lusciniola seebohmi* Grant have not been collected since Whitehead's time. My own work in the vicinity of Baguio and in the mossy

[66] Many of the early specimens came from "Manilla," but few of them were collected in the vicinity of Manila; certainly not these two species, for no one has found either of them in the lowlands and no one ever will. How the types of these two rare species and no others came out of the mountains probably will never be known.

[67] See Grant, W. R. O., On the birds of the Philippine Islands. Part II. The highlands of north Luzon, 5,000 feet, Ibis VI 6 (1894) 501–522. Grant described nineteen new species in this paper, but some of the species included in Grant's paper were collected at lower elevations and near the coast, as can be determined by an examination of Whitehead's notes, Ibis VII 5 (1899). For example, under *Cinnyris jugularis* (vel *C. obscurior* Grant), Whitehead says: "We met with this species as high as 3,000 feet in Benguet." Under *Oriolus albiloris* he says: "The unique specimen obtained was shot in the Benguet mountains at an altitude of 2,000 feet."

It is unfortunate that Whitehead's notes were not published with Grant's reports on the collections. With regard to this Grant says: "We cannot help thinking, however, that the delay in publishing these valuable notes, which cannot fail to be of the greatest interest, is a mistake, as such information would greatly enhance the value of the papers published on his collections, which are at present, of necessity, somewhat dry reading, dealing, as they do, merely with the birds from a scientific point of view."

[68] Grant, W. R. O., Ibis VII 1 (1895) 106–117.

forest at Pauai, on Mount Pulog, and on Polis Mountain has yielded just one additional novelty, *Prionochilus anthonyi* McGregor.[69] The discovery of this remarkably distinct species indicates that there may be yet a few unknown species in this vast, elevated area in which no thorough collecting has been done.

The number of species to be found in the mossy forest in Luzon is small, and the number of species confined to it is very much smaller. Only twenty-two species were seen near Pauai (Haight's), which is a very favorable locality for birds. The following species appear to be confined to the mossy forest:

Leucotreron marchei (Oustalet). Mount Data and Polis Mountain; rare.
Pyrrhula leucogenys Grant. Common at Pauai and at other localities in the mossy forest.
Rhinomyias insignis Grant. Pauai and Mount Data; rare.
Pitta kochi Brüggemann. Known only from Mount Data.
Lusciniola seebohmi Grant. Known only from Mount Data.
Prionochilus anthonyi McGregor. Known only from Polis Mountain.

Some of these species may turn up at much lower altitudes. *Loxia luzoniensis* seems to be confined to the pine regions without regard to altitude. Nearly all of the other species so far recorded from the mossy forests of Luzon are known also from the broad-leafed forest below the pine belt, and many of them are abundant in the lowland forests, below 500 meters' altitude.

BIRDS OF THE HIGHLANDS OF NORTHERN LUZON

The following species are all that have been recorded in northern Luzon from above 1,200 meters' altitude.

The list is based on the lists of Whitehead's collections published by Grant, on Whitehead's field notes, and on my own published records. From Whitehead's notes it is clear that some of the species included by Grant as coming from the highlands were really collected in the lowlands. For example, *Oriolus albilorus* and *O. isabellæ* are common at less than 100 meters' altitude in suitable forest. Some of the other specimens reported by Grant as coming from "5,000 feet" were undoubtedly collected at much lower altitudes. My own experience in the Mountain Province as well as in other parts of Luzon has been of help in preparing this list.

Excalfactoria lineata (Scopoli). A characteristic lowland species that may be found within the lower limits of the highlands. Recorded by Whitehead from 1,200 meters.[70]

[69] Philip. Journ. Sci. § D 9 (1914) 531, pl. 1.

[70] The altitudes given by Whitehead in feet have been changed to meters; the odd quantities of less than 50 meters are of no consequence and are not recorded.

Gallus gallus (Linnæus). A lowland species; rare in the highlands; Whitehead found it at 2,100 meters in Lepanto.

Turnix ocellata (Scopoli). Found by Whitehead at 1,800 meters in Benguet, but certainly rare at such an altitude.

Phapitreron leucotis (Temminck). Common in the lowlands; recorded by Whitehead at 2,100 meters.

Leucotreron marchei (Oustalet). A high-mountain species probably rarely found below 2,000 meters.

Ptilocolpa carola (Bonaparte). Common at about 1,300 meters, but known also at sea level, from the vicinity of Manila.

Columba griseigularis (Walden and Layard). A forest species found from sea level to 2,300 meters.

Macropygia tenuirostris (Bonaparte). From sea level to about 2,800 meters.

Hypotænidia philippensis (Linnæus). From sea level to 1,500 meters at the base of Mount Data.

Limnobænus fuscus (Linnæus). From sea level to 1,500 meters at the base of Mount Data.

Gallinula chloropus (Linnæus). Common at sea level; on a small lake in Benguet at 1,200 meters.

Tachybaptus philippinensis (Bonnaterre). Common in the lowlands; one recorded from 1,500 meters at the base of Mount Data.

Gallinago megala Swinhoe. Abundant in the lowlands during migration; noted by Whitehead in a marsh at 1,200 meters.

Gallinago gallinago (Linnæus). Rarer than *G. megala;* Whitehead got one at 1,200 meters.

Butorides javanica (Horsfield). A lowland species extending up to about 1,200 meters at least.

Accipiter confusus (Hartert). From the lowlands up to 2,400 meters.

Lophotriorchis kieneri (Geoffroy St. Hilaire). A rare hawk of the lowlands; Whitehead killed one "on our journey to Lepanto." No altitude is given by him.

Spizaëtus philippensis Gurney. A forest hawk; Whitehead saw one on the seacoast and another at 1,200 meters in Benguet.

Spilornis holospilus (Vigors). The serpent eagle is a lowland species, but Whitehead records it from "the highlands of North Luzon" without giving the altitude.

Butastur indicus (Gmelin). A common migrant in many parts of the Philippine Islands. Whitehead says of it: "Common during the winter months in North Luzon."

Haliastur intermedius Gurney. Common in the lowlands. Whitehead says: "This Kite soon found our camp on Monte Data, and was almost a daily visitor."

Falco ernesti Sharpe. Rare; Whitehead collected "a fully adult male on the summit of Monte Data."

Falco severus Horsfield. Seen in the lowlands and at 1,200 meters in Benguet. Whitehead collected a male at over 2,100 meters in Lepanto.

Pseudoptynx philippensis Kaup. Whitehead found this species in Benguet and in Isabela, but gives no altitude. I obtained one at 1,200 meters in Benguet and have not seen it in the lowlands.

Otus longicornis (Grant). Known only from Benguet, at about 1,200 meters, and Mount Data, at about 2,100 meters.

Otus whiteheadi (Grant). Known only from Mount Data. Whitehead says that he heard it in Benguet.

Prioniturus montanus Grant. Very common in the highlands from 1,200 to about 2,900 meters. It is also found at considerably lower altitudes. In the coast forest it is replaced by *P. discurus* and *P. luconensis*.

Loriculus philippensis (P. L. S. Müller). From near sea level to about 1,200 meters.

Yungipicus validirostris (Blyth). From sea level to about 2,400 meters.

Batrachostomus microrhynchus Grant. From 1,200 to over 2,400 meters. This is the only species of frogmouth known from Luzon, and it may yet be found in the lowlands.

Eurystomus orientalis (Linnæus). Abundant from sea level up to 1,200 meters.

Alcedo bengalensis Gmelin. Abundant at sea level and fairly common at 1,200 meters.

Halcyon gularis (Kuhl). A characteristic species of the lowlands; extends to at least 1,200 meters in Benguet.

Hydrocorax hydrocorax (Linnæus). A forest bird of the lowlands, probably not found above 1,200 meters.

Penelopides manillæ (Boddaert). The range of this small hornbill seems to coincide with that of the last preceding species. Neither of them is a mountain bird.

Merops philippinus Linnæus. This species and *Merops americanus* (P. L. S. Müller) are common enough in the lowlands; Whitehead records *M. philippinus* from 1,500 meters in Benguet.

Caprimulgus manillensis Walden. This is a lowland species, but Whitehead found it at 1,200 meters in Benguet. Whitehead does not mention *C. griseatus* as being found so high as this. He found *Lyncornis* at 900 meters although Grant has included both of these genera in the Benguet list. While they may occur at the lower limits of our highlands, they are much commoner in the lowlands.

Hemiprocne major (Hartert). From the sea coast up to about 1,200 meters.

Collocalia whiteheadi Grant. Common at from 1,200 to 2,800 meters, but also extending into the lowlands. The type came from Mount Data.

Collocalia fuciphaga (Thunberg). A lowland species, found also at about 1,200 meters in Benguet and at 2,100 meters on Mount Data.

Collocalia isonota (Oberholser). Found in the lowlands and from 1,200 to 2,300 meters in the highlands.

Hierococcyx spaverioides (Vigors). This was collected by us at 1,200 meters, but is probably more of a lowland species.

Cacomantis merulinus (Scopoli). Very common in the lowlands and found up to at least 1,200 meters.

Lepidogrammus cumingi (Fraser). This endemic species is usually found in the lowlands, but Whitehead records it at 2,100 meters.

Chrysocolaptes hæmatribon (Wagler). This woodpecker is usually common in the lowland forest, but has been found in the highlands at from 1,200 to about 2,800 meters.

Thriponax confusus Stresemann. The range of this large woodpecker coincides with that of the next preceding species.

Pitta kochi Brüggemann. This pitta has been found only on Mount Data.

Hirundo striolata (Boie). Whitehead records this species from 1,500 meters in Benguet. Mosque swallows are abundant at low altitudes during migration, and some of them are resident. Perhaps the breeding birds belong to a distinct race or subspecies.

Hemichelidon griseosticta Swinhoe. Probably a winter migrant only. Common in the lowlands and found up to at least 1,200 meters.

Muscicapula westermanni Sharpe. This appears to be a highland species; it is abundant at from 1,200 to 2,400 meters.

Muscicapula luzoniensis Grant. From 1,200 to 2,800 meters; Whitehead found it commoner at higher altitudes than he did in Benguet.

Rhipidura cyaniceps (Cassin). This is the Luzon representative of the forest fan-tailed flycatchers. It is common in the lowlands and at various altitudes up to 2,400 meters in the highlands.

Rhinomyias insignis Grant. Whitehead collected this species on Mount Data at 2,400 meters, and I found it near Pauai at about the same altitude. It is probably confined to the mossy forest.

Culicicapa helianthea (Wallace). A common highland species, from about 1,200 to over 2,800 meters. Also found in the lowlands.

Cryptolopha nigrorum Moseley. Found at all elevations in the highlands; it appears to be commoner at the higher elevations.

Eumyias nigrimentalis (Grant). Abundant in the highlands at all altitudes; Whitehead records it from as low as 900 meters.

Artamides striatus (Boddaert). I consider this to be a lowland species, but we found it at about 1,200 meters; Whitehead met with it at 2,100 meters.

Pericrocotus novus McGregor. Found at about 1,200 meters in Benguet and at about 2,400 meters on Polis Pass. This species probably occurs at all altitudes where there is suitable forest.

Pericrocotus cinereus Lafresneye. This is a migratory species that is at times abundant in the lowlands; it has been found up to about 1,200 meters.

Iole gularis (Pucheran). All species of *Iole* are characteristic of the lowlands, but *Iole gularis* is also abundant at about 1,200 meters in Benguet and occurs on Mount Pulog at about 2,400 meters.

Pseudotharrhaleus caudatus Grant. Very little is known about this shy bird; we got three specimens at about 1,200 meters in Benguet, but Whitehead found it only on Mount Data where he collected three specimens. It must be considered an exclusively highland genus until it is discovered in the lowlands.

Zosterornis whiteheadi Grant. This species is abundant at all elevations above about 4,000 feet. It reaches the lowlands in northern Luzon.

Brachypteryx poliogyna Grant. This appears to be an exclusively highland species and is perhaps most abundant at from 1,800 to 2,400 meters' altitude.

Planesticus thomassoni (Seebohm). This black thrush is characteristic of the Luzon highlands above about 1,200 meters.

Turdus chrysolaus Temminck. This Asiatic thrush occurs as a migrant in the Luzon highlands.

Turdus obscurus Gmelin. A migrant, like the last preceding.

Oreocincla varia (Pallas). A migrant found by Whitehead at between 1,800 and 2,400 meters.

Petrophila manillensis (J. R. Forster). Common from the lowlands to about 1,200 meters.

Chaimarrornis bicolor Grant. A characteristic highland species at from 1,200 to 1,800 meters; it is not known from the lowlands.

Calliope calliope (Pallas). This beautiful species is found in the lowlands during the winter, and Whitehead says that it occurs up to the summits of the highest mountains.

Locustella lanceolata (Temminck). This is probably only a winter migrant; we collected a few specimens at about 1,200 meters in Benguet.

Cisticola cisticola (Temminck). At about 1,200 meters in Benguet.

Cisticola exilis (Vigors and Horsfield). This was found at about 1,200 meters. Both species of *Cisticola* are commoner in the lowlands.

Megalurus palustris Horsfield. At about 1,200 meters in Benguet.

Megalurus tweeddalei McGregor. Whitehead records this species as occurring at 1,500 meters. The two species of *Megalurus* are much commoner in the lowlands.

Acanthopneuste borealis (Blasius). This is an abundant migrant throughout the lowlands and reaches at least the lower altitudes in the highlands.

Tribura seebohmi (Grant). The unique specimen was taken by Whitehead at 1,800 meters in Lepanto.

Horornis canturiens (Swinhoe). A winter visitor up to 1,500 meters.

Horornis seebohmi (Grant). Fairly common in the highlands at from 1,200 to 2,400 meters.

Phyllergates philippinus Hartert. Occurs at from 1,200 to 1,800 meters.

Artamus leucorynchus (Linnæus). Very abundant in the lowlands and up to about 1,200 meters.

Cephalophoneus validirostris (Grant). This species seems to occur only in the highlands at from 1,200 to 2,400 meters.

Cephalophoneus nasutus (Scopoli). This species occurs in the lowlands and extends into the highlands up to about 1,800 meters.

Hyloterpe albiventris Grant. This is the characteristic thickhead of the highlands up to about 2,400 meters' altitude, but Whitehead records it as occurring at 150 meters in Abra; we found it at about the same altitude in northern Luzon. It is, however, the highland species of *Hyloterpe* and is generally replaced by *H. philippinensis* in the lowland forests.

Pardaliparus elegans (Lesson). Common in forests at all altitudes, from sea level to the forests on Mounts Pulog and Data.

Callisitta mesoleuca (Grant). From 1,200 to 2,400 meters. At what altitude this species is replaced by the lowland species, *C. œnochlamys*, is not known.

Zosterops meyeni Bonaparte. This species seems to be unrestricted by altitude for it is found in the lowlands and on Mount Data.

Zosterops whiteheadi (Hartert). Described from Benguet specimens. Whitehead got *Z. aureiloris* Grant at 300 meters in Abra. The vertical range of the various silvereyes that have been credited to Luzon is doubtful. Possibly none of them is exclusively highland.

Dicæum luzoniense Grant. Common at 1,200 meters in Benguet; found by Whitehead on the summit of Mount Data. It is probably a highland species.

Prionochilus anthonyi McGregor. Known only from Polis Mountain.

Dicæum pygmæum (Kittlitz). A common species in many parts of the Islands and recorded by Whitehead as being found up to 1,800 meters.

Dicæum obscurum Grant. Known only from Benguet at 1,200 to 1,500 meters.

Eudrepanis jefferyi Grant. Whitehead gives the range of this species as from 1,500 to 2,300 meters; I collected it at about 1,200 meters. The other Philippine species of *Eudrepanis* occur in the lowlands of other islands; no thorough collecting has been done in Luzon, and *E. jefferyi* may be eventually taken in lowland forest.

Leptocoma henkei (Meyer). Commoner in the lowlands than in the mountains; Whitehead found it at about 1,500 meters.

Motacilla melanope Pallas. A lowland species found up to about 1,200 meters.

Budytes leucostriatus Homeyer. Common near the coast during migration; also recorded in Benguet at about 1,200 meters.

Anthus hodgsoni Richmond. Occurs during migration up to 1,800 meters.

Anthus rufulus Vieillot. Abundant in the lowlands and also recorded from the lower mountainous parts of northern Luzon.

Anthus gustavi Swinhoe. A migratory species that occurs from sea level up to about 1,200 meters.

Mirafra philippinensis Ramsay. Fairly common at low altitudes and occurs up to 1,200 meters.

Loxia luzoniensis Grant. Probably occurs in northern Luzon wherever there are pine trees; it is not known to occur below about 1,200 meters.

Munia jagori Martens. Abundant at low altitudes and noted at 1,200 meters.

Emberiza pusilla Pallas. A rare migrant, recorded from Benguet at 1,200 meters.

Emberiza sulphurata Temminck and Schlegel. A migrant; commoner than *E. pusilla* and found from the coast up to 1,800 meters' altitude.

Munia jagori Martens. Abundant at low altitudes and noted at 1,200 meters in Benguet.

Munia cabanisi Sharpe. Much rarer than *M. jagori* and with about the same vertical range in Luzon.

Uroloncha everetti (Tweeddale). Rare; its vertical range is about the same as that of the two species of *Munia* mentioned.

Reichenowia brunneiventris (Grant). Whitehead has recorded this species as being found at 600 meters in Benguet and at 2,300 meters on Mount Data.

Sarcops calvus (Linnæus). This starling is characteristic of the lowlands and is found up to about 1,200 meters.

Corvus philippinus Bonaparte. Common in nearly all of the Islands and occurs in Benguet up to about 1,200 meters.

BIRDS OF THE HIGHLANDS OF OTHER ISLANDS

Mindoro, Negros, and Mindanao, in addition to Luzon, have yielded highland species. Several collectors have visited Mindoro, but only two seem to have collected at what can be called highland stations. Whitehead succeeded in reaching an altitude of "nearly 6,000 feet" where he secured only two species that were new to science; namely, *Planesticus mindorensis* (Grant) and *Zonophaps mindorensis* (Whitehead).[71]

In 1906 Mearns headed an expedition that pushed to the summit of Mount Halcon.[72] The results in birds were disappointing, for this party, like Whitehead's, encountered incessant rain at high altitudes. Mearns has described the following from Mindoro: *Cyornis mindorensis*, from 150 meters' altitude; *Zosterops halconensis*, from 1,400 meters' altitude; and *Dicrurus balicassius mindorensis*, from the lowlands. Probably none of these is an exclusively highland species.

In Negros Whitehead collected only two new highland species; namely, *Planesticus nigrorum* (Grant) and *Brachypteryx brunneiceps* Grant.[73]

Mindanao contains lofty mountains on a scale similar to Luzon, and many striking species have been brought to light by Goodfellow, Waterstradt, and Mearns. Further exploration, especially of the higher mountains, will doubtless result in additions to the known bird fauna of Mindanao. Most of the following species are confined to the highlands of Mindanao:

Trichoglossus johnstoniæ Hartert. Mount Apo.

Prioniturus waterstradti Rothschild. Mount Apo, at 900 to 2,500 meters.

Prioniturus malindangensis Mearns. Mount Lebo, a spur of Mount Malindang, at 1,500 meters.

Chrysocolaptes montanus Grant. A partially alpine form, also found on the coast.

Chrysocolaptes malindangensis Mearns. Mount Malindang, at 1,800 meters.

Muscicapula montigena Mearns. Mount Apo, at 1,800 meters.

Rhipidura nigrocinnamomea Hartert. Mount Apo.

Rhipidura hutchinsoni Mearns. Mount Malindang, at 1,200 to 2,700 meters.

Rhinomyias goodfellowi Grant. Mount Apo.

Rhinomyias mindanensis Mearns. Mindanao (in general?).

Cryptolopha mindanensis Hartert. Mount Apo.

Cryptolopha malindangensis Mearns. Mount Malindang, at 2,700 meters.

Eumyias nigriloris (Hartert). Mount Apo.

Malindangia mcgregori Mearns. Mount Malindang, at 1,200 to 2,700 meters.

Pericrocotus johnstoniæ Grant. Probably a lowland species.

Pseudotharrhaleus unicolor Hartert. Mount Apo.

Pseudotharrhaleus malindangensis Mearns. Mount Malindang, at 2,700 meters.

Macronous montanus Mearns. Pantar, at 610 meters; and Mount Apo, at 1,220 meters.

[71] Grant, W. R. O., Ibis VII 2 (1896) 457–477.

[72] See Merrill, E. D., Philip. Journ. Sci. § A 2 (1907) 179.

[73] Grant, W. R. O., Ibis VII 2 (1896) 525–565.

Leonardina woodi (Mearns). Mount Apo, at 1,220 meters.
Brachypteryx mindanensis Mearns. Mount Apo, at 1,220 meters.
Brachypteryx malindangensis Mearns. Mount Malindang, at 2,700 meters.
Planesticus kelleri (Mearns). Mount Apo, at 1,800 meters.
Planesticus malindangensis (Mearns). Mount Malindang, at 1,500 to 2,700 meters.
Geokichla mindanensis Mearns. Mount Apo, at 2,000 meters.
Phyllergates heterolæmus Mearns. At 2,000 meters.
Hyloterpe apoensis Mearns. Mount Apo, at 1,800 meters.
Pardaliparus mindanensis Mearns. Mount Apo, at 1,800 meters.
Zosterops vulcani Hartert. Mount Apo.
Zosterops malindangensis Mearns. Mount Malindang, at 1,800 meters.
Hypocryptadius cinnamomeus Hartert. Mount Apo.
Dicæum apo Hartert. Mount Apo.
Dicæum davao Mearns. Seems to be a lowland species.
Dicæum nigrilore Hartert. A mountain species?
Æthopyga boltoni Mearns. Mount Apo, at 1,900 meters.
Pyrrhula steerei Mearns. Mount Apo, at 1,700 meters.
Lamprocorax todayensis Mearns. Mount Apo, at 1,200 meters.
Goodfellowia miranda Hartert. Mount Apo.

In the preceding consideration of the forest species of Philippine birds I have tried to indicate that many of the lowland forest genera persist to considerable elevations, in some cases without change of species. On the other hand it has been noticed that in Luzon, above about 1,200 meters' altitude, the lowland species in several genera are replaced by other, more or less distinct, species; for example, in *Prioniturus, Callisitta, Dicæum, Leucotreron* (subgenus *Neoleucotreron*), *Pitta, Otus, Lanius, Hyloterpe,* and *Rhinomyias.*

The highlands also yield genera that are unrepresented in the lowlands. Among these are *Pseudotharrhaleus, Brachypteryx, Planesticus, Chaimarrornis, Tribura, Loxia, Malindangia, Goodfellowia, Hypocryptadius, Leonardina,* and *Pyrrhula.* Some of these genera are found only in the Philippine Islands, while the others are represented in neighboring and distant parts of the world.

LOCAL DISTRIBUTION OF ENDEMIC PHILIPPINE BIRDS

If we consider the distribution of the endemic species of Philippine birds we find that certain species occur in nearly all the islands of the Archipelago. *Corvus philippinus, Pycnonotus goiavier,* and *Oriolus acrorhynchus* are example of these, and such species are usually abundant. Other species are the sole members of their respective genera and are confined to single islands; such are *Dasycrotapha speciosa, Malindangia mcgregori,* and *Goodfellowia miranda.*

Most of the endemic species are confined to single islands or to groups of islands, while the genera to which they belong are represented in other islands by other endemic species.

Walden [74] long ago remarked that—

As might be anticipated from analogy with other isolated areas, some of the Philippine Islands, although only separated by narrow seas, possess species peculiar to themselves. Although well defined, these are strictly representative forms.

Steere has expressed this phase of distribution in the following words:

The law of distribution of non-migratory land-birds of the Philippines may be stated as follows:—*Every genus is represented by only a single species in one place.* Or, in more general terms, as follows:—*No two species structurally adapted to the same conditions will occupy the same area.* [Italics are given as in the original.] [75]

The first statement of Steere's law seems rather unfortunate, for "place" is a word of too general meaning. It is hard to understand why he did not use "island," which seems from the context to be what he meant. If the law were restated with more precise words it would read: "No genus is represented by more than one species in any island." As a matter of fact there are many genera of which this is not true. This was recognized by Steere, and he makes the following statement:

In 17 genera and 74 species each genus is represented in the islands by several species, two or more of which may be found inhabiting the same island; but the species thus found together, with the same generic name, differ greatly in size, colouring, or other characteristics, and belong to different natural sections or subgenera.

Authors have already attempted in several cases to raise the natural sections of these genera [Steere's list D] to generic rank.

By "other characteristics" Steere seems to have intended food, kind of country inhabited, and whether a species is social or solitary. Although these characteristics, as well as size and coloring, may be made use of in generic descriptions they are not considered to be valid generic characters.

Steere admits that the two species of Philippine bee eaters "probably exist together on every island of the group." He then says that they differ in habits and food; therefore they belong to different subgenera; hence, they are not an exception to

[74] Trans. Zool. Soc. London 9^2 (1875) 131.

[75] Ibis VI 6 (1894) 419. In the Auk 11 (1894) 239, Steere gave his law in a slightly different form, as follows: "*The genus is represented by but a single species in a place.*" and "*No two species near enough alike structurally to be adapted to the same conditions will occupy the same area.*"

Steere's law. These two species of *Merops* do differ in colors, but they are certainly of nearly the same size, and other observers do not agree with Steere's statement that they differ in habits. If they do not belong to one subgenus then genera and subgenera mean nothing. Steere gives several other genera that seem to conflict with his law, and his explanations for these are similar to his explanation for *Merops*.

There are other cases of two species of one genus occurring in one place that Steere did not know of. It would be interesting to know the generic characters on which Steere would separate *Leptocoma sperata* from *L. henkei* and *Oriolus albiloris* from *O. isabellæ*. The two species of *Leptocoma* can be found feeding in the same tree; and the two species of forest orioles, which were unknown to Steere, inhabit exactly the same kind of woods; in fact my first specimens were killed in one grove of trees in Bataan Province.

The second part of Steere's law, or the law "in more general terms," seems to be meaningless, for if two species, of the same genus or of different genera, occupy the same area, this fact proves that they are adapted to the same conditions.

It is not my intention to say any more about Steere's law, for the evidence has been fully discussed by Worcester, but the distribution of some of the species that do conform to Steere's law is interesting. The distribution of the three species of the endemic genus *Hydrocorax* illustrates what Steere intended to express in his law. *Hydrocorax hydrocorax* inhabits Luzon and Marinduque; the bill and casque are entirely bright red, the upper outline of the casque is straight, and the anterior end overhangs the culmen. *Hydrocorax mindanensis* inhabits Mindanao and Basilan; the casque and the basal half of the bill are bright red; the terminal half of the bill is whitish; the outline of the bill is similar to that of *H. hydrocorax*. *Hydrocorax semigaleatus* inhabits Samar, Leyte, Biliran, Bohol, and Panaon; the bill is red and whitish as in *H. mindanensis;* the casque is contracted in front, its anterior end sinking to the culmen and not forming an anterior overhanging projection. The last species is the type of *Platycorax* Oberholser.

The distribution of the endemic species of a nonendemic genus is illustrated by *Loriculus*.

Loriculus philippensis (P. L. S. Müller) is found in Luzon and in some of the small islands near it.

Loriculus mindorensis Steere is confined to Mindoro.

Loriculus bournsi McGregor inhabits Romblon, Tablas, and Sibuyan.

Loriculus regulus Souancé is found in the central islands Negros, Guimaras, Panay, Masbate, and Ticao.
Loriculus chrysonotus Sclater is confined to Cebu.
Loriculus siquijorensis Steere is confined to Siquijor.
Loriculus worcesteri Steere inhabits Samar, Leyte, and Bohol.
Loriculus apicalis Souancé is known from Mindanao, Dinagat, and Bazol.
Loriculus dohertyi Hartert is confined to Basilan.
Loriculus bonapartei Souancé inhabits Sulu, Tawitawi, and Bongao.

It is important to note that the genus *Loriculus* has no representative in Palawan, on the west, and in the Babuyanes and the Batanes, north of Luzon.

On the basis of evidence afforded by the distribution of endemic species, such as those just given, Steere[76] divided the Islands into subprovinces, and most of these divisions have survived the test of more detailed work based upon much more material.

The sub-provinces proposed are—first, the Northern Philippines, consisting of Luzon and Marinduque, and a number of other small islands about Luzon; second, Mindoro; third, the Central Philippines, made up of the islands of Panay, Negros, Guimaras, Zebu, Bohol, and Masbate; fourth, the Eastern Philippines, comprising the islands of Samar and Leyte; fifth, the Southern Philippines, embracing the great island of Mindanao, with Basilau [sic], and perhaps Sulu; and sixth, the Western Philippines, consisting of the islands of Paragua or Palawan, and Balabac.

In the main Steere's subprovinces are the same as the divisions now recognized. It seems rather curious that Steere made no use of previous records, even the results of his own first trip to the Islands seemingly being ignored by him. He says:[77]

In this study only collections made by the members of the [Steere] party have been used. * * * About five thousand specimens of birds were collected by the party, these belonging to about four hundred species. They were collected on seventeen distinct islands of the archipelago, which were chosen, from their size and location, as representative of the whole.

These collections, while not comprising examples of all the species known from the islands, are so nearly complete that any just conclusions drawn from their study must be accepted as truths which further exploration will only strengthen.

Everett[78] has published an excellent paper in which is presented the evidence for considering that Palawan and Balabac are more strongly Bornean than Philippine. Everett[79] has also

[76] Nature 39 (1888) 37, 38. This article is dated "Manila July 2, 1888."
[77] Ibis VI 6 (1894) 412. The article in the Auk differs slightly from this.
[78] Proc. Zool. Soc. London (1889) 220–228.
[79] Ibis VII 1 (1895) 21–39.

shown that Balabac is closely related to Palawan in regard to its birds.

Worcester [80] has published a very detailed review of Steere's work, taking advantage of much information in regard to distribution that was not available to Steere, notably the results of the Menage expedition and of Whitehead's numerous collections from the highlands.

Since Worcester and Burns [81] published their list a great deal of detailed work has been done on the distribution of the lowland species. Most of this has been published by Grant, W. E. Clarke, Worcester, Mearns, and McGregor.

In 1906 Worcester [82] republished his conclusions as to the divisions of the Islands that can be recognized, these conclusions being somewhat modified and extended by the work on distribution of Philippine birds that had been done since 1900.

It would be difficult to state the matter in clearer or more concise form than Worcester has done; and I shall quote from him in full, adding a few remarks of my own in square brackets. Worcester considers that the Philippine Islands may be divided into zoölogically distinct groups as follows:

(1) The Palawan group, consisting of Palawan and the small islands adjacent to it, Balabac, Cagayan Sulu, and the Cuyos and Calamianes Islands. The birds of this group show a very strong Bornean element. The line of demarcation between the Philippines, zoölogically speaking, and the Palawan Islands passes between Sibutu and the coast of Borneo and extends thence northward through the Sulu Sea east of the Cuyos group and through Mindoro Strait. [I do not include Cagayan Sulu in the Palawan group. The identification of specimens of *Pycnonotus plumosus* Blyth from Cagayan Sulu [83] adds to the previously existing evidence of the Bornean affinity of this island.]

(2) The central Philippines, comprising the Islands of Negros, Panay, [Bantayan,] [84] Guimaras, Masbate, and Ticao. They form a well-defined natural group, although in the case of Masbate and Ticao there are indications of immigration from Luzon. [Marilison and Batbatan, off the coast of Antique Province, Panay, have yielded no species that would indicate the faunal relationships of these small islands.] [85]

(3) Mindoro and some of the islands immediately adjacent to it, including Semerara and doubtless also Ylin. [A few birds have been recorded

[80] Proc. U. S. Nat. Mus. **20** (1898) 567–617.

[81] Op. cit. 551–564.

[82] In McGregor, R. C., and Worcester, D. C., A Hand-list of Birds of the Philippine Islands. Bureau of Government Laboratories, Manila **36** (1906) 5.

[83] McGregor, R. C., Philip. Journ. Sci. § D **11** (1916) 274.

[84] See McGregor, R. C., Philip. Journ. Sci. § A **2** (1907) 310.

[85] Bureau of Science collections of 1918; results unpublished.

from Caluya, from Sibay, and from Libagao;[86] all of them are common lowland species of wide distribution in the Philippines.]

(4) Luzon, Catanduanes, Marinduque, and Lubang. [Polillo belongs with this group, although it has three endemic species; its plants show some peculiar features.]

(5) Samar, Leyte, [Biliran,] and Bohol. * * * [The last collection made in Bohol included many species not previously known from that island; these fully confirm the belief that Samar, Leyte, and Bohol form a distinct group.[87] A small collection made by me in Biliran[88] shows that this island is merely a fragment of Leyte; these two islands are so near each other that no other result could have been expected.]

(6) Mindanao and the islands immediately adjacent to it form a group by themselves.

(7) Basilan must be separated from Mindanao on account of the fact that it has a number of representative forms of species characteristic of Mindanao. [*Orthotomus mearnsi* and *Loriculus dohertyi*, of Basilan, described since Worcester wrote the above, furnish further evidence of the difference between Basilan and Mindanao.]

(8) Bongao, Tawi Tawi, Lapoc, and Sulu form a well-marked natural group, to which Sibutu must probably be added.

(9) Tablas, Romblon, and Sibuyan show no evidence of having been connected with any of the neighboring larger islands. They have a number of peculiar species of birds, and Tablas and Romblon should probably be classed together. [Banton shows a slight relationship to Romblon. Cresta de Gallo, south of Sibuyan, is little more than a sand bar.]

(10) Cebu cannot be regarded as one of the central Philippine group but must be classed by itself.

(11) The Batanes Islands [= the Babuyanes] have a strong Formosan element among their birds. It remains to be seen whether the Babuyanes Islands [= the Batanes] must be grouped with them or must be considered as detached fragments of northern Luzon. [This paragraph is badly mixed. At the time that it was written we had a small collection from Fuga and a large collection from Calayan, both in the Babuyanes, but nothing was known of the birds of the Batanes. Since then we have secured collections from Camiguin, in the Babuyanes, and from Batan, in the Batanes; we also have a few, mostly unimportant, specimens from Dalupiri, Babuyan Claro, Y'Ami, and Sabtan. Although Camiguin, Calayan, and Batan, and perhaps some of the other islands of these two groups, show differences from each other, they all differ so much from Luzon that they form a group quite as distinct as some of the others considered above.]

(12) Siquijor, Cagayancillo, and Cresta de Gallo are islands of recent origin and their bird faunæ have been derived from neighboring islands. [Siquijor has three endemic species and lacks some of the central-island species, but it would be grouped with the central islands if with any. The fauna of Cagayancillo is more puzzling. *Cinnyris aurora*, a characteristic Palawan species, is as abundant there as it is on Cuyo; but *Dicruropsis*, which is common on Cuyo, is not found on Cagayancillo. *Zosterops richmondi*, endemic to the latter island, represents a genus that is unknown

[86] McGregor, R. C., Philip. Journ. Sci. 1 (1906) 698.

[87] See McGregor, R. C., Philip. Journ. Sci. § A 2 (1907) 315–333.

[88] Bureau of Science collection; results unpublished.

in the Palawan group; *Centropus viridis*, also found on Cagayancillo, is strictly non-Palawan. We found only eleven species of birds on Cresta de Gallo and none of them, except *Zosterops nigrorum*, has a restricted range in the Philippines.]

The total number of species of birds known from the Philippine Islands is 760, distributed in 292 genera; 477 species and 26 genera are endemic. These numbers include the shore and water birds, most of which are nonendemic both as to genera and species.

If the land birds alone be considered the numbers are approximately as follows:

Genera	209
Species	639
Endemic genera	26
Endemic species	469
Generic endemism (per cent)	12+
Specific endemism (per cent)	73+

These numbers are given for what they are worth; to be of real interest they should be compared with similar numbers for Borneo, Celebes, Papua, etc., but such numbers are not at hand.

The endemic species of Philippine land birds and their distribution by groups of islands are given in Table 2. The numbers in the box heads correspond with the numbers on the map, Plate 1, and with the paragraphs on pages 415 and 416.

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands.*

[An asterisk indicates an endemic genus.]

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan.	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
PHASIANIDÆ.											
Polyplectron napoleonis Less	×										
TURNICIDÆ.											
Turnix fasciata (Temm.)	×	×	×	×					×	×	
ocellata (Scop.)				×							
whiteheadi Grant				×							
worcesteri McG				×							
suluensis Mearns								×			
celestinoi McG					×						

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands*—Continued.

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan.	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
TRERONIDÆ.											
Sphenocercus australis McG	----	----	----	----	----	----	----	----	----	----	×
Osmotreron axillaris (Bp.)	----	×	×	×	×	×	×	----	×	×	----
everetti Roths	----	----	----	----	----	----	----	×	----	----	----
Phapitreron amethystina Bp.*	----	----	----	×	×	×	----	----	----	----	----
cinereiceps B. and W	----	----	----	----	----	----	----	×	----	----	----
brunneiceps B. and W	----	----	----	----	----	----	×	----	----	----	----
frontalis B. and W	----	----	----	----	----	----	----	----	----	×	----
maculipectus B. and W	----	×	----	----	----	----	----	----	----	----	----
leucotis (Temm.)	----	----	×	×	----	----	----	----	----	----	----
occipitalis Salvad	----	----	----	----	----	----	×	----	----	----	----
nigrorum Sharpe	----	×	----	----	----	----	----	----	×	×	----
albifrons McG	----	----	----	----	×	----	----	----	----	----	----
samarensis Mearns	----	----	----	----	×	----	----	----	----	----	----
brevirostris Tweed	----	----	----	----	----	×	----	×	----	----	----
Leucotreron occipitalis (Bp.)	----	×	×	×	×	×	×	----	×	×	----
leclancheri (Bp.)	×	×	×	×	×	----	----	----	×	×	×
marchei (Oust.)	----	----	----	×	----	----	----	----	----	----	----
merrilli McG	----	----	----	×	----	----	----	----	----	----	----
Muscadivores nuchalis (Cabanis)	----	----	×	×	----	×	----	----	----	----	×
chalybura (Bp.)	----	×	×	×	×	×	×	----	×	×	----
palawanensis (Blas.)	×	----	----	----	----	----	----	----	----	----	----
langhornei (Mearns)	----	----	----	----	----	×	----	----	----	----	----
Ptilocolpa carola (Bp.)*	----	----	×	×	----	----	----	----	×	----	----
nigrorum Whitehead	----	×	----	----	----	----	----	----	----	----	----
mindanensis Grant	----	----	----	----	----	×	----	----	----	----	----
Zonophaps poliocephala (Hartl.)	----	×	×	×	×	×	×	×	×	×	----
mindorensis (Whitehead)	----	----	×	----	----	----	----	----	----	----	----
COLUMBIDÆ.											
Macropygia tenuirostris Bp	×	×	×	×	×	×	×	×	×	----	----
phæa McG	----	----	----	----	----	----	----	----	----	----	×
CLARAVIIDÆ.											
Gallicolumba luzonica (Scop.)	----	----	----	×	----	----	----	----	----	----	----
criniger (Jacq. and Puch.)	----	----	----	----	×	×	×	----	----	----	----
keayi (Clarke)	----	×	----	----	----	----	----	----	----	----	----
menage (B. and W.)	----	----	----	----	----	----	----	×	----	----	----
platenæ (Blas.)	----	----	×	----	----	----	----	----	----	----	----
FALCONIDÆ.											
Accipiter confusus Hartert	----	×	×	×	×	×	----	----	----	×	----
Spizaëtus philippensis Gurney	×	×	×	×	----	----	×	----	----	----	----
Pithecophaga jefferyi Grant *	----	----	----	×	×	×	----	----	----	----	----

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands*—Continued.

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
FALCONIDÆ—Continued.											
Spilornis holospilus (Vigors)			×	×	×	×	×	×		×	
panayensis Steere		×							×		
Baza magnirostris Gray				×		×					
leucopais Sharpe	×				×				×		
Microhierax erythrogenys (Vigors)			×	×	×						
meridionalis Grant					×	×				×	
STRIGIDÆ.											
Pseudoptynx philippensis Kaup*				×							
gurneyi Tweedd						×					
mindanensis Grant						×					
Otus megalotis (Gray)				×							
everetti (Tweedd.)	×				×	×	×				
fuliginosus (Sharpe)	×										
sibutuensis (Sharpe)								×			
longicornis (Grant)				×							
mindorensis (Whitehead)			×								
whiteheadi (Grant)				×							
cuyensis McG	×										
steerei Mearns								×			
calayensis McG											×
romblonis McG									×		
boholensis McG					×						
Ninox philippensis Bp		×		×	×						
everetti Sharpe								×			
spilocephala Tweedd						×	×				
spilonota B. and W			×						×	×	
reyi Oust								×			
mindorensis Grant			×								
plateni Blas			×								
Strix whiteheadi (Sharpe)	×										
LORIIDÆ.											
Trichoglossus johnstoniæ Hartert						×					
CACATUIDÆ.											
Cacatua hæmaturopygia (P. L. S. Müll.)	×	×	×	×	×	×	×	×	×	×	
PSITTACIDÆ.											
Prioniturus verticalis Sharpe								×			
montanus Grant				×							
discurus (Vieill.)		×		×	×	×	×	×	×	×	

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands*—Continued.

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan.	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
PSITTACIDÆ—Continued.											
Prioniturus waterstradti Roths						×					
malindangensis Mearns						×					
mindorensis Steere			×								
cyaneiceps Sharpe	×										
luconensis Steere				×							
Tanygnathus lucionensis (Linn.)	×	×	×	×	×	×	×	×	×	×	
everetti Tweedd		×		×		×					
freeri McG				×							
burbidgei Sharpe								×			
Bolbopsittacus lunulatus (Scop.)*				×							
intermedius Salvad					×						
mindanensis Steere						×					
Loriculus chrysonotus Scl										×	
regulus Souancé		×									
bournsi McG									×		
philippensis (P. L. S. Müll.)				×							
mindorensis Steere			×								
siquijorensis Steere		×									
apicalis Souancé						×					
dohertyi Hartert							×				
worcesteri Steere					×						
bonapartei Souancé								×			
PODARGIDÆ.											
Batrachostomus septimus Tweedd						×	×				
microrhynchus Grant				×							
menagei B. and W		×									
ALCEDINIDÆ.											
Pelargopsis gouldi Sharpe	×		×	×							
gigantea Walden		×			×	×	×	×	×	×	
smithi (Mearns)		×									
Ceyx cyanopectus Lafres		×	×	×					×		
argentata Tweedd						×	×				
flumenicola Steere					×						
nigrirostris B. and W		×								×	
melanura Kaup				×							
mindanensis Steere						×	×				
samarensis Steere					×						
bournsi Steere		×				×	×	×	×	×	
goodfellowi Grant						×					

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands*—Continued.

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan.	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
ALCEDINIDÆ—Continued.											
Halcyon ochrothorectis (Oberh.)	×	×	×	×		×			×		×
gularis (Kuhl)		×	×	×	×	×	×		×	×	
winchelli Sharpe		×			×	×	×	×	×	×	
hombroni (Bp.)						×					
lindsayi (Vigors)				×							
moseleyi (Steere)		×									
BUCEROTIDÆ.											
Hydrocorax hydrocorax (Linn.)*				×							
mindanensis (Tweedd.)						×	×				
semigaleatus (Tweedd.)					×						
Anthracoceros montani (Oust.)								×			
Gymnolæmus lemprieri (Sharpe)*	×										
Penelopides panini (Bodd.)*		×									
manillæ (Bodd.)				×							
talisi Finsch[a]				×							
subnigra McG				×							
mindorensis Steere			×								
affinis Tweedd						×					
basilanica Steere							×				
samarensis Steere					×						
Craniorrhinus leucocephalus (Vieill.)						×					
waldeni Sharpe		×									
MEROPIDÆ.											
Merops americanus P. L. S. Müll	×	×	×	×	×	×			×	×	×
CAPRIMULGIDÆ.											
Lyncornis macrotis (Vigors)			×	×		×	×				
Caprimulgus griseatus Wald		×	×	×		×			×	×	
mindanensis Mearns						×					
manillensis Wald	×	×	×	×	×	×	×		×	×	
HEMIPROCNIIDÆ.											
Hemiprocne major (Hartert)		×	×	×					×	×	
MICROPODIDÆ.											
Collocalia whiteheadi Grant[b]	×		×	×	×				×	×	×
origenis Oberh						×					
troglodytes Gray	×	×	×	×	×	×			×	×	
marginata Salvad		×	×	×	×	×			×	×	×
isonota Oberh			×	×		×		×			

[a] Described from Cagayan, Luzon; this is possibly the young of *P. manillæ*.

[b] Another subspecies is based on Palawan specimens. Several local subspecies have been described that I do not include in this table.

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands*—Continued.

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan.	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
MICROPODIDÆ—Continued.											
Chætura dubia McG	----	----	×	×	----	----	----	----	----	----	----
picina Tweedd	----	----	----	----	×	×	----	----	----	----	----
Tachornis pallidior McG	----	×	----	×	×	×	----	----	----	×	----
TROGONIDÆ.											
Pyrotrogon ardens (Temm.)	----	----	----	×	×	×	×	----	----	----	----
CUCULIDÆ.											
Surniculus velutinus Sharpe	----	×	×	×	×	×	×	×	----	----	----
Eudynamys frater McG	----	----	----	----	----	----	----	----	----	----	×
Centropus mindorensis (Steere)	----	----	×	----	----	----	----	----	----	----	----
carpenteri Mearns	----	----	----	----	----	----	----	----	----	----	×
steeri B. and W	----	----	×	----	----	----	----	----	----	----	----
viridis (Scop.)	----	×	×	×	×	×	×	×	×	×	×
melanops Less	----	----	----	----	×	×	×	----	----	----	----
unirufus (Cab. and Heine)	----	----	----	×	----	----	----	----	----	----	----
Dryococcyx harringtoni Sharpe *	×	----	----	----	----	----	----	----	----	----	----
Dasylophus superciliosus (Cuv.)*	----	----	----	×	----	----	----	----	----	----	----
Lepidogrammus cumingi (Fraser)*	----	----	----	×	----	----	----	----	----	----	----
PICIDÆ.											
Yungipicus validirostris (Blyth)	----	----	×	×	----	----	----	----	----	----	----
maculatus (Scop.)	----	×	----	----	----	----	----	----	----	×	----
menagei B. and W	----	----	----	----	----	----	----	----	×	----	----
leytensis Steere	----	----	----	----	×	----	----	----	----	----	----
fulvifasciatus Hargitt	----	----	----	----	----	×	×	----	----	----	----
ramsayi Hargitt	----	----	----	----	----	----	----	×	----	----	----
siasiensis Mearns	----	----	----	----	----	----	----	×	----	----	----
Tiga everetti Tweedd	×	----	----	----	----	----	----	----	----	----	----
Chrysocolaptes erythrocephalus Sharpe	×	----	----	----	----	----	----	----	----	----	----
hæmatribon (Wagler)	----	----	----	×	----	----	----	----	----	----	----
lucidus (Scop.)	----	----	----	----	----	×	×	----	----	----	----
montanus Grant	----	----	----	----	----	×	----	----	----	----	----
rufopunctatus Hargitt	----	----	----	----	×	----	----	----	----	----	----
xanthocephalus W. and L	----	×	----	----	----	----	----	----	----	----	----
Lichtensteinipicus funebris (Val.)	----	----	----	×	----	----	----	----	----	----	----
fuliginosus (Tweedd.)	----	----	----	----	×	×	----	----	----	----	----
Thriponax confusus Stresemann[c]	----	----	----	×	----	----	----	----	----	----	----
pectoralis Tweedd	----	----	----	----	×	----	----	----	----	----	----
multilunatus McG	----	----	----	----	----	×	×	----	----	----	----
suluensis Blas	----	----	----	----	----	----	----	×	----	----	----
philippinensis Steere	----	×	----	----	----	----	----	----	----	----	----
mindorensis Steere	----	----	×	----	----	----	----	----	----	----	----
hargitti Sharpe	×	----	----	----	----	----	----	----	----	----	----

[c] This is the distribution of the Philippine forms of *Thriponax* given by Stresemann, Nov. Zool. **20** (1913) 318–320.

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands*—Continued.

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan.	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
EURYLÆMIDÆ.											
Sarcophanops steeri (Sharpe)*						×	×				
samarensis Steere					×						
PITTIDÆ.											
Pitta erythrogastra Temm	×	×	×	×	×	×	×	×	×	×	
propinqua (Sharpe)	×										
kochi Brüggemann				×							
atricapilla Less	×	×	×	×	×	×	×	×	×	×	
steeri Sharpe					×	×					
MUSCICAPIDÆ.											
Cyornis herioti Ramsay				×							
philippinensis Sharpe		×	×	×	×	×	×	×	×	×	
lemprieri Sharpe	×										
platenæ (Blas.)	×										
Muscicapula luzoniensis Grant			×	×							(d)
nigrorum Whitehead		×									
montigena Mearns						×					
basilanica (Sharpe)						×	×				
samarensis B. and W					×						
Gerygone simplex Cab			×	×							
rhizophoræ Mearns						×		×			
Camiguinia helenæ (Steere)*					×	×					×
Cyanomyias cœlestis (Tweedd.)*		×		×		×	×		×		
Rhipidura superciliaris (Sharpe)						×	×				
samarensis (Steere)					×						
albiventris (Sharpe)		×									
cyaniceps (Cassin)				×							
sauli B. and W									×		
nigrocinnamomea Hartert						×					
hutchinsoni Mearns						×					
nigritorquis Vigors	×	×	×	×	×	×	×	×	×	×	
Xeocephus rufus (Gray)		×	×	×	×				×	×	
cinnamomeus Sharpe						×	×	×			
cyanescens Sharpe	×										
Terpsiphone periopthalmica (Grant)				×							×
Rhinomyias albigularis B. and W		×									
goodfellowi Grant						×					
ruficauda (Sharpe)					×	×	×				
mindanensis Mearns						×					

[d] The *Muscicapula* from Calayan is nearly related to *M. luzoniensis*, but is a distinct, undescribed species.

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands*—Continued.

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan.	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
MUSCICAPIDÆ—Continued.											
ocularis B. and W								×			
insignis Grant				×							
Cryptolopha olivacea (Moseley)		×		×	×	×		×			
cebuensis Dubois										×	
nigrorum Moseley		×	×	×							
mindanensis Hartert						×					
malindangensis Mearns						×					
xanthopygia Whitehead	×										
Eumyias panayensis Sharpe[e]		×									
nigrimentalis (Grant)			×	×							
nigriloris (Hartert)						×					
CAMPOPHAGIDÆ.											
Artamides difficilis (Hartert)	×										
guillemardi Salvad								×			
striatus (Bodd.)				×							
kochi Kutter					×	×	×				
panayensis Steere		×									
mindorensis Steere			×						×		
cebuensis Grant										×	
Malindangia mcgregori Mearns*						×					
Edolisoma cærulescens (Blyth)				×							
alterum Ramsay										×	
panayense Steere		×									
everetti Sharpe								×			
mindanense (Tweedd.)						×	×				
elusum McG			×	×							
Pericrocotus marchesæ Guillem								×			
novus McG		×		×							
leytensis Steere					×						
johnstoniæ Grant						×					
Lalage melanoleuca (Blyth)			×	×							
minor (Steere)					×	×					
PYCNONOTIDÆ.											
Chloropsis palawanensis (Sharpe)	×										
flavipennis (Tweedd.)						×				×	
Irena cyanogastra Vigors				×							
ellæ Steere					×						
melanochlamys Sharpe						×	×				
tweeddali Sharpe	×										

[e] Hartert records this species as occurring in Obi Major.

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands*—Continued.

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan.	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
PYCNONOTIDÆ—Continued.											
Hypsipetes fugensis Grant											×
batanensis Mearns											×
camiguinensis McG											×
Iole striaticeps Sharpe	×										
everetti (Tweedd.)					×	×					
haynaldi (Blas.)								×			
rufigularis (Sharpe)						×	×				
gularis (Pucheran)				×	×	×				×	
guimarasensis Steere		×									
mindorensis Steere			×								
siquijorensis Steere		×									
cinereiceps B. and W									×		
monticola B. and W										×	
Poliolophus urostictus (Salvad.)*				×	×	×	×				
Trichophorus frater (Sharpe)	×										
palawanensis (Tweedd.)	×										
Pycnonotus goiavier (Scop.)		×	×	×	×	×	×	×	×	×	
cinereifrons (Tweedd.)	×										
TIMELIIDÆ.											
Pseudotharrhaleus caudatus Grant*				×							
unicolor Hartert						×					
griseipectus Mearns						×					
malindangensis Mearns						×					
Turdinus rufifrons (Tweedd.)	×										
Ptilocichla falcata Sharpe*	×										
basilanica Steere							×				
mindanensis Steere						×					
minuta B. and W					×						
Anuropsis cinereiceps (Tweedd.)	×										
Dasycrotapha speciosa Tweedd.*		×									
Zosterornis striatus Grant*				×							
whiteheadi Grant				×							
dennistouni Grant				×							
pygmæus Grant					×						
plateni (Blas.)						×					
capitalis (Tweedd.)					×	×	×				
nigrocapitatus (Steere)					×						
affinis McG				×							
Mixornis woodi Sharpe	×										
cagayanensis Guillem.[f]											

[f] *Mixornis cagayanensis* inhabits Cagayan Sulu only.

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands*—Continued.

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan.	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
TIMELIIDÆ—Continued.											
Macronous striaticeps Sharpe	-	-	-	-	-	-	×	-	-	-	-
mindanensis Steere	-	-	-	-	×	×	-	-	-	-	-
montanus Mearns	-	-	-	-	-	×	-	-	-	-	-
kettlewelli Guillem.	-	-	-	-	-	-	-	×	-	-	-
Leonardina woodi (Mearns)*	-	-	-	-	-	×	-	-	-	-	-
Brachypteryx poliogyna Grant	-	-	×	×	-	-	-	-	-	-	-
brunneiceps Grant	-	×	-	-	-	-	-	-	-	-	-
mindanensis Mearns	-	-	-	-	-	×	-	-	-	-	-
malindangensis Mearns	-	-	-	-	-	×	-	-	-	-	-
TURDIDÆ.											
Planesticus mindorensis (Grant)	-	-	×	-	-	-	-	-	-	-	-
thomassoni (Seebohm)	-	-	-	×	-	-	-	-	-	-	-
mayonensis (Mearns)	-	-	-	×	-	-	-	-	-	-	-
kelleri (Mearns)	-	-	-	-	-	×	-	-	-	-	-
nigrorum (Grant)	-	×	-	-	-	-	-	-	-	-	-
malindangensis (Mearns)	-	-	-	-	-	×	-	-	-	-	-
Geokichla cinerea B. and W.	-	-	×	-	-	-	-	-	-	-	-
mindanensis Mearns	-	-	-	-	-	×	-	-	-	-	-
Chaimarrornis bicolor Grant	-	-	-	×	-	-	-	-	-	-	-
Copsychus mindanensis (Bodd.)	-	×	×	×	×	×	×	×	×	×	-
Kittacincla luzoniensis (Kittl.)	-	-	-	×	-	-	-	-	-	-	-
parvimaculata McG.	-	-	-	×	-	-	-	-	-	-	-
superciliaris B. and W.	-	×	-	-	-	-	-	-	-	-	-
cebuensis Steere	-	-	-	-	-	-	-	-	-	×	-
nigra Sharpe	×	-	-	-	-	-	-	-	-	-	-
SYLVIIDÆ.											
Tribura seebohmi (Grant)	-	-	-	×	-	-	-	-	-	-	-
Orthotomus frontalis Sharpe	-	-	-	-	×	×	-	-	-	-	-
mearnsi McG	-	-	-	-	-	-	×	-	-	-	-
castaneiceps Walden	-	×	-	-	-	-	-	-	-	-	-
derbianus Moore	-	-	-	×	-	-	-	-	-	-	-
chloronotus Grant	-	-	-	×	-	-	-	-	-	-	-
cinereiceps Sharpe	-	-	-	-	-	×	×	-	-	-	-
nigriceps Tweedd	-	-	-	-	-	×	-	-	-	-	-
samarensis Steere	-	-	-	-	×	-	-	-	-	-	-
Megalurus tweeddalei McG	-	×	×	×	×	×	×	-	×	×	-
Horornis seebohmi (Grant)	-	-	-	×	-	-	-	-	-	-	-
Phyllergates philippinus Hartert	-	-	-	×	-	-	-	-	-	-	-
heterolæmus Mearns	-	-	-	-	-	×	-	-	-	-	-

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands*—Continued.

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan.	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
LANIIDÆ.											
Cephalophoneus validirostris (Grant)			×	×							
suluensis Mearns								×			
Hyloterpe philippinensis Walden				×							
apoensis Mearns		×			×	×	×				
fallax McG											×
illex McG											×
albiventris Grant			×	×							
whiteheadi Sharpe	×										
winchelli B. and W		×							×	×	
homeyeri (Blasius)								×			
PARIDÆ.											
Pardaliparus elegans (Less.)			×	×	×					×	
albescens McG		×									
edithæ McG											×
mindanensis Mearns						×					
suluensis Mearns								×			
amabilis (Sharpe)	×										
Penthornis semilarvatus (Salvad.)*		×		×							
tessacourbe (Scop.)						×					
SITTIDÆ.											
Callisitta palawana (Hartert)	×										
œnochlamys (Sharpe)		×		×						×	
mesoleuca (Grant)				×							
lilacea (Whitehead)					×	×	×				
CERTHIIDÆ.											
Rhabdornis mystacalis (Temm.)*				×							
longirostris McG		×									
minor Grant					×	×	×				
inornatus Grant					×						
ZOSTEROPIDÆ.											
Zosterops meyeni Bp				×					×		×
whiteheadi Hartert				×							
vulcani Hartert						×					
halconensis Mearns			×								
batanis McG											×
siquijorensis B. and W		×									
boholensis McG					×						
everetti Tweedd										×	
basilanica Steere						×	×	×			

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands*—Continued.

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan.	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
ZOSTEROPIDÆ—Continued.											
Zosterops meyleri McG.											×
richmondi McG.[g]											
luzonica Grant				×							
aureiloris Grant			×	×							
nigrorum Tweedd		×							×		
goodfellowi Hartert						×					
malindangensis Mearns						×					
Hypocryptadius cinnamomeus Hartert *						×					
DICÆIDÆ.											
Dicæum retrocinctum Gould			×								
hæmatostictum Sharpe		×									
papuense (Gm.)		×		×	×	×	×			×	×
luzoniense Grant				×							
apo Hartert						×					
bonga Hartert					×						
dorsale Sharpe		×									
pallidius B. and W										×	
xanthopygium Tweedd			×	×							
intermedium B. and W									×		
sibuyanicum B. and W									×		
assimile B. and W								×			
sibutuense Sharpe								×			
cinereigulare Tweedd					×	×					
besti Steere		×									
flaviventer Meyer										×	
pygmæum (Kittlitz)	×	×	×	×	×				×		×
davao Mearns						×					
hypoleucum Sharpe							×	×			
mindanense Tweedd						×	×	×			
everetti Tweedd					×						
obscurum Grant				×							
nigrilore Hartert						×					
NECTARINIIDÆ.											
Prionochilus johannæ Sharpe	×										
quadricolor Tweedd										×	
olivaceus Tweedd					×	×	×				
bicolor B. and W						×					
inexpectatus Hartert		×	×	×	×						
anthonyi McG				×							

[g] *Zosterops richmondi* is known only from Cagayancillo and so cannot be placed in any island group of this table.

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands*—Continued.

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan.	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
NECTARINIIDÆ—Continued.											
Acmonorhynchus æruginosus (B. and W.)			×	×		×			×	×	
affinis Zimmer	×										
Æthopyga magnifica Sharpe		×							×	×	
boltoni Mearns						×					
shelleyi Sharpe	×										
bella Tweedd					×	×					
arolasi B. and W								×			
bonita B. and W		×								×	
flavipectus Grant			×	×							
rubrinota McG				×							
Eudrepanis pulcherrima Sharpe					×	×	×				
jefferyi Grant				×							
decorosa McG					×					×	
Leptocoma sperata (Linn.)	×	×	×	×	×	×			×		×
henkei (Meyer)				×							
juliæ (Tweedd.)						×	×	×			
Cyrtostomus flagrans (Oust.)				×							
guimarasensis (Steere)		×									
jugularis (Linn.)		×	×	×	×	×	×	×	×	×	
aurora Tweedd	×										
Anthreptes chlorigaster Sharpe		×		×		×	×		×	×	
wiglesworthi Hartert								×			
cagayanensis Mearns[h]											
griseigularis Tweedd			×	×	×	×					
Arachnothera flammifera Tweedd					×	×	×				
dilutior Sharpe	×										
philippinensis (Steere)					×	×					
ALAUDIDÆ.											
Mirafra philippinensis Ramsay			×	×		×					
FRINGILLIDÆ.											
Loxia luzoniensis Grant				×							
Pyrrhula leucogenys Grant				×							
steerei Mearns						×					
PLOCEIDÆ.											
Munia jagori Martens	×	×	×	×	×	×	×	×	×	×	×
cabanisi Sharpe		×	×	×							
Uroloncha everetti (Tweedd.)	×	×	×	×	×	×	×	×	×	×	×
Reichenowia brunneiventris Grant				×	×						

[h] Cagayan Sulu only.

TABLE 2.—*Showing the distribution of endemic species of Philippine land birds by groups of islands*—Continued.

Species.	(1) Palawan group.	(2) Central islands.	(3) Mindoro.	(4) Luzon group.	(5) Samar-Leyte.	(6) Mindanao.	(7) Basilan.	(8) Bongao-Sulu.	(9) Romblon group.	(10) Cebu.	(11) Babuyanes-Batanes.
EULABETIDÆ.											
Sarcops calvus (Linn.)*			×	×		×	×	×	×		
melanonotus Grant		×	×	×	×	×	×		×	×	
Eulabes palawanensis Sharpe	×										
Goodfellowia miranda Hartert*						×					
Lamprocorax panayensis (Scop.)	×	×	×	×	×	×	×	×	×	×	×
todayensis Mearns						×					
ORIOLIDÆ.											
Oriolus acrorhynchus Vigors	×	×	×	×	×	×	×	×	×	×	×
isabellæ Grant				×							
albiloris Grant				×							
samarensis Steere					×	×					
steeri Sharpe		×									
basilanicus Grant						×	×				
cinereogenys B. and W								×			
assimilis Tweedd										×	
DICRURIDÆ.											
Dicrurus balicassius (Linn.)			×	×							
striatus Tweedd					×	×	×				
sulensis Hartert								×			
mirabilis (Wald. and Lay.)		×								×	
Dicruropsis palawanensis (Tweedd.)	×										
cuyensis (McG.)	×										
worcesteri (McG.)			×								
menagei (B. and W.)									×		
Bhuchanga palawanensis Whitehead	×										
CORVIDÆ.											
Corvus philippinus Bp	×	×	×	×	×	×	×	×	×	×	×
pusillus Tweedd	×		×								
samarensis Steere					×	×					

(156)

It is interesting to note that the endemic species *Munia jagori*, *Uroloncha everetti*, *Lamprocorax panayensis*, *Oriolus acrorhynchus*, and *Corvus philippinus* are found in all of the island groups, or subprovinces. *Centropus viridis* is unique in being the only endemic species that reaches all groups except the Palawan group. The isolation of the Babuyanes and Batanes is evident when it is noted that *Cacatua hæmaturopygia*, *Tanygnathus lucionensis*, *Pitta erythrogastra*, *P. atricapilla*, and *Rhipidura nigritorquis* are found in none of those northern islands. Five common endemic species are found in all groups except Palawan and the Babuyanes-Batanes; these species are *Zonophaps poliocephala*, *Cyornis philippinensis*, *Pycnonotus goiavier*, *Copsychus mindanensis*, and *Cyrtostomus jugularis*.

Most of the endemic land birds are confined to single islands or groups of islands, and they can be used to indicate the relative distinctness of the various island groups. Counting the species that are confined to single groups of islands the following results are obtained:

	Species.
Palawan group	40
Central islands	32
Mindoro	17
Luzon group	61
Samar-Leyte	27
Mindanao	51
Basilan	7
Bongao-Sulu	30
Romblon group	9
Cebu	12
Babuyanes-Batanes	14

In general it may be stated that large islands of diversified topography, extensive highlands, and large areas of uncut lowland forest yield more species than do small low islands or islands from which most of the primary forest has been cut. In small islands, such as Cuyo, Cagayancillo, and Batan, there must be few if any unknown resident species, because it takes but a few days to visit all parts of any one of them. In Luzon, Mindoro, and Mindanao there are large areas of uncut forest, both lowland and highland, and no thorough zoölogical exploration has been carried on in any of these islands. Most of the work done so far has been the hurried gathering of specimens in limited areas for the purpose of discovering new species and adding data on distribution. None of this work has been either intensive or extensive.

Aside from the possible discovery of unknown species, ornithological work in any of the islands of the Archipelago will yield great quantities of information on the food, the nesting habits, the molts, and the migration of Philippine birds.

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3. *Chloropsis palawanensis* (Sharpe), two upper figures; *Ptilocichla falcata* Sharpe, lower figure. (From a photograph of the plate in the Transactions of the Linnean Society of London, 1877.)

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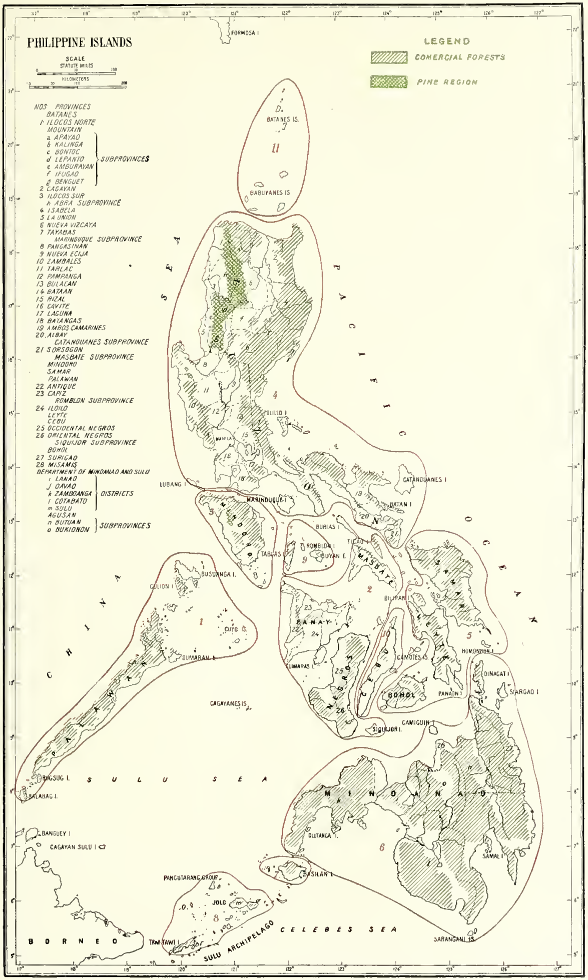

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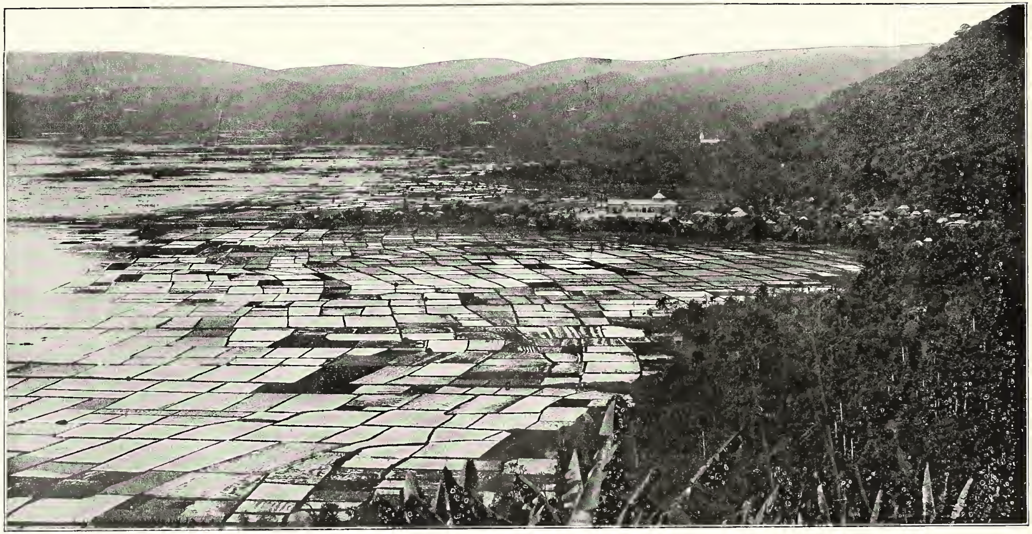

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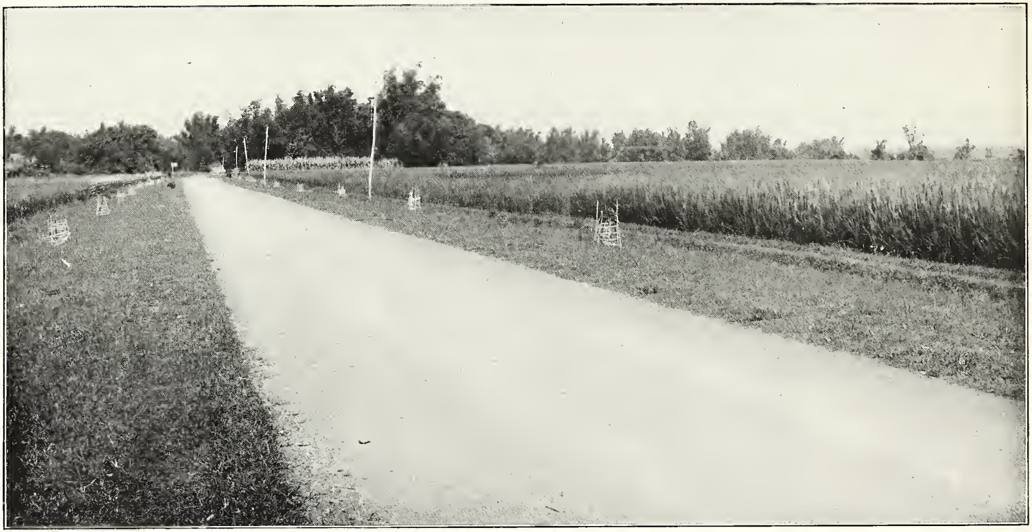

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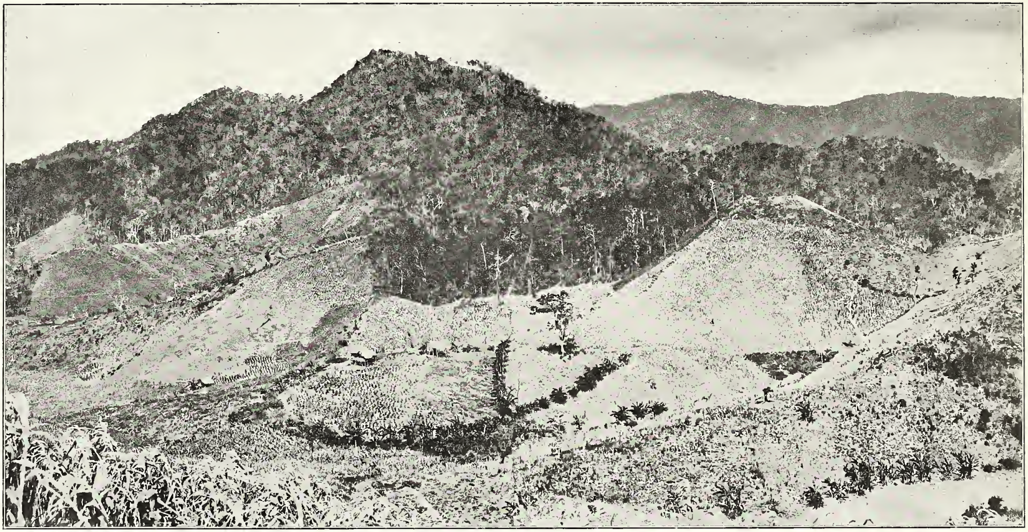

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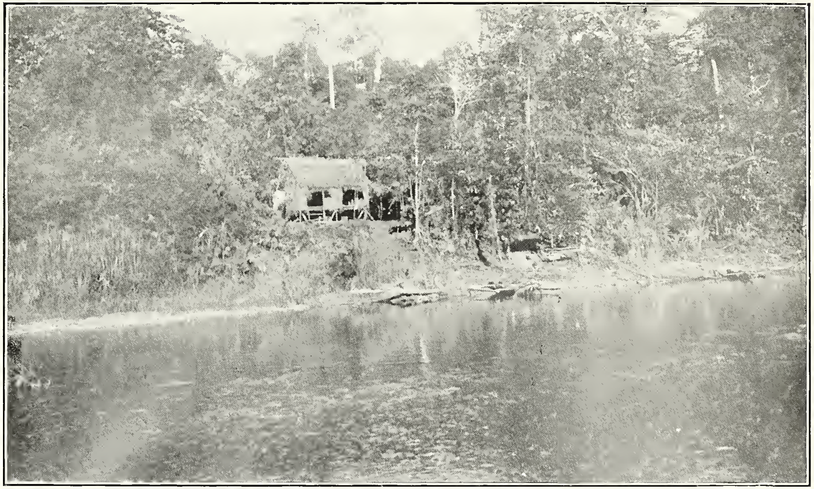

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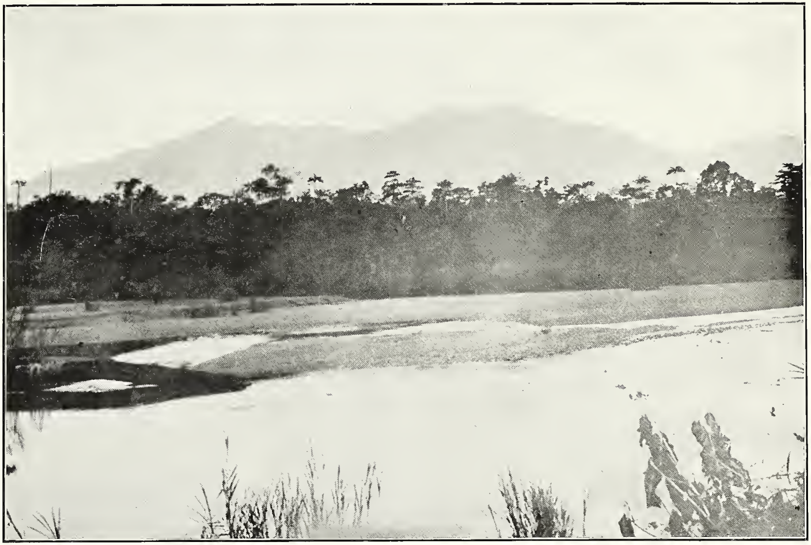

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Fig. 2. Dasycrotapha speciosa Tweeddale.

Fig. 3. Chloropsis palawanensis (Sharpe) and Ptilocichla falcata Sharpe.

Fig. 4. Dicæum xanthopygium Tweeddale and Uroloncha everetti (Tweeddale).

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Fig. 2. Penelopides manillæ (Boddaert).

Fig. 3. Hydrocorax hydrocorax (Linnæus).

Fig. 4. Thriponax pectoralis Tweeddale.

PLATE 20.

Fig. 1. Tanygnathus everetti Tweeddale.

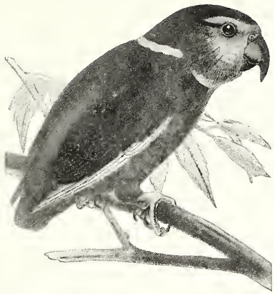

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Fig. 3. Syrnium whiteheadi Sharpe.

Fig. 4. Pithecophaga jefferyi Grant.

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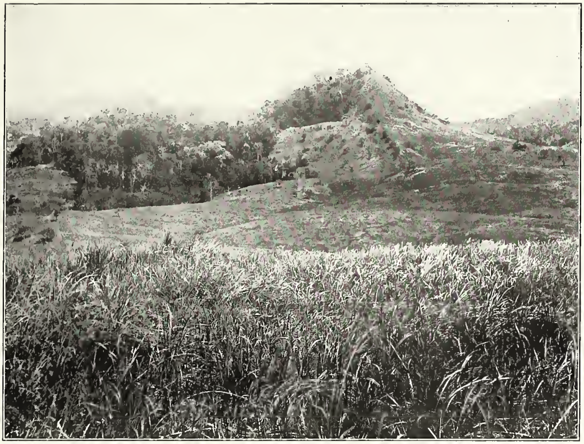

Fig. 1. Grassland near Port Banga, Mindanao.

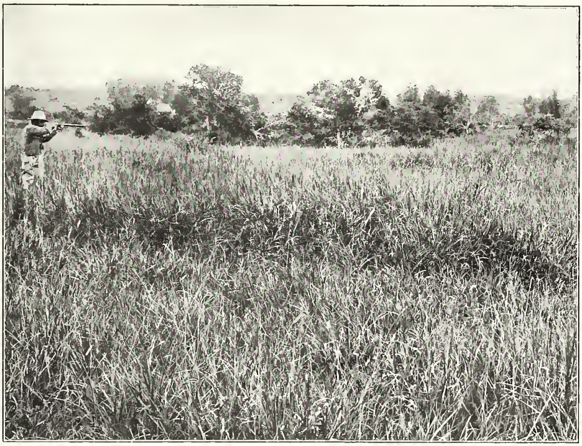

Fig. 2. Grassland near Bagabag, Luzon.

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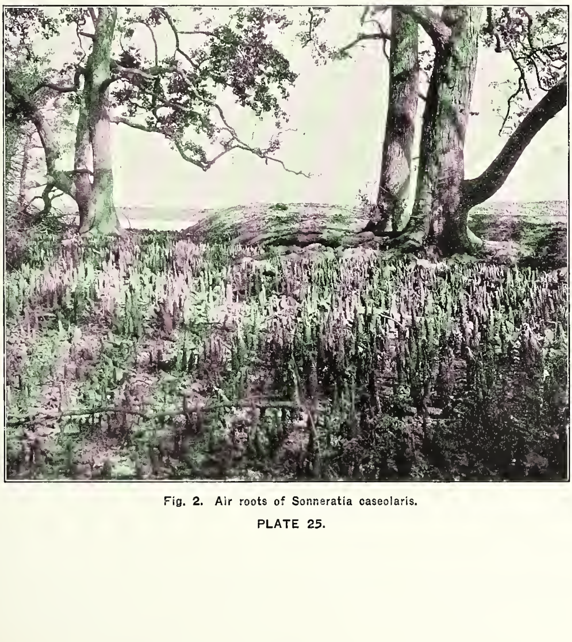

Fig. 2. Air roots of Sonneratia caseolaris.

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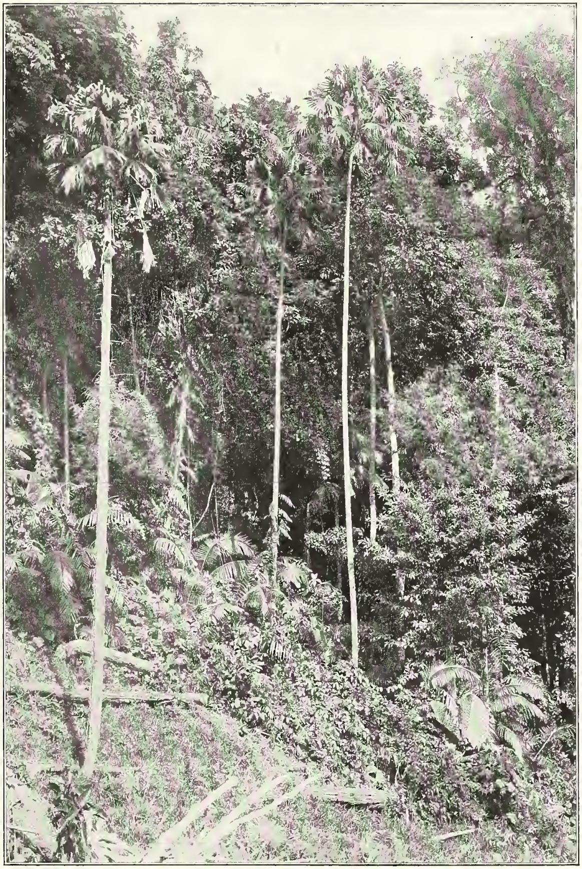

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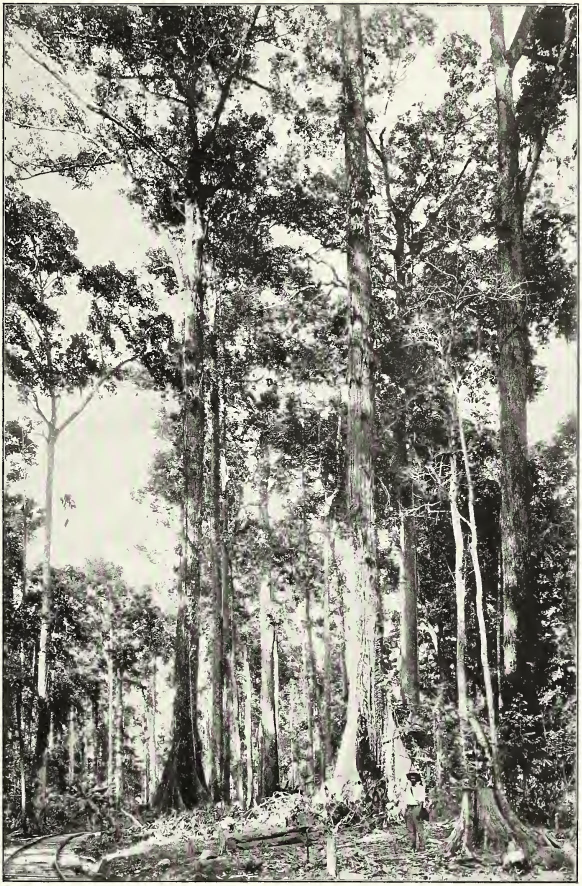

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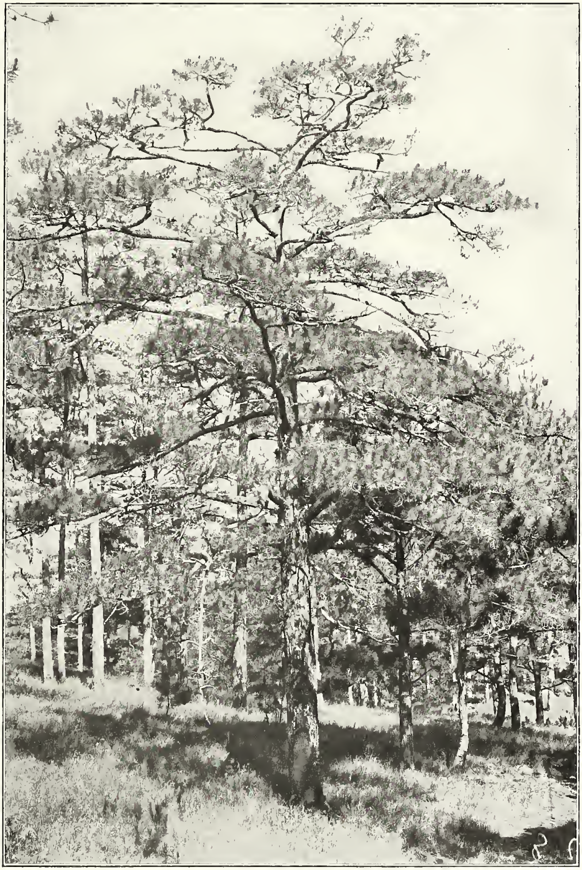

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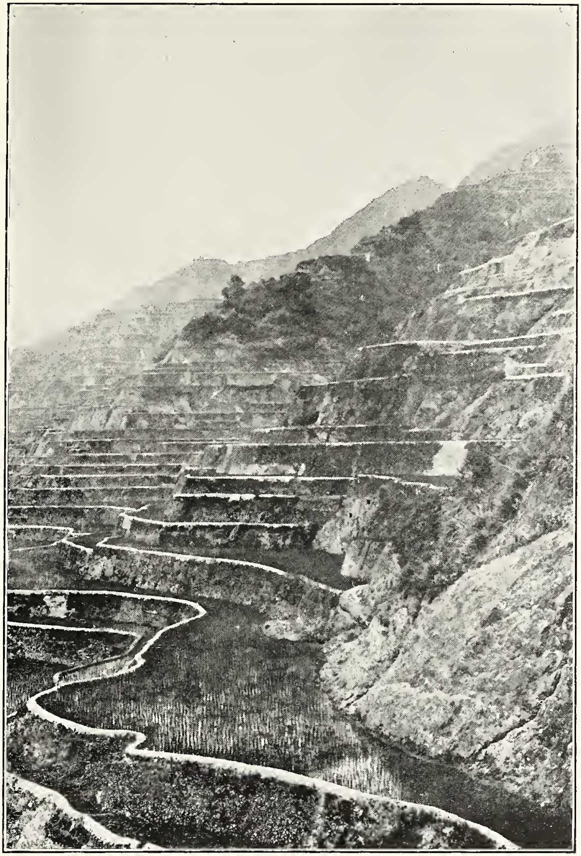

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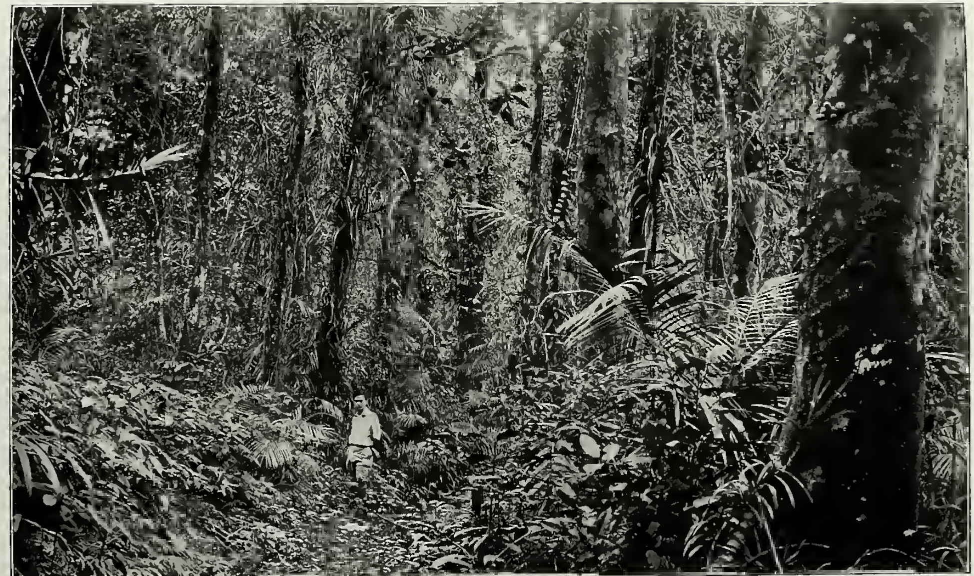

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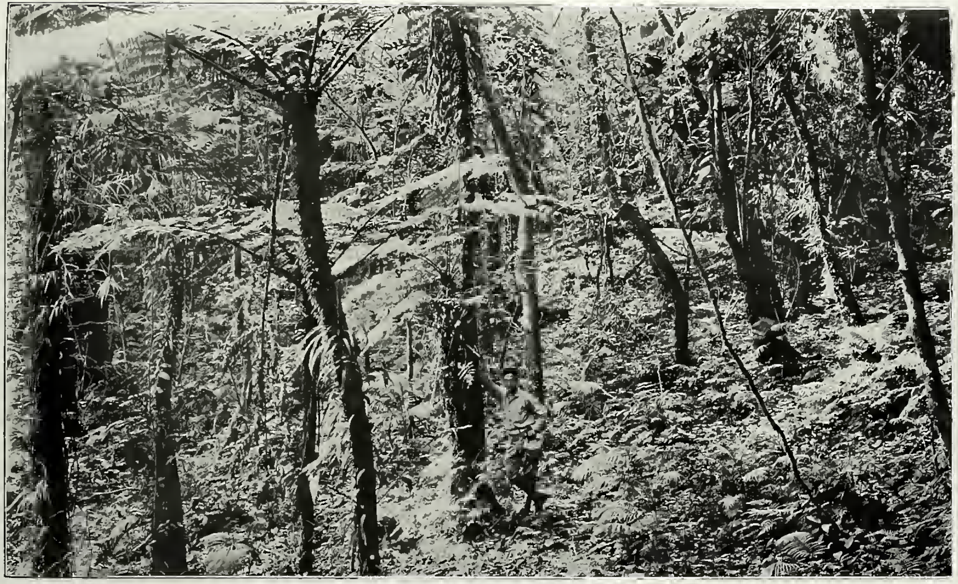

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 16 MAY, 1920 No. 5

CORROSION OF IRON IN SULPHURIC ACID. EFFECT OF CHROMIUM COMPOUNDS [1]

By GEORGE W. HEISE and AMANDO CLEMENTE

Of the Bureau of Science, Manila

ONE TEXT FIGURE

The use of passivifying agents in inhibiting the corrosion of iron is, of course, well known. Thus, the addition of potassium dichromate to water has been suggested as a means of preventing boiler corrosion.[2]

Under certain conditions, however, substances that ordinarily passivify may increase the rate of corrosion. For example, the rate of corrosion of iron in a salt solution is accelerated by the addition of potassium dichromate because, according to Friend,[3] a reaction occurs whereby free acid is formed, as follows:

$$H_2O + K_2Cr_2O_7 + 2NaCl \rightleftarrows K_2CrO_4 + Na_2CrO_4 + 2HCl.$$

In the presence of free acid, potassium dichromate acts as a depolarizer, removing hydrogen, and thus facilitates the dissolution of the iron. The accelerated corrosion of iron in sulphuric acid in the presence of potassium chromate and dichromate was determined experimentally by Watts [4] who reported as follows:

> The great increase in corrosion caused by the addition of potassium chromate was therefore rather surprising. A comparison * * * sug-

[1] Received for publication, February 27, 1918.

[2] Cushman, A. S., Bull. U. S. Dept. Agr. **30** (1907).

[3] Friend, J. N., Journ. Iron and Steel Inst. **2** (1908) 9, quoted by Friend, J. N., Corrosion of Iron and Steel. Longmans, Green & Co. (1911) 163.

[4] Watts, O. P., The effect of various substances on the rate of corrosion of iron by sulphuric acid, Trans. Am. Electrochem. Soc. **21** (1912) 337–353.

gests that the protective action heretofore ascribed to chromates may really be due solely to the chromium which they contain, and not to the chromate as such.

The stimulative action of potassium chromate and dichromate is in striking contrast to the protection afforded by chromium sulphate. Chromealum is a much less efficient protective agent per unit of chromium than chromium sulphate. These experiments indicate the possibility of a revision in our ideas of the manner in which chromates protect iron from rusting, and may lead to the substitution of chromium salts for the chromates heretofore used to render iron "passive."

Among the data accumulated by us, in the course of an extensive series of corrosion tests, are results which have direct bearing on the question of the effect of the addition of chromium compounds on the corrosion of iron in sulphuric acid. Since there seems to be no good prospect for the completion of this series as originally planned, these rather fragmentary results are offered at this time, as of possible interest.

The series of experiments to be described shows the effect on the corrosion of iron in sulphuric acid, (1) of varying concentration of sulphuric acid and of potassium dichromate, and (2) of additions of chromium salts.

EXPERIMENTAL

The iron used was a sample of very pure commercial sheet iron, over 99.8 per cent pure, but containing a very small amount of copper. It was cut into strips 10 centimeters long and 2.5 centimeters wide, cleaned of mill scale by being made the cathode in a bath of sulphuric acid,[5] dipped in a weak caustic alkali solution, scrubbed, rinsed, dried, and kept packed in lime until wanted.

The corrosion tests were made in half-liter, wide-mouthed, glass bottles, covered with watch glasses. The sulphuric acid used was chemically pure and free from arsenic, 400 cubic centimeter portions of solution being used in each test. All tests were performed in a large water bath (covered to avoid any disturbing factor due to light) in which the temperature was maintained at $28° \pm 1.0°$ C.

The following data were obtained:

[5] Reed, C. J., Trans. Am. Electrochem. Soc. 11 (1907) 181.

TABLE 1.—*Effect of addition of potassium dichromate on the corrosion of iron in 0.5 N sulphuric acid.*

Experiment No.	Potassium dichromate added.	Weight of iron.	Loss due to corrosion in 20 hours.
	Grams per liter.	*Grams.*	*Grams.*
1	0.0	15.055	0.070
2	0.0	15.884	0.073
3	2.5	14.231	0.517
4	2.5	14.176	0.474
5	6.25	15.410	1.163
6	6.25	15.301	1.125
7	12.5	13.985	2.071
8	12.5	15.756	2.109
9	18.75	15.007	1.775
10	18.75	13.948	1.726
11	25.0	15.457	0.002
12	25.0	15.462	0.002
13	37.5	15.774	0.001
14	37.5	15.101	0.003

The corrosion of iron in 0.5 *N* sulphuric acid became progressively greater with increasing additions of potassium dichromate, until a maximum was reached. Further additions of potassium dichromate decreased the amount of corrosion, the iron becoming passive when between 18.75 and 25 grams of potassium dichromate were present in a liter of 0.5 *N* sulphuric acid.

Very similar results are obtained with normal sulphuric acid as shown by the data in Tables 2 and 3.

TABLE 2.—*Effect of addition of potassium dichromate on the corrosion of iron in normal sulphuric acid.*

Experiment No.	Potassium dichromate added.	Weight of iron.	Loss due to corrosion in 21 hours.
	Grams per liter.	*Grams.*	*Grams.*
15	0.0	14.624	0.156
16	2.5	15.597	0.587
17	2.5	14.953	0.563
18	12.5	15.768	2.219
19	12.5	15.216	2.225
20	25.0	15.489	4.166
21	25.0	14.122	4.129
22	50.0	15.109	3.334
23	50.0	15.424	3.336
24	75.0	14.578	0.000
25	75.0	14.999	0.000

As in the experiments recorded with 0.5 *N* acid, the corrosion of iron with increasing potassium dichromate concentration in normal sulphuric acid first increased, then decreased, and finally was entirely inhibited. A much greater salt concentration was necessary, however, to effect passivity than was required in the case of the more dilute acid. These first experiments indicated a maximum corrosion rate with a concentration between 25 and 50 grams of salt per liter, and passivity beyond 50 grams of potassium dichromate per liter of acid. To locate these points more closely, the experiments explained in Table 3 were performed.

TABLE 3.—*Effect of addition of potassium dichromate on the corrosion of iron in normal sulphuric acid.*

Experiment No.	Potassium dichromate added.	Weight of iron.	Loss after 24 hours.
	Grams per liter.	*Grams.*	*Grams.*
26	0	14.841	0.143
27	0	14.755	0.125
28	30	16.119	4.331
29	30	15.031	4.278
30	35	14.692	3.715
31	35	15.526	3.820
32	40	15.217	3.659
33	40	15.770	3.695
34	45	13.883	3.633
35	45	13.798	3.518
36	50	15.040	0.002
37	50	15.323	3.429
38	55	14.577	0.005
39	55	15.201	3.453
40	60	15.486	3.517
41	60	15.108	3.432
42	65	15.306	3.281
43	65	14.638	0.003
44	70	15.405	0.003
45	70	15.239	0.002

As in the preceding experiments, increasing quantities of potassium dichromate decreased the amount of corrosion. With additions above 45 grams of salt per liter results became exceedingly irregular, and no definite passivifying concentration was determined, though passivity was effected in individual cases for concentrations as low as 50 grams of salt per liter.

With 2 *N* sulphuric acid, the addition of potassium dichromate induced no passivity, as shown in Table 4, even when the acid solution was saturated with the salt.

TABLE 4.—*Effect of addition of potassium dichromate on the corrosion of iron in 2 N sulphuric acid.*

Experiment No.	Potassium dichromate added.	Weight of iron.	Loss due to corrosion in 21 hours.
	Grams per liter.	*Grams.*	*Grams.*
46	0	15.685	0.201
47	25	14.974	4.314
48	25	14.998	4.408
49	50	15.424	6.802
50	50	15.295	6.727
51	75	15.510	6.808
52	75	14.633	6.231
53	100	15.240	6.683
54	100	15.871	6.809

The amount of potassium dichromate added (40 grams) was more than would dissolve in 400 cubic centimeters of 2 *N* acid, indicating that iron could not be passivified in acid saturated with potassium dichromate. With additions of more than 20 grams of the salt, the rate of corrosion no longer increased, which would seem to show that, but for the limited solubility of potassium dichromate, passivity might have been effected even in 2 *N* acid.

Table 5 shows the progressive corrosion of iron in sulphuric acid containing potassium chromate and potassium dichromate.

TABLE 5.—*Corrosion of iron in 10 per cent sulphuric acid. Effect of potassium chromate and potassium dichromate.*

Experiment No.	Addition.	Weight of iron.	Loss after— 19 hours.	29 hours.	48 hours.	73 hours.	Total loss in 169 hours.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
55	None	15.399	0.163	0.204	0.177	0.170	0.714
56	do	15.762	0.142	0.141	0.159	0.160	0.602
57	Potassium chromate (K_2CrO_4) 2.5 g	15.296	0.387	0.265	0.162	0.186	1.000
58	do	18.455	0.611	0.218	0.133	0.192	1.154
59	Potassium dichromate ($K_2Cr_2O_7$) 2.5 g	15.807	0.545	0.268	0.146	0.185	1.144
60	do	18.211	0.579	0.226	0.167	0.262	1.234

The foregoing data show that both chromate and dichromate first accelerate corrosion; but that, after reduction to chromium salt has once taken place, the rate of corrosion is very similar to that taking place in acid alone, indicating that chromium salts have little or no effect. This conclusion was corroborated by the experiments recorded in Table 6.

TABLE 6.—*Corrosion of iron in normal sulphuric acid. Effect of addition of chromium compounds.*

[Addition equivalent to 2.5 grams metal per liter of solution.]

Experiment No.	Addition.	Weight of iron.	Loss after— 24 hours.	Loss after— +25 hours.	Total loss in 49 hours.
		Grams.	*Grams.*	*Grams.*	*Grams.*
61	None	15.914	0.173	0.189	0.362
62	Chromium sulphate[a]	15.972	0.230	0.201	0.431
63	do	15.574	0.176	0.191	0.367
64	Chromium chloride	14.605	0.266	0.266	0.532
65	do	14.563	0.365	0.312	0.677

[a] Added as chromic hydroxide.

Chromium chloride showed some acceleratory effect, but this was very slight as compared with the effects noted with chromates or dichromates.

DISCUSSION OF RESULTS

The amount of potassium dichromate necessary to passivify iron became progressively greater as the sulphuric acid concentration increased. In half-normal sulphuric acid, iron became passive with a potassium dichromate concentration above 19 grams per liter; in normal acid the critical concentration of potassium dichromate was above 50 grams; in twice-normal acid iron did not assume the passive state.

With increasing potassium dichromate concentrations, the corrosion in half-normal and in normal acid first increased and then gradually decreased. In twice-normal acid the corrosion rose to a maximum as in less concentrated acid, but showed no decrease.

The corrosion data in Tables 1, 2, and 4 are shown graphically in fig. 1. They indicate that, below the concentration which effects maximum corrosion, the amount of corrosion is proportional to the potassium dichromate concentration.

The marked inhibition of the corrosion of iron by chromium salts, recorded by Watts,[6] was not confirmed with the sample of iron used in the present investigation. This discrepancy may,

[6] Loc. cit.

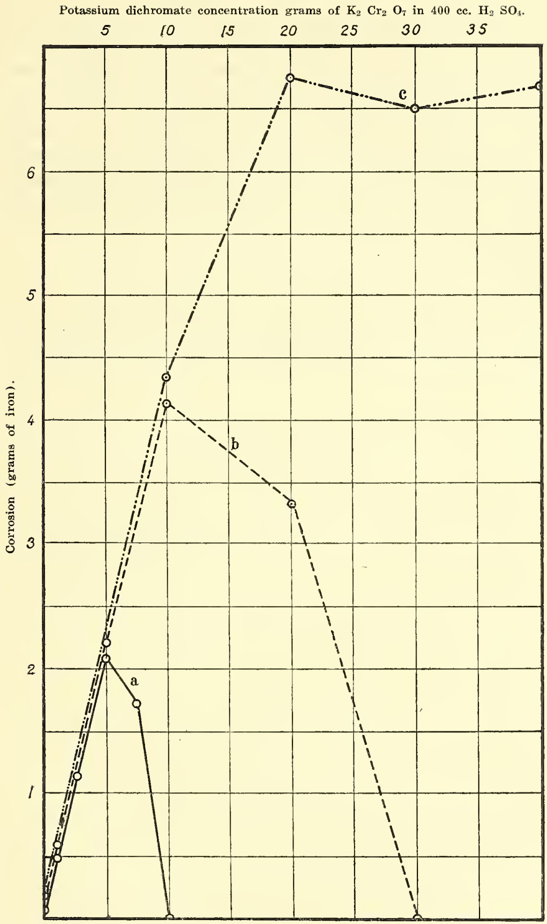

FIG. 1. The effect of potassium dichromate on corrosion of iron in sulphuric acid. Line *a*, 0.5 *N* sulphuric acid, 20 hours; line *b*, *N* sulphuric acid, 21 hours; line *c*, 2 *N* sulphuric acid, 22 hours.

however, be due to differences in the iron used and in the acid concentration employed. Though the effect of an alloyed metal on the corrosion of iron in acid may be markedly different than the effect of the same metal added to the acid in the form of a salt,[7] it may be of interest to point out that Monnartz [8] found that the addition of chromium to iron increased, if anything, the solubility of the resulting alloy in hydrochloric or sulphuric acid, conclusions which are in good agreement with our results.

This work has furnished no evidence to show that the passivifying effect of chromates or dichromates on iron is due to their chromium content.

[7] Burgess, C. F., and Aston, J., Influence of various elements on the corrodibility of iron, Journ. Ind. Eng. Chem. 5 (1913) 458–462.

[8] Monnartz, P., The study of the Fe-Cr alloys with particular regard to their solubility toward acids, Metallurgie 8 (1911) 161, 193; Chem. Abst. 5 (1911) 3035.

ILLUSTRATION

TEXT FIGURE

FIG. 1. Chart, showing the effect of potassium dichromate on corrosion of iron in sulphuric acid.

ON THE IDENTITY OF AEGIPHILA VIBURNIFOLIA JUSSIEU

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ONE PLATE

In 1806 Jussieu [1] described as new a supposedly Philippine species which he called *Aegiphila viburnifolia,* the genus appertaining to the Verbenaceae, and all its species being confined to tropical America. No attempt seems to have been made to determine the identity of the species until 1911, when at my request the late Dr. C. B. Robinson, in passing through Paris, looked up Jussieu's type and supplied me with a few notes regarding it and also a photograph of it. Both he and Dr. Gagnepain failed to recognize the genus to which it really belonged, although both agreed that it appertained to the Celastraceae. From a not very critical examination of the photograph in 1914, I determined Jussieu's species as being the same as the Philippine one described in 1908 as *Euonymus philippinensis* Merr. & Rolfe, and erroneously adopted the binomial *Euonymus viburnifolius* Merr. for the Philippine form. A reëxamination of the photograph, the description, and Dr. Robinson's notes shows clearly that this disposition of Jussieu's species is erroneous, but that it is clearly the Malayan form described by King in 1896 as *Elaeodendron subrotundum.* An adjustment of the synonymy follows:

ELAEODENDRON VIBURNIFOLIUM (Juss.) comb. nov. Plate 1.

Aegiphila viburnifolia Juss. in Ann. Mus. Paris 7 (1806) 76; Walp. Repert. 4 (1844–48) 124; Schauer in DC. Prodr. 11 (1847) 655.

Elaeodendron subrotundum King in Journ. As. Soc. Beng. 65 [2] (1896) 356; Merr. in Journ. Str. Branch Roy. As. Soc. 76 (1917) 93.

I have examined the following material representing the species: "Philippines," *Sonnerat,* photograph of the type ex Herb. Jussieu. Malay Peninsula, Selangor, *Burkill 1248;* Johore, *Ridley 12481.* Singapore, *Baker 5850.* Borneo, Sarawak, *Foxworthy 119;* British North Borneo, *Foxworthy 623.*

[1] Ann. Mus. Paris 7 (1806) 76.

The species is not represented in our Philippine collections, and the type may not have come from the Archipelago. It is indicated on the original label as "Philippines herb. D. Commerson sans nom," and on a second label "Philippines. Plantes récoltées par Sonnerat et données a Commerson." Sonnerat on his voyage to India and China [2] stopped at Malacca, a locality within the known range of *Elaeodendron viburnifolium*, and he may have collected the specimen there. Or again he may well have collected it in the Philippines at Jolo (Yolo) [3] on his first voyage, where he stopped for a short time after leaving Zamboanga (Sambouangue). The Sulu Archipelago, including Jolo, has been very slightly explored from a botanical standpoint, and a species growing in or near the mangrove swamps on the east coast of Borneo is certainly to be expected in similar habitats in Sulu Archipelago. Whether or not the type was really from the Philippines, *Aegiphila viburnifolia* Juss. is clearly identical with *Elaeodendron subrotundum* King, and Jussieu's specific name should be adopted for the species.

For the common Philippine form to which I erroneously applied the binomial *Euonymus viburnifolius* [4] another name is necessary, and I can now see no reason why *Euonymus cochinchinensis* Pierre should not be adopted, as I can detect no constant differential differences between it and *E. philippinensis* Merr. & Rolfe. The synonymy will then be as follows:

EUONYMUS COCHINCHINENSIS Pierre Fl. Forest. Cochinch. 4 (1894) *t. 309*; Pitard in Lécomte Fl. Gén. Indo-Chine 1 (1912) 873, *fig. 108*.

Euonymus timorensis Turcz. in Bull. Soc. Nat. Mosc. 31 [1] (1858) 447; F.-Vill. Novis. App. (1880) 46; Vidal Phan. Cuming. Philip. (1885) 103, non Zipp.

Euonymus philippinensis Merr. & Rolfe in Philip. Journ. Sci. 3 (1908) Bot. 238.

Indochina, *Thorel 2080!, Harmand, Godefroy!, Pierre!* (all det. Pitard). Siam, *Annandale 1585!, 1829!*. Malay Peninsula, Pahang, *Burn-Murdoch!* (all det. as *E. javanicus* Blume). I refer the following Philippine material here: LUZON, Cagayan Province, *Adduru 68, 179:* Ilocos Norte Province, *Bur. Sci. 33209 Ramos:* Benguet Subprovince, *Elmer 6462*, *Bur. Sci. 3551 Mearns, Williams 1024:* Pangasinan Province, *For. Bur. 21677 Domingo, For. Bur. 19452 Agama:* Nueva Ecija Province, *Bur.*

[2] Sonnerat, P., Voyage aux Indes Orientales et a la Chine 2 (1782) 99–103.

[3] Sonnerat, P., Voyage a la Nouvelle Guinée (1776) 136.

[4] Philip. Journ. Sci. 9 (1914) Bot. 312.

Sci. 26322 Ramos & Edaño: Rizal Province, *Merrill Phil. Pl. 1078, Bur. Sci. 4612, 1037, 1443 Ramos:* Batangas Province, *Merrill Phil. Pl. 1897, For. Bur. 21562 Tamesis:* Tayabas Province, *Bur. Sci. 26735 Ramos, For. Bur. 10267 Curran, Merrill 3356.* MINDORO, *Cuming 1552.* PALAWAN, *Bur. Sci. 15541 Fenix.* BANCALAN, *Weber.* BALABAC, *Weber.* SAMAR, *For. Bur. 24655 Lasquety.* MASBATE, *Merrill 3064.* PANAY, *For. Bur. 15125 Cenabre.* MINDANAO, Bukidnon Subprovince, *Bur. Sci. 24946 Fenix.* In primary forests at low altitudes, often common.

ILLUSTRATION

PLATE 1. *Elaeodendron viburnifolium* (Juss.) Merr. Photograph of the type specimen in the herbarium of the Paris Museum of Natural History.

PLATE 1. ELAEODENDRON VIBURNIFOLIUM (JUSS.) MERR.

SOME ASPECTS OF THE SALT REQUIREMENTS OF YOUNG RICE PLANTS [1]

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ONE PLATE AND NINE TEXT FIGURES

INTRODUCTION

One of the most important human activities has long dealt with the improvement of methods for securing plant products upon which human nutrition depends. The scientific problems of the nutrition of plants are thus closely connected with the practice of agriculture, and agriculturists as well as plant physiologists have already accomplished much toward outlining and solving some of these problems, with reference to many different kinds of plants. The mineral nutrition and the salt requirements of plants have recently received a great deal of attention, and the methods employed in experimentation in this field are being rapidly improved. Among the methods that have yielded valuable results as to the physiological needs of plants the so-called "water-culture" method is important. By this method the culture plants are grown with their roots in aqueous solutions of various inorganic salts, in various proportions, these solutions having various total concentrations. This may be called the method of solution cultures, although of course the source from which the plants absorb their mineral nutrients is an aqueous solution even when soil or sand is used. "Water culture" is employed in a general sense to denote such solution cultures, but, as Shive [2] has pointed out, actual water cultures (with distilled or otherwise purified water) are seldom of much value in nutritional experimentation, partly because pure water not

[1] Botanical contribution from the Johns Hopkins University, No. 61. A brief preliminary report of some of the results presented in this paper was given before the 1918 (Baltimore) meeting of the Physiological Section of the Botanical Society of America.

[2] Shive, John W., A study of physiological balance in nutrient media, Physiol. Res. 1 (1915) 327–397, 331. See also True, R. H., Harmful action of distilled water, Am. Journ. Bot 1 (1914) 255–273; Hibbard, R. P., The question of the toxicity of distilled water, ibid. 2 (1915) 389–401.

only does not supply the mineral salts needed by the plant, but it also acts to remove salts already within the plant body. The study to be reported in this paper deals with the growth of young rice plants (*Oryza sativa,* variety "Wateribune") in aqueous solution cultures. No attempt will be made here to review studies made on culture solutions, but the readers are referred to Tottingham's [3] monograph which gives a very complete resumé of earlier solution-culture experimentation with plants and to later papers that appeared on the subject. A brief review, however, will be made of previous studies on rice which appear to have a direct bearing on the present problem.

REVIEW OF PREVIOUS EXPERIMENTS ON THE MINERAL NUTRITION OF RICE

The present studies deal with solution cultures, as has been said, and they may serve as a small contribution toward a better knowledge of this field of physiology. Such studies, however, must of course involve some particular kind of organism and the rice plant was chosen as the experimental subject, for several reasons. In the first place, it seemed that the extensive aspect of our knowledge of this phase of physiology deserved attention; there are so many different sorts of plants, and generalizations for all plants are perhaps too easily formed from knowledge of a few kinds. The aim was to select a plant that would probably show some important physiological differences from the ones thus far studied. At the same time the plant used should be one of considerable human interest, for plant production and the practical applications of plant physiology are always demanding more scientific knowledge than is available. These studies were to be purely physiological, but the plant used might well be one of agricultural interest. Also, of course, the plant selected must be suited to solution-culture experiments; soils, and even sand cultures, present problems that are so complicated as to be almost hopeless until some of the simpler problems offered by solution cultures become better understood. Choosing the experimental subject at a time when agricultural operations loomed very large on the world's horizon, when the whole of civilization was in the tightening grip of a quasi famine, it was natural first to consider what plants are

[3] Tottingham, Wm. E., A quantitive chemical and physiological study of nutrient solutions for plant cultures, Physiol. Res. 1 (1914) 133–245. See also Shive, J. W., The freezing points of Tottingham's nutrient solutions, Plant World 17 (1914) 345–353.

most important to the human race. If wheat be the most important, then perhaps rice may be the second. Wheat had been studied considerably, though much remains to be done with it, but rice had received no attention by the newer methods of solution culture. Also, various writers had presented evidence to the effect that rice differs from wheat and many other plants in that rice is able to utilize ammonium as a source of nitrogen. Rice also appeared to be well suited to solution cultures. Finally, rice is perhaps the most important plant in the writer's home country; it forms the main vegetable source of food for the great majority of the population of the Philippine Islands, and it is a very important agricultural crop there, as well as in many other parts of the world. Large amounts of it are grown in the southern and western United States, in Italy, India, Africa, Japan, Spain, etc. Lowland rice was selected for the experiments to be reported in this paper.

These studies may therefore be regarded as furnishing some contribution to our knowledge of the physiology of the rice plant, just as they contribute somewhat to our knowledge of solution culture and the mineral nutrition of plants in general. The recent intensive study of the mineral nutrition of plants, through the employment of the systematic schemes of Schreiner and Skinner (1910), Tottingham (1914), Shive (1915), and others, has not thus far included the rice plant, but several valuable studies of a less extensive and systematic sort have been reported for rice. The following paragraphs give a resumé of previous work on the salt nutrition of rice, with which the writer is familiar.

The problem of the mineral nutrition of rice immediately brings up the question of ammonium salts as possible sources of nitrogen for plant nutrition. It appears that plants differ in regard to their ability to utilize ammonium salts. An early publication dealing with this question is that of Bouchardat.[4] He employed culture solutions with several forms of inorganic ammonium compounds ("sesquicarbonate," bicarbonate, sulphate, "chlorhydrate," and nitrate of ammonium) and experimented on the growth of *Mimosa pudica* in these solutions. He concluded that the ammonium salts used were not only useless as sources of nitrogen for the plant employed, but that they were highly toxic when supplied in certain concentrations. It was

[4] Bouchardat, A., De l'action des sels ammoniacaux sur la vegetaux, Compt. Rend. Acad. Sci. Paris **16** (1843) 322–324.

over thirty years later that Lehmann [5] published an account of experiments which seemed to show that ammonium sulphate may be a source of nitrogen for certain higher plants. He employed solution cultures and supplied all the necessary elements in all cases, but some cultures were furnished with nitrogen as a nitrate (calcium nitrate), while the nitrogen of others was supplied as an ammonium salt (ammonium sulphate). He observed that maize plants developed normally for forty-one days (from the seed) in solutions containing ammonium sulphate, while the plants with calcium nitrate showed only poor growth during that period. After this first period of forty-one days, however, his "nitrate" plants recovered and continued with good growth, while his "ammonium" plants became chlorotic and sickly. Also, Lehmann observed that the chlorotic plants of his nitrate group within the first forty-one day period might be made to assume normal growth and appearance, if they were transplanted to a culture solution containing ammonium sulphate; in two days they became green. Furthermore, when healthy plants of his ammonium group were similarly transplanted to a solution containing sodium nitrate, they soon became pale and sickly.

The same author obtained similar results with tobacco plants grown in sand cultures. He supplied the necessary minerals, furnishing nitrogen either as ammonium sulphate or as sodium nitrate. The plants grown in the medium containing ammonium sulphate were healthy and grew normally from the beginning to the end of the experiment. Those supplied with nitrogen as sodium nitrate were chlorotic and unhealthy during the first half of the vegetative period, but they afterwards became green and vigorous, although the final yield was much lower than that obtained from the cultures with ammonium sulphate as the source of nitrogen.

Lupine plants grown in sand cultures in Lehmann's experiments gave better vegetative growth when nitrogen was supplied as sodium nitrate than when it was furnished as ammonium sulphate, but the yield of seed was larger in the latter case.

From these studies Lehmann came to the conclusion that some plants require nitrate nitrogen, others require ammoniacal nitrogen, and still others require one of these two forms of nitrogen during the early stages of growth and the other form during the later stages. While the experimentation on which

[5] Lehmann, Jul., Ueber die zur Ernährung der Pflanzen geeignetste Form des Stickstoffes, Biedermann's Centralbl. Agr.-Chem. 7 (1875) 403–409.

Lehmann based these conclusions would not now be considered as convincing in itself, yet his general conclusions still appear to stand. Of course the modern problem of the nitrogen requirements of plants involves not only nitrates and ammonium salts, but also nitrites and many other compounds containing nitrogen, and must take account of such topics as nitrification, denitrification, and the assimilation of elemental nitrogen. The question regarding the direct utilization of ammonium salts by specific agricultural plants bids fair to maintain an important position in agronomic discussions for a long time to come. It will of course be necessary that each important kind of plant be made the subject of special and rather elaborate experimentation.

Without here attempting to summarize the literature of this broad subject, attention may be directed to Hutchinson and Miller's [6] experiments and to their discussion. They grew wheat and peas in solution culture and also in sand culture. They conclude that—

> * * * agricultural plants of various kinds can produce normal growth when supplied with nitrogen in the form of ammonium salts under conditions which exclude the possibility of nitrification. Some plants grow equally well with ammonium salts or nitrates as source of nitrogen. Other plants, while assimilating ammoniacal nitrogen in the absence of nitrates, appear to prefer nitrates. It is less certain whether ammonium salts can ever produce better final results than nitrates although we have indications that this may be the case.

In connection with the doubt expressed by Hutchinson and Miller, "whether ammonium salts can ever produce better final results than nitrates," the studies on rice by Nagaoka, Kelley, and others, which will be mentioned later, are of interest.

Turning to the rice plant in particular, the problem of its salt nutrition has been touched upon from almost all angles, but in a rather hit-and-miss way. Kellner [7] conducted perhaps the first solution-culture experiments on lowland rice, with the aim of determining whether this plant thrives best with one or another form of nitrogen-bearing salt. He grew his plants in nutrient solutions supplying all the essential chemical elements for normal growth of ordinary higher plants. In one solution nitrogen was supplied as potassium nitrate, and in another as ammonium sulphate, and his experiments were repeated several

[6] Hutchinson, H. B., and Miller, N. H. J., Direct assimilation of ammonium salts by plants, Journ. Agr. Sci. **3** (1909) 179–194.

[7] Kellner, O., Agriculturchemische Studien über die Reiscultur, Landw. Versuchsst. **30** (1884) 18–32.

times, using the same salts but varying the amounts. He concluded that paddy rice in the early stages of its development grew better in a nutrient medium supplied with ammoniacal nitrogen than in one supplied with nitrate nitrogen, while during the later stages of development the nitrate proved to be a better source of nitrogen than was the ammonium salt. He also tried culture solutions containing the other necessary elements and having the ammonium salt and the nitrate both present at once, and found that the combination of these forms of nitrogen gave better growth than did either form alone.

The beneficial effect of ammonium sulphate, as well as the unsuitability of nitrates as sources of nitrogen for rice, were also observed by Nagaoka,[8] who carried out a series of rather extensive pot and plot experiments with upland and lowland varieties of rice grown to maturity. He began his cultures with plants about 42 days old, so that the plants had passed beyond the first stages of growth before they were tested. By means of pot cultures with soil he compared the growth and the yield of a lowland rice supplied with different amounts of ammonium sulphate with those of the same variety supplied, separately, with one of the salts, sodium nitrate, potassium nitrate, calcium nitrate, barium nitrate, strontium nitrate, and magnesium nitrate. He found that plants grown in the media supplying nitrogen in the form of ammonium sulphate alone were green and produced much tillering (branching at the base of the stem), while plants "fed" with one of the nitrates were yellowish and produced but little tillering. The six nitrates tested were about alike in this effect. Nagaoka observed, however, that the seed ripened ten days earlier when the plants had been supplied with a nitrate than when they had been supplied with the ammonium salt.

The field-plot experiments of Nagaoka were planned to study the fertilizer values of sodium nitrate and ammonium sulphate. In these experiments he applied one or the other of the two salts to the soil. The fertilizer application was made before planting and also at intervals during the growth of the plants. Lowland rice was again used and, as in his previous pot experiments, the yield obtained showed that ammonium sulphate was about two and one-half times as good as sodium nitrate in this respect.

In another set of pot experiments, with upland as well as low-

[8] Nagaoka, M., On the behavior of the rice plants to nitrates and ammonium salts, Bull. Coll. Agr. Imp. Univ. Tokyo 6 (1904) 285–334.

land rice, Nagaoka used a soil to which a fertilizer without nitrogen was similarly applied in all cases. To the pots of one group he added different amounts of sodium nitrate, and to those of another group he added different amounts of ammonium sulphate. Some of the pots of each treatment were kept wet, as in rice paddies, while in other pots the soil was kept merely moist. The results obtained showed that ammonium sulphate gave better yields than did sodium nitrate, for both forms of rice and for both soil-moisture conditions. The ammonium salt was always absorbed to a greater extent than was the nitrate, but the upland variety absorbed more sodium nitrate than did the lowland variety. As to the moisture content of the soil, both varieties gave good yields in either one of the two moisture conditions studied, but the results were better with lowland rice in wet soil and with upland rice in merely moist soil.

The apparent failure of the rice plant to utilize nitric nitrogen and its apparent preference for the ammoniacal form were ascribed by Nagaoka to the fact that paddy rice does "not accumulate a sufficient quantity of sugar in the leaves to convert all of the nitric acid absorbed into protein." The chlorotic appearance of the plants supplied with nitrogen solely as nitrates might be "due to the physiological influence of accumulated nitrates." Nagaoka pointed out that the soil of pots receiving large additions of nitrate gave a slight nitrite reaction, and he suggested that denitrification (resulting in the formation of nitrites from nitrates in the soil) might take place in the rice paddy through the action of microörganisms, so that the excessive amount of nitrites thus formed might poison the plants.

Daikuhara [9] also found that the application of certain ammonium compounds to the soil was beneficial to rice. He used sand cultures to which limestone and magnesium sulphate were added in various proportions. He also added sodium nitrate to one pot and ammonium sulphate to another. To a third pot ammonium nitrate was added. The total yield (grain and straw) showed that, under the conditions of the experiment, ammonium sulphate was about two and one-half times as beneficial as was sodium nitrate, thus confirm'ng the general conclusion of Nagaoka. Daikuhara found also that the fertilizer value of ammonium nitrate was intermediate between the values of ammonium sulphate and sodium nitrate.

[9] Daikuhara, G., On the application of magnesium in the form of magnesium sulphate for the needs of the rice plant, Bull. Imp. Central Agr. Exp. Sta. Japan 1 (1905) 24–29.

Aso and Bahadur [10] found that a combination of ammonium sulphate and disodium phosphate produced better results with paddy rice in the field than did combinations of any other salts in their tests.

Krauss [11] also reported results from pot and field experiments with rice, indicating that (of the different nitrogenous fertilizers that he tested) ammonium sulphate ranked above calcium nitrate and sodium nitrate by the criterion of yield of grain.

The superior fertilizer value of ammonium sulphate, as compared with the values of sodium nitrate, calcium nitrate, magnesium nitrate, and ammonium nitrate, was also noted for the rice plant by Kelly.[12] He employed lowland rice in both field and pot cultures, adding nitrogenous fertilizers before planting and, in other cases, at intervals during the culture period. The cultures supplied with ammonium sulphate showed good growth and gave good yields of both straw and grain, while those in which nitrogen was supplied to the soil only as sodium nitrate gave but low yields. Apparently this nitrate was ineffective as a fertilizer. He also found that the ammonium salt applied before planting proved more beneficial than did the same salt applied at intervals during the culture period. In pot cultures the addition of nitrate to the soil proved beneficial in the latter part of the growth period, from near the flowering stage to maturity. This last observation agrees with that recorded for maize by Lehmann (1875). Kelly suggested that this difference in the response of the rice plant to soil fertilization with sodium nitrate and with ammonium sulphate, might be due to the fact that the lowland rice plant "has in a large measure lost the power of reducing nitrates," which, in turn, might be due to the fact that this plant has been "grown for centuries under conditions that largely exclude the formation of nitrates." While these considerations may be of interest in connection with genetics and phylogeny, still the physiological reasons for the observed state of affairs (which must be sought in the plant itself) remain untouched. From the standpoint of genetics it may be asked whether the paddy rice plant ever had the power of reducing nitrates. Kelley appreciated the unsatisfactory sta-

[10] Aso, K., and Bahadur, R., On the influence of the reaction of the manure upon the yield, Bull. Coll. Agr. Imp. Univ. Tokyo 7 (1906) 39–46.

[11] Krauss, F. G., Ann. Rept. Hawaii Agr. Exp. Sta. 1907 (1907) 67–90. Ibid. 1908 (1908) 65–84.

[12] Kelley, W. P., The assimilation of nitrogen by rice, Hawaii Agr. Exp. Sta. Bull. 24 U. S. Dept. Agr., Washington, D. C., 1911.

tus of the problem, however, and ended his discussion by emphasizing the need for much more study along these lines; he said that "further experiments will be conducted to determine the correctness of this view," but this promise has apparently not yet been fulfilled.

Similar beneficial effects of ammonium sulphate upon rice plants were observed by Daikuhara and Imaseki,[13] with pot cultures. They found that ammonium sulphate alone was superior to sodium nitrate alone and also to a combination of these two salts.

From field experiments W. H. Harrison [14] concluded that nitrates were unsuitable for rice, but that ammonium compounds, or manures that yield ammonia under anaërobic conditions of fermentation, were of great value. J. B. Harrison,[15] on the other hand, reported that the application of ammonium sulphate to field plats of rice resulted in a decreased yield. This lower yield, however, was thought to be due to lodging, which occurred on account of the very luxuriant growth that took place in the plats supplied with ammonium sulphate rather than to any directly injurious effect of the salt.

Further experimental evidence in favor of the idea that ammonium salts are good sources of nitrogen for rice is available from later work by Kelley,[16] who conducted a series of field trials. Ammonium sulphate was added to one plat and sodium nitrate to another, the addition being made before the time of planting. To the soils of other plats nitrogenous fertilizers were added from time to time during the development of the plants. The results agreed in indicating the superiority of ammonium sulphate over sodium nitrate. Kelley concluded that—

> a complete fertilizer proved no more effective than ammonium sulphate alone, whereas the application of both ammonium sulphate and potassium sulphate caused a decrease as compared with that obtained from ammonium sulphate alone.

[13] Daikuhara, G., and Imaseki, T., On the behavior of nitrate in paddy soils, Bull. Imp. Central Agr. Exp. Sta. Japan 1 (1907) 7–36. (Cited by Kelley, 1911.)

[14] Harrison, W. H., The principles of paddy manuring, Journ. Board Agr. Brit. Guiana 6 1 (1912) 37–40. Ibid. 6 2 (1912) 71–77.

[15] Harrison, J. B., Experiments with varieties of rice at the Botanic Garden, 1912, Journ. Board Agr. Brit. Guiana 7 (1913) 42–43.

[16] Kelley, W. P., Rice soils of Hawaii: Their fertilization and management, Hawaii Agr. Exp. Sta. Bull. 31 U. S. Dept. Agr., Washington, D. C. (1914).

Besides the various nitrates and ammonium salts, other forms of nitrogen-bearing substances have been tried with rice, but a review of the literature on these will not be given here.

SUMMARY

From the foregoing review of the more definite contributions that have been made toward a knowledge of the mineral nutrition of rice, it appears that there is good reason to suppose that:

(1) This plant requires the same chemical elements as do other higher plants.

(2) The young plants are not suited to deriving their nitrogen from nitrates but thrive very well when ammonium sulphate (or probably other ammonium salt, such as the chloride, nitrate, etc.) is supplied.

(3) Older plants are able to derive their nitrogen supply from nitrates, but may be able to thrive without the nitrate ion when the ammonium ion is supplied at a proper rate.

None of the points just mentioned is at all well established in a quantitative way; much of the experimentation on which our present knowledge of these matters is based has been carried on with field soils, whose various properties were mostly unknown, so that (for this reason among others) the results of different experimenters are generally not logically comparable. The apparent importance of the relation between nitrate and ammonium as sources of nitrogen for young rice plants, and of the question regarding the physiological balance for rice between the three main kations that are generally required by plants (potassium, calcium, and magnesium), makes it appear that more attention needs to be given to the simpler physiological aspects of these relations. It was with these points particularly in mind that the solution-culture studies on rice seedlings here to be reported were undertaken. This work is presented as a beginning only. As is general in such cases, the experimental analysis is very incomplete and probably more questions are raised than are answered, even in a preliminary way. In spite of the enormous amount of work needed to obtain satisfactory conclusions regarding the physiological problems dealt with by the solution-culture method, it seems obvious that the relations of any given plant form to the soil in which it is growing will hardly be understood at all well before the behavior of that plant toward free solutions has been rather thoroughly worked out. Furthermore, if the problems of plant nutrition that are

presented by solution cultures are complex, those presented by soil cultures are many times more complex. While field experimentation with agricultural plants will of course go on in large volume, for economic reasons it seems desirable that the simpler physiological problems that may be attacked by solution cultures should be dealt with whenever opportunity allows. It should be repeatedly emphasized that the aim of study of this sort is to bring about a better understanding of the nutritional requirements of the plants considered, not to give information regarding the fertilizer treatment of soils. After the plant itself is fairly well understood when growing under the simplest possible sets of conditions, then soil experimentation may perhaps be planned so as to furnish results directly valuable in field culture. The studies here reported deal simply with the rice plant as a machine, and the solution-culture method offers the simplest form of satisfactory root environment that can be devised. The problems of the physical and chemical characteristics of any soil that might be employed are here avoided altogether.

GENERAL SURVEY OF THE PRESENT STUDY

These studies were planned to throw some light on the salt relations of young lowland rice plants when grown in solution cultures in a greenhouse. It was proposed, first, to find out whether any set of salt proportions and total concentrations possible with the 3-salt type of solution, studied by Shive, might be suitable for good growth of the young rice plants. As was already foreshadowed in the results of earlier workers with rice, it turned out that it is impossible to obtain good growth of this plant (for the first few weeks of its growth from the seed) in any one of these 3-salt solutions.

It was then proposed to supply the plants with the ammonium ion, following the suggestions of the literature. This was done by employing the single ammonium salt, ammonium sulphate; other ammonium salts were not tested. Since ammonium is a kation, and since there is no question but that the rice plant requires all three of the main kations (potassium, calcium, and magnesium) needed by higher plants in general, it logically follows that ammonium cannot be directly supplied in a complete, nutrient solution unless the latter contains four salts. The second stage of these studies therefore dealt with a 4-salt type of solution containing the four kations (potassium, calcium, magnesium, and ammonium) as well as the generally requisite anions (nitrate, phosphate, and sulphate). Many different sets of salt proportions and a number of different total concentrations of this 4-salt type of nutrient solution were tested, and certain ones of these proved to be excellent for the plants employed.

The question then arose, whether the presence of the nitrate ion in the medium might not be either unnecesary or even positively harmful to the young rice plants, and the third stage of these studies dealt with still another 4-salt type solution, which contained all the generally necessary mineral elements but contained no nitrate. Nitrogen was supplied here only as ammonium sulphate. This type of solution was also tested with many different sets of salt proportions and with a number of different total concentrations. The results showed that some of these solutions gave very good general growth, but the best of them were not as good as the best ones containing nitrate; this type of solution always produced a characteristic leaf injury.

The work here reported was carried out in the Laboratory of Plant Physiology of the Johns Hopkins University; and the writer's acknowledgments and thanks are hereby expressed for the facilities of that laboratory, and for instruction, advice, and guidance given him by Prof. B. E. Livingston and Dr. H. E. Pulling.

EXPERIMENTATION

SEEDS AND SEEDLINGS

The rice used in this study was kindly furnished by the United States Department of Agriculture. It is of the lowland type bearing the name "Wateribune," and this stock of seed was grown, under irrigation, at the Crowley Station of the Louisiana Agricultural Experiment Station. This variety is often grown on a small scale without irrigation in the Southeastern States, but always with very moist soil.

In starting an experimental series, about two thousand seeds were first placed in about 300 cubic centimeters of tap water in an open glass pan (15 centimeters in diameter), where they were allowed to soak for twenty-four hours. They were then placed between folds of wet absorbent paper (paper toweling, about like thin filter paper), where they remained another twenty-four hours. At the end of this period germination was visibly beginning so that the plumule protruded slightly. The germinating seeds were next distributed on a net of paraffined cotton threads (mosquito netting, mesh about 1.5 millimeters square), which was stretched horizontally over the opening of a cylindrical earthen jar (55 centimeters in diameter and 40 centimeters deep). The jar was kept full of tap water so that the seeds were supported at about the surface of the liquid. Unlike wheat, this rice does not ferment rapidly when the water about it remains unchanged, and this fact, together with the large volume (about 90 liters) of water lying below the seeds, made it seem unnecessary to change the water during the germination period. The germination jar stood in a greenhouse room, exposed to sunlight. The seedlings remained on the net till the shoots were from 3 to 5 centimeters long, requiring a period of from ten to fifteen days, depending on weather conditions, especially temperature.

At the end of the germination period uniform and apparently vigorous seedlings were selected for the cultures.[17] These were placed in a dish of tap water, from which they were taken one by one, and mounted in paraffined cork stoppers of the form used by Shive (1915). Each stopper had six holes and six seedlings were held, one in each hole, by means of properly compressed plugs of cotton. These preparations were then put in place in the openings of the culture bottles, which were of the 250 cubic centimeter form used by Shive (1915). Cardboard covers like the ones described by that writer (1915) were placed around the bottles so as to keep the interior nearly dark. Each bottle contained 250 cubic centimeters of the proper nutrient solution and the roots of the seedlings were almost entirely immersed in the liquid. The seeds were supported just beneath the lower surface of the stopper and were not in contact with the liquid.

SOLUTIONS

SINGLE-SALT STOCK SOLUTIONS

In preparing the culture solutions single-salt solutions of half-volume molecular[18] concentration were first prepared. The salts used were "Baker analyzed" monopotassium phosphate (KH_2PO_4), calcium nitrate [$Ca(NO_3)_2$], magnesium sulphate ($MgSO_4$), ammonium sulphate [$(NH_4)_2SO_4$] and monocalcium phosphate [$Ca(H_2PO_4)_2$].[18] No attempt was made to dry the salts or to determine their water contents, the data on water

[17] On internal differences between seedlings that might be supposed to be alike, see Stiles, W., On the the relation between the concentration of the nutrient solution and the rate of growth of plants in water culture, Ann. Bot. 29 (1915) 89–96.

[18] The stock solution of monocalcium phosphate was twelfth-molecular instead of half-molecular.

content furnished on the label being taken as a basis for preparing the solution in each case. Doubtless some errors were introduced by this procedure. The study was to be only preliminary in character, however, and this kind of work always involves many unknown and uncontrollable conditions, some of which are surely more influential in determining the growth of the plants than are the errors introduced by employing the manufacturers' data on water content, so that special analyses (with their relatively great consumption of time) seemed undesirable in the present case. It was at first intended that samples of the single-salt stock solutions should be subjected later to quantitative determinations, in order to obtain their actual concentrations, but time was finally lacking for this. It is undoubtedly better, in work of this kind, to make up the solutions and then determine their concentrations by analytical methods, than to attempt to dry the salts to a known water content before dissolving. The errors here considered of course apply only to calcium nitrate, ammonium sulphate, and monocalcium phosphate; the other two salts are practically dry as they come on the market.

The ferric phosphate ($FePO_4$) used was prepared according to the procedure of Shive and Tottingham; that is, the ferric nitrate [$Fe(NO_3)_3$] was allowed to react with monopotassium phosphate (KH_2PO_4), forming the precipitate, which was then thoroughly washed with distilled water. The precipitate divides very finely and settles to the bottom of the container only after considerable time. When this material was needed for addition to the culture bottles (when new cultures were to be started or solutions were to be renewed) the bottle containing the precipitate and its supernatant water were thoroughly shaken so as to give a uniform suspension. Five cubic centimeters of this suspension, containing about 11 milligrams of ferric phosphate, were added to each 250 cubic centimeters of culture solution. The slight further dilution resulting from this addition of 5 cubic centimeters of water to each 250 cubic centimeters of culture solution was regarded as insignificant.

The distilled water used was that of the laboratory, derived from a Barnstead still, the same as was used by Hawkins,[19] Shive (1915), and Tottingham (1914).

[19] Hawkins, Lon A., The influence of calcium, magnesium and potassium nitrates upon the toxicity of certain heavy metals toward fungus spores, Physiol. Res. 1 (1913) 57–92.

THE STOCK CULTURE SOLUTIONS

Three types of nutrient solution were studied:

(1) The 3-salt type studied by Shive (1915, 1917) with wheat and buckwheat,[20] which has been called the 3-salt type I by Livingston and Tottingham.[21] This contains, besides a small amount of ferric phosphate, the three salts monopotassium phosphate, calcium nitrate, and magnesium sulphate.

(2) A 4-salt type with both ammonium and nitrate. This contains, besides ferric phosphate, the four salts monopotassium phosphate, calcium nitrate, magnesium sulphate, and ammonium sulphate. It will be termed the 4-salt type A.

(3) A 4-salt type with ammonium but without nitrate. This contains, besides ferric phosphate, the four salts monopotassium phosphate, monocalcium phosphate, magnesium sulphate, and ammonium sulphate. It will be termed the 4-salt type B.

For each of these three types stock culture solutions were prepared from the requisite single-salt stock solutions and distilled water, the total concentrations of the stock culture solutions of each type being alike and as high as that used for the most concentrated culture solution. No ferric phosphate was added to the stock culture solutions. For each type there were as many of these stock solutions as there were different sets of salt proportions in the list to be tested. From any given stock culture solution the various total concentrations needed for the cultures employing that particular set of salt proportions could be readily obtained, either directly or by simple dilution. These concentrated stock culture solutions were stored in much-used glass bottles (of about 3.5 liters' capacity), practically in darkness, and they were drawn upon from time to time as the culture solutions were renewed. In the case of the 3-salt type these stock culture solutions were kept for about a month; in the case of the two 4-salt types they were kept twice as long. In no case was there any evidence suggesting alteration in the stock solutions; at least none beyond the occasional appearance of small fungus colonies, which were always removed with a glass tube as soon as they became conspicuous.

The employment of concentrated stock culture solutions from which the actual culture solutions were obtained, by simple dilution—a procedure that saves very much time, tends to simplify the culture work, and avoids the possibility of many errors

[20] Shive, John W., A study of physiological balance of buckwheat grown in three-salt solutions, New Jersey Agr. Exp. Sta. Bull. 319 (1917) 5–63.

[21] Livingston, B. E., and Tottingham, Wm. E., A new three-salt nutrient solution for plant culture, Am. Journ. Bot. 5 (1918) 337–346.

—was made possible in these studies by the adoption of a new method of dealing with salt proportions. Whereas Tottingham, Shive, and others have based their salt proportions on the partial osmotic values of the various component salts (thus involving the principle of increased dissociation with greater dilution), the salt proportions of the present studies were considered without regard to ionization and were stated simply as molecular salt proportions. All stock culture solutions for any given type were planned to contain the same number of salt molecules per unit of volume; they differed from one another only in the manner in which this number was apportioned among the three or four different kinds of molecules (salts). When this method is adopted the several salts are placed together in the stock culture solution, with a certain set of molecular salt proportions, and the addition of water to this solution does not alter these proportions; they remain the same for all dilutions of this stock solution, although the total concentration is changed by the dilution process. This method of treatment does not at all imply that the various molecules of salt all remain intact in the mixed solution; it is of course appreciated that dissociation must be supposed to occur, and to a higher degree with successively lower total concentrations; but the degree of dissociation of each of the component salts in any culture solution becomes a matter for special study and does not enter into the simple description of the solution.

It can be seen that this plan makes it possible to state the salt proportions with much greater simplicity than can be attained when osmotic salt proportions are employed; that the statement of atomic proportions (and also of ionic proportions, calling an atomic group an ion whether or not it is dissociated from its molecule) is similarly simplified; and that any total osmotic value (total concentration) that is lower than that of the stock culture solution in question may be obtained for any given set of molecular salt proportions by simple dilution from the corresponding stock culture solution. Of course the osmotic value of any solution is determined, for any temperature, etc., by (1) the salts employed, (2) their molecular proportions, and (3) their various degrees of ionization. This value may be approximately calculated by making certain assumptions, but the most satisfactory way to determine it is by means of the freezing-point method. All osmotic values mentioned in this paper are merely rough approximations derived from the values obtained by Tottingham and Shive for somewhat similar mixtures. Lack of time prevented the actual determinations of the freezing points of the solutions used in these experiments.

The three series of stock culture solutions will now be described in order.

Three-salt type I.—Fifteen different sets of molecular salt proportions were tested for this solution type. The fifteen different stock culture solutions all agree in having a total of 0.0245 gram-molecule of salt per liter and the molecular partial concentration of each of the three salts differs from solution to solution throughout the series by increments of one-seventh of the total molecular concentration; that is, by increments of 0.0035 gram-molecule. These fifteen different 3-salt stock solutions may be designated according to the positions of the points representing them on a 3-coördinate diagram similar to the one used by Schreiner and Skinner, Shive, and others. The diagram here used is shown in fig. 1. The different sets of molecular salt proportions will be named by formulas similar to those employed by Shive, only that the letter S will be here used (for solution) instead of C (for culture). R1S1 is the solution represented by the lower left apex of the triangular diagram; R1S3 is the one represented by the third point from the left end of the lowest row of points; R3S3 is represented by the third point, counting from the left, in the third row; R5S1 is represented by the top apex of the diagram (since the fifth row has but a single point), etc. In this diagram every solution of the lowest row has one-seventh of its total molecular concentration made up of monopotassium phosphate, every one on the left margin has one-seventh made up of calcium nitrate, and every one on the right margin has one-seventh made up of magnesium sulphate.

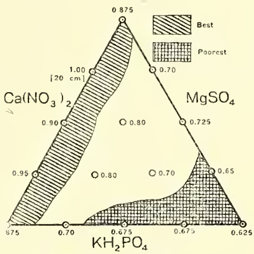

FIG. 1. Relative values of top length for series 4, with 3-salt solution type I (increments of one-seventh, total concentration of 0.0061 gram-molecule per liter or 0.23 atmsophere). Lightly shaded area includes best-balanced sets of salt proportions, heavily shaded area includes poorest sets.

The different sets of molecular salt proportions and the molecular partial concentrations of the one salt monopotassium phosphate are shown in Table 1. From these data the molecular partial concentrations of the other two salts can be readily computed.

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TABLE 1.—*Description of stock culture solutions of 3-salt type I.*

[Total concentration 0.0245 gram-molecule (of all salts taken together) per liter.]

Solution No.	Molecular salt proportions KH_2PO_4 $Ca(NO_3)_2$ $MgSO_4$.	Volume of molecular partial concentration of KH_2PO_4.	Solution No.	Molecular salt proportions KH_2PO_4 $Ca(NO_3)_2$ $MgSO_4$.	Volume of molecular partial concentration of KH_2PO_4.
R1S1	1 : 1 : 5	0.0035	R3S1	3 : 1 : 3	0.0105
S2	1 : 2 : 4		S2	3 : 2 : 2	
S3	1 : 3 : 3		S3	3 : 3 : 1	
S4	1 : 4 : 2		R4S1	4 : 1 : 2	0.0140
S5	1 : 5 : 1		S2	4 : 2 : 1	
R2S1	2 : 1 : 4	0.0070	R5S1	5 : 1 : 1	0.0175
S2	2 : 2 : 3				
S3	2 : 3 : 2				
S4	2 : 4 : 1				

Four-salt type A.—(Monopotassium phosphate, calcium nitrate, magnesium sulphate, ammonium sulphate). Thirty-five different sets of molecular salt proportions were tested for this solution type. The thirty-five stock culture solutions all agree in having a total of 0.0384 gram-molecule of salt per liter and the molecular partial concentration of each of the four salts differs from solution to solution throughout the series by increments of one-eighth of the total molecular concentration; that is, by increments of 0.0048 gram-molecule. These thirty-five different 4-salt stock solutions may be designated according to the positions of the points representing them on a 4-coördinate (solid) diagram similar to the one used by Tottingham. The diagram here used is shown in fig. 2. It is like that employed by Tottingham except that the several equilateral triangles on which the equilateral tetrahedron is built are here represented somewhat in perspective and are placed one above the other, the tetrahedron itself being indicated in outline and having its vertical axis represented as much longer than the other axes, in order to accommodate for the perspective views of the component triangles. Tottingham represented the several triangles all on the same plane,

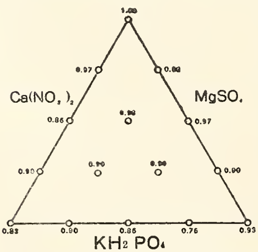

FIG. 2. Relative values of root length for series 4, with 3-salt solution type I (increments of one-seventh, total concentration of 0.0061 gram-molecule per liter or 0.23 atmosphere).

where they could be drawn as equilateral without distortion. The different sets of molecular salt proportions will be named by formulas similar to those employed by Tottingham, the letter S being here used in place of the C in his formulas. T1R1S1 is the solution (or set of salt proportions) represented by the lower front apex of the diagram; T1R2S4 is the one represented by the fourth point, counting from the left, in the second row from the front of the lowest triangle; T3R1S2 is represented by the second point, counting from the left, in the front row of the third triangle from the bottom; T5R1S1 is represented by the top apex of the tetrahedron (since the fifth triangle has but a single point), etc. In this diagram every solution of the lowest triangle has one-eighth of its total molecular concentra-

TABLE 2.—*Descriptions of stock culture solutions of 4-salt types A and B (A, with both ammonium and nitrate; B, without nitrate).*[a]

[Total concentration, 0.0384 gram-molecule (of all salts taken together) per liter.]

Solution No.	Molecular salt proportions KH_2PO_4 $(NH_4)_2SO_4$ $Ca(NO_3)_2$ $MgSO_4$.	Volume of molecular partial concentration of KH_2PO_4	Solution No.	Molecular salt proportions KH_2PO_4 $(NH_4)_2SO_4$ $Ca(NO_3)_2$ $MgSO_4$.	Volume of molecular partial concentration of KH_2PO_4.
T1R1S1	1:1:1:5		T2R1S1	2:1:1:4	
S2	1:1:2:4		S2	2:1:2:3	
S3	1:1:3:3		S3	2:1:3:2	
S4	1:1:4:2		S4	2:1:4:1	
S5	1:1:5:1		R2S1	2:2:1:3	
R2S1	1:2:1:4		S2	2:2:2:2	
S2	1:2:2:3		S3	2:2:3:1	0.0096
S3	1:2:3:2	0.0048	R3S1	2:3:1:2	
S4	1:2:4:1		S2	2:3:2:1	
R3S1	1:3:1:3		R4S1	2:4:1:1	
S2	1:3:2:2		T3R1S1	3:1:1:3	
S3	1:3:3:1		S2	3:1:2:2	
R4S1	1:4:1:2		S3	3:1:3:1	
S2	1:4:2:1		R2S1	3:2:1:2	0.0144
R5S1	1:5:1:1		S2	3:2:2:1	
			R3S1	3:3:1:1	
			T4R1S1	4:1:1:2	
			S2	4:1:2:1	0.0192
			R2S1	4:2:1:1	
			T5R1S1	5:1:1:1	0.0240

[a] The salts named are those of type A; for type B, monocalcium phosphate replaced calcium nitrate as here given.

tion made up of monopotassium phosphate, each of those of the front margin of each triangle has one-eighth made up of ammonium sulphate, every one of the left margin of each triangle has one-eighth made up of calcium nitrate, and every one of the right margin has one-eighth made up of magnesium sulphate, etc. The solution at the top apex of the solid diagram (T5R1S1) has the salt monopotassium phosphate represented by five-eighths of its total molecular concentration, while each of the remaining three salts is represented by only one-eighth of the total.

The different sets of molecular salt proportions for solution types A and B, and the molecular partial concentrations of the one salt monopotassium phosphate, are shown in Table 2. From these data the molecular partial concentrations of the other three salts can be readily computed.

Four-salt type B.—(Monopotassium phosphate, monocalcium phosphate, magnesium sulphate, ammonium sulphate.) This type of solution differs from type A only in this particular, that it contains no calcium nitrate but has its calcium supplied as monocalcium phosphate. While type A contains both ammonium and nitrate as the nitrogen-bearing ions, type B contains only ammonium. Type B was studied in the same way as type A and the solution designations, salt proportions, total molecular concentrations, etc., are alike for the two types.

THE CULTURE SOLUTIONS

Each time a supply of culture solution was required, for starting a culture or for the renewal of its solution, this supply was prepared by merely drawing off some of the corresponding stock solution (in a few cases) or else by diluting some of that stock solution, the degree of dilution being of course determined by the total concentration required for the particular culture in question. Finally, after the solution for any series had been placed in the culture bottles, the ferric phosphate suspension was added. The culture solutions thus prepared were not stored in quantity and each lot was always placed at the disposal of the plants within twenty-four hours after it had been made up.

In renewing the solutions a set of culture bottles were first prepared and filled with their respective solutions. Then each cork, bearing its plants, was transferred from the bottle used during the previous period to the corresponding bottle of the newly prepared set. The plants were thus out of solution only momentarily.

Since the physical, chemical, and physiological properties of any complex solution depend (for any temperature, etc.) upon (1) the nature of the solutes contained, (2) their proportions in the mixture, and (3) the total concentration of the solution,[22] it is of course necessary, in such a study as this, to make comparisons between various nutrient solutions not only with reference to the kinds of salts used and their proportions in the solution, but also with reference to total concentration. It was therefore planned to determine approximately the best total concentration (for the growth of these seedling rice plants under the non-solution conditions employed for each culture series) for each set of salt proportions tested. This means that several different degrees of dilution of each one of the thirty-five stock culture solutions already characterized, had to be employed. Table 3 shows the different total concentrations that were actually used in each case. It also shows the time of year when each series of tests was made, as indicated by the dates. The different series are set forth under each of the three solution types in the order of their total concentrations.

During the culture period the culture solutions were renewed at intervals of three or four days, after the first five days. In connection with this sort of work it should not be forgotten that a given solution begins to alter in respect to its chemical and physical properties as soon as it is brought into contact with the plant roots, and that this alteration continues (in unknown ways) until the old, altered solution is removed and replaced by a fresh one having the standard properties of the old one at the start. The supply of the various ions and molecules at the absorbing surfaces of the roots is of course determined by the respective partial concentrations of these in that

[22] Different writers state this generalization in various ways, frequently from a distinctly not all-inclusive point of view. Some misunderstandings as to the nature of the questions involved and considerable resultant discussion have occurred in the literature, but the matter is too complicated for the present writer to attempt a broad discussion of it here. Especially have students of solution cultures given particular attention to these three controlling conditions as related to the physiological value of a nutrient solution. Whatever may prove to be the most useful way of giving quantitative values to these conditions, it seems quite clear that a plant growing in an aqueous solution may be made to grow faster or slower, better or worse, by altering any one, or two, or all three, of these characteristics of the solution; provided of course that other environmental conditions are not altered in a compensating manner, that the change or changes in the solutions are sufficiently great, and that the changed conditions are maintained for a sufficient length of time.

portion of the solution that lies closely adjacent to the root surfaces. These partial concentrations should of course be maintained constant in experiments of this kind, but the large

TABLE 3.—*Summary of the experimental series, showing dates, solution type, and total molecular concentration (also estimated osmotic value as a fraction of an atmosphere of pressure) for each series.*

Series.	Date (1918).		Total concentration.[a]					
	Beginning.	Ending.	3-salt type I.		4-salt type A.		4-salt type B.	
			Gram-molecule per liter.	Atmosphere.	Gram-molecule per liter.	Atmosphere.	Gram-molecule per liter.	Atmosphere.
1	March 21	April 11	0.002	0.01				
2	March 21	April 11	0.012	0.05				
3	March 24	April 11						
4	February 22	March 14						
5	March 21	April 11	0.0061	0.23				
6	March 24	April 11						
7	March 21	April 11	0.0123	0.46				
8	March 24	April 11						
9	March 21	April 11	0.0245	0.93				
10[b]	March 11	April 5	0.0002	0.01				
11			0.0012	0.05				
12			0.0061	0.23				
13			0.0123	0.93				
14	June 19	July 9			0.0008	0.04		
15	May 24	June 14			0.0016	0.08		
16	June 19	July 9						
17	May 1	May 22						
18	May 24	June 14			0.0038	0.20		
19	June 19	July 9						
20	June 19	July 9			0.0077	0.40		
21	May 24	June 14			0.0192	1.00		
22	May 1	May 22			0.0384	2.00		
23	August 3	August 23						
24	September 9	September 29					0.0008	0.04
25	August 3	August 23						
26	September 9	September 29					0.0016	0.08
27	August 3	August 23					0.0038	0.20
28	September 9	September 29						

[a] Total fraction of a gram-molecule of all salts per liter, and estimated osmotic value as a fraction of an atmosphere of pressure.

[b] Series 10, 11, 12, and 13 were with wheat, for comparison with the results obtained by Shive.

amounts of solutions needed and the work involved to accomplish this made it seem undesirable to attempt the use of continuously renewed solutions [23] in these preliminary studies; when

[23] Trelease, S. F., and Free, E. E., The effect of renewal of culture solutions on the growth of the young wheat plants in water-cultures, Johns Hopkins Univ. Cir. (March, 1917) 425 and 426.

the time is ripe for it, continuous renewal will surely be resorted to. With the present state of knowledge and technic it may be remarked that the solutions in culture bottles are probably always in a state of convection, so that the solution next to the roots is probably never very different from that at a greater distance. It may therefore be supposed that the culture solution alters as a whole and at a much lower rate than would be the case close to the roots if convection were prevented (as by the presence of sand, agar, etc.). Sufficiently rapid convection would amount to continuous renewal of the solution around any given root; and, if the volume of solution held in the culture bottle is great enough (or if the alteration in the solution, caused by the activity of the roots, is slow enough), then the rate of alteration becomes insignificant, so that the solution about the roots may be considered as being practically maintained constant as to its properties. It has frequently been mentioned in the literature that, if continuous and rather rapid renewal of culture solutions is not employed, the desideratum is more nearly approached with greater volume of the solution (size of culture jar) and greater frequency of renewal. In the present studies 250 cubic centimeters of solution were always employed for six plants, and solution renewal occurred at intervals of three or four days after the first five days, as has been said. The experimental conditions would of course have been more nearly ideal with a larger volume and with more frequent renewal. It may well be that the nature of the results obtained would have been insignificantly different had the conditions been more nearly ideal, but the results presented below are to be regarded as applicable only with reference to the general method here employed. With more time and more work other and farther-reaching results might surely be obtained, along this line as well as along other lines.

A chemical condition that is more or less definitely effective within the liquid media of solution cultures, but that is seldom or never adequately dealt with in this kind of work, is the oxygen supply of the root systems. It is clear that most roots require free oxygen [24]—that they are aërobic—and there is reason to believe that rice [25] belongs in this class. It may be conjectured, however, that the roots of young rice plants do

[24] Free, E. E., The effect of aëration on the growth of buckwheat in water-cultures, Johns Hopkins Univ. Cir. (March, 1917) 198 and 199.

[25] Nagai, I., Some studies on the germination of the seed of Oryza sativa, Journ. Coll. Agr. Imp. Univ., Tokyo 3 (1916) 109–158.

not require a very high partial concentration of oxygen in the solution in which they are growing, since these plants thrive excellently when rooted in mud containing large amounts of organic matter (reducing agents). No special method was employed to aërate the solutions in the tests here considered, but it may be assumed that all cultures were about alike in this regard and that the supply of oxygen to the root surfaces was considerable. The solutions were of course exposed to the air, for the corks bearing the seedlings were far from airtight. That good growth was obtained in some cultures indicates that the oxygen supply was adequate, at least with reference to the non-oxygen conditions employed. With more or less rapid supply of oxygen to the roots, and possibly with other solution and non-solution conditions than those here giving best growth, it is of course possible that still better growth might be obtained. No attempt was made to study the influence of oxygen partial concentration in the media used in these experiments.

From the preceding paragraphs it is clear that the solution conditions (salts, salt proportions, total concentration, oxygen partial concentration, as well as the partial concentrations of excreted substances) altered in some unascertained manner from the time the seedlings were placed in the culture bottles to the time of the first renewal of the solution. At the time of renewal the solution conditions were suddenly brought back to the state in which they were at the beginning of the culture. Then alteration began once more and continued for three or four days, when these conditions were again brought back to standard. The standardization of these conditions was subsequently repeated at intervals of three or four days till the end of the culture period.

No attempt was made to determine how the solutions changed between renewals. The line of study here suggested has attracted considerable attention in the past and will surely be continued by plant physiologists, but it has not yet been applied to rice in any thorough manner.

THE NON-SOLUTION CONDITIONS OF THE ENVIRONMENT

By non-solution conditions of the surroundings are here meant all those conditions that may have influenced the growth of these plants, excepting the conditions that are determined directly by the salts, salt proportions, and total concentration of each culture solution. These non-solution conditions of the evironment were practically the same for all the cultures of any single series, and they were the same for all series that were carried out simultaneously (see dates given in Table 3). To approach practical uniformity among simultaneous cultures, the culture bottles were placed on motor-driven rotating tables such as were used by Shive (1915). The tables stood in one of the greenhouse rooms, being located as those of Shive had been.

During the course of each culture series records of the air temperature in the greenhouse in which the cultures were carried out were obtained by means of a thermograph in the shade, under one of the rotating tables. Daily records of the evaporating power of the air and of radiation (sunshine) were also made, by means of the radio-atmometer (white and black spheres).[26] These records will serve to show, in a general way, the temperature, the moisture, and the total radiation conditions for each experiment series.

PLANT RECORDS

For some cultures the volume of solution remaining in the culture bottle at each solution renewal was measured, and the volume absorbed by the plants for the preceding period was determined. Finally, from these determinations was obtained the total volume of solution absorbed by the plants for the entire three-week period. This may be taken as practically the same as the total volume of water transpired during the period.

At the end of the experiment period each set of cultures was separated into three groups representing good, medium, and poor growth, respectively, and a representative from each group was photographed. Notes on the appearance of the plants and the mean lengths of tops and of roots were approximately determined. The plants were then removed from the stopper, the remnant of the seed was discarded in each case, and the tops were severed from the roots at the point of attachment to the seed. The dry weights of tops and of roots (the six plants in each culture being treated as a whole) were then obtained in the usual way, the drying being done finally at a temperature of about 105°C.

In some cases the green weights of tops were approximately determined, to obtain information on the water content, etc. The severed tops from each culture were immediately transferred into a test tube which was then closed and stored in a refrigerator until weighing could be accomplished, which in this case

[26] Livingston, B. E., Atmometry and the porous cup atmometer, Plant World 18 (1915) 21–30, 51–74, 95–111, 143–149.

was within twenty-four hours. The tube with its contents was weighed, the plant material was removed (and preserved for the dry-weight determination), and the tube was finally weighed dry. From the data thus obtained the green weight and the water content of the tops were determined, the latter being finally expressed as percentage on the basis of green weights.

RESULTS

AËRIAL CONDITIONS OF THE EXPERIMENT SERIES

Before proceeding to the presentation of the results obtained from the plants it will be well to present, once for all, the data that characterize the aërial conditions for the various experiment

TABLE 4.—*Maximum and minimum temperatures and average daily atmometric and radio-atmometric indices for the different experiment periods.*

Series No.	Experiment period (1918). Beginning.		Experiment period (1918). Ending.		Days.	Air temperature. Maximum.	Air temperature. Minimum.	Average daily atmometric index.[a] Maximum.	Average daily atmometric index.[a] Minimum.	Average daily atmometric index.[a] Average.	Average daily radio-atmometric index.[a] Maximum.	Average daily radio-atmometric index.[a] Minimum.	Average daily radio-atmometric index.[a] Average.
						°C	°C	cc.	cc.	cc.	cc.	cc.	cc.
4	February	22	March	14	20	33	9	26.9	12.0	20.2	------	------	------
10, 11, 12, 13	March	11	April	5	25	32.2	8.5	38.9	11.1	23.0	------	------	------
1, 2, 5, 7, 9	March	21	April	11	21	32.2	8.0	27.2	11.1	22.3	------	------	------
3, 6, 8	March	24	April	11	18	32.2	8.0	26.8	11.1	22.2	------	------	------
15, 18, 21	May	24	June	14	21	33.0	1.40	------	------	------	------	------	------
14, 16, 19, 20	June	19	July	9	20	35.0	14.0	27.6	6.3	18.1	2.7	.77	1.8
23, 25, 27	August	3	August	23	20	39.0	15.0	30.4	14.3	18.2	3.2	.63	1.9
24, 26, 28	September	9	September	29	20	30.0	9.0	19.7	6.2	12.0	2.1	.54	1.2

[a] The atmometric index is the daily rate of water loss from standard white spherical porous-cup atmometer. The radio-atmometric index is the daily excess of water loss from standard black spherical atmometer, above that from the white.

series as far as these were obtained. This information will aid in making comparisons with similar series that have been carried out by other students or that may be carried out in the future, and will also furnish some fragmentary evidence regarding the sort of aërial conditions that prevail in a greenhouse at Baltimore for the seasons considered. They are set forth in Table 4.

PLANT RECORDS

The numerical plant data derived from these experiments and to be considered below include the following values, though these values were not all obtained for all cultures or for all series:

(1) Dry yield of tops (six plants).
(2) Dry yield of roots (six plants).
(3) Green weight of tops (six plants) and percentage of water content.
(4) Total absorption (six plants).
(5) Water requirement per unit of dry weight.
(6) Approximate length of tops (mean for six plants).
(7) Approximate length of roots (mean for six plants).

The results will be presented below, the three types of solution being considered in order.

THREE-SALT TYPE I (MONOPOTASSIUM PHOSPHATE, CALCIUM NITRATE, MAGNESIUM SULPHATE)

Numerical data were not generally obtained for the rice plants grown in the 3-salt solutions of type I, since it was evident throughout these series that none of the cultures were producing what might be called good growth; all exhibited much poorer growth than was obtained from the better solutions of the two types with ammonium. As to the comparative physiological values of the fifteen different sets of salt proportions tested, solutions R1S1, R2S1, R3S1, R4S1, and R5S1 always appeared to be nearly alike and much better than any of the others, while solutions R1S3, R1S4, R1S5, and R2S4 were nearly alike and always belonged to the poor group. These statements refer to all the different total concentrations tested. The comparative values of the fifteen different sets of salt proportions may be represented by the length values for tops, which were obtained for series 4. The relative quantities standing for these top values are shown in the diagram of fig. 1, for which the largest value (actually 20 centimeters) is considered as unity. It is seen at once that the region nearest the left margin of this diagram represents the best-balanced sets of salt proportions, while the region of the right apex represents the poorest sets.

The solution represented by the right apex itself (R1S5) is by far the poorest of the series, giving tops only 62.5 per cent as long as those given by solution R4S1, which is the best of the series. This means that solutions having relatively low partial concentrations of the calcium salt are the best. None of the five best sets of salt proportions has over one-seventh of its molecular total made up of calcium nitrate. The three solutions having four-sevenths or five-sevenths made up of calcium nitrate (which are also characterized by low partial concentration of magnesium sulphate) all lie in the poor group.

The root lengths were also obtained for series 4, and they are shown by their relative values on the diagram of fig. 2, but they bring out no clear generalization. In this case unity (1.00) represents an actual value of 14.5 centimeters.

Although the 3-salt solutions of the present study are planned by volume-molecular rather than by osmotic salt proportions (the latter having been used by Shive), yet it will be of interest to compare the generalization stated above for these young rice plants, with the outcome of Shive's series for wheat (1915), buckwheat (1917), and soy bean.[27]

The triangular diagrams in question are shown in fig. 3, in which the diagram of fig. 1 is repeated for the sake of comparison. Considering the main regions of good and poor growth, as marked on these diagrams, for wheat it appears that the best sets of salt proportions are near the center of the triangle, with the three salts in somewhat nearly equal proportions, while the poorest sets have very low partial concentrations of monopotassium phosphate and calcium nitrate and very high partial concentrations of magnesium sulphate. For buckwheat low or medium partial concentrations of calcium nitrate together with medium partial concentrations of monopotassium phosphate represent the best sets of proportions, while the poorest sets have low partial concentrations of magnesium sulphate together with medium and high concentrations of monopotassium phosphate. For soy bean [these data have been derived from Shive's table of results given (1918) on page 109] it appears that low partial concentrations of monopotassium phosphate clearly limit the region of good balance, while high ones represent poor balance. It is remarkable that the diagram for soy bean is very similar to that for rice, except that good physiological balance for soy bean seems to require a very low supply of monopotassium phos-

[27] Shive, John W., Toxicity of monobasic phosphates towards soy-beans grown in soil- and solution-cultures, Soils Sci. 5 (1918) 87–122.

phate, while calcium nitrate seems to constitute a corresponding limit for rice; if the soy-bean diagram were rotated a third of a revolution in the clockwise direction it would correspond very closely to the rice diagram.

The points just brought out emphasize what seems likely to be a very important general principle in the science of plant nutrition; namely, that different plant forms may require entirely

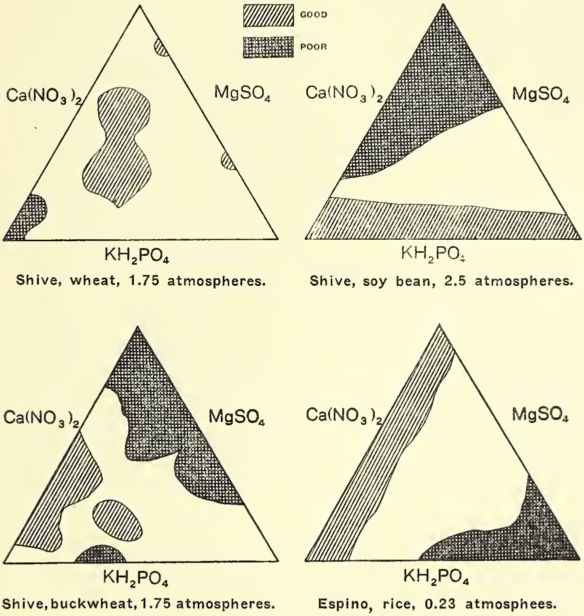

FIG. 3. Good and poor sets of salt proportions for four plant forms.

different sets of salt proportions for good physiological balance. The comparison just made involves only four plants and no two show a tendency to agree as to the solution characteristics that give best growth. It is of course to be expected that, as the salt requirements of other plants are made known, and as those of the plants here considered become better understood, it will be found that there are a number of types of salt requirement, among which the different plant forms will be found to be distributed. It should be emphasized that the data for the four plants thus far studied indicate no solution as well balanced for all, although those with lowest partial concentrations of both monopotassium phosphate and calcium nitrate should be well balanced for both soy bean and rice.

Aside from the question of salt proportions, it is to be noted that Shive's best solutions for wheat and buckwheat have osmotic values of 1.75 atmospheres, and that the best solution he records for soy bean has an osmotic value of 2.5 atmospheres; while the best total concentration for rice, with this type of solution, proved to be about 0.2 atmosphere. In connection with all these considerations it is to be remembered that none of these 3-salt solutions gave really good growth to the young rice plants; what is termed "good" on the lowest diagram of fig. 3 is only relatively good—that is, the best obtained with this solution type. It is thus suggested that the best solution for these rice plants will be found to have a very low total concentration, as compared with the best solutions for wheat, buckwheat, and soy bean. This is borne out by the findings to be reported in the following sections of this paper.

It seems, therefore, that the total concentration best suited to the growth of a given plant is determined not only by the salts and salt proportions but also by the kind of plant considered; also probably by the developmental stage of the plant and by the non-solution conditions of the environment. Different plant forms show different requirements with respect to the total concentration as well as with regard to salt proportions.

The general appearance of the rice plantlets after growing three weeks in the best of these 3-salt solutions is shown by the photograph, Plate 1, fig. 6.

FOUR-SALT TYPE A (MONOPOTASSIUM PHOSPHATE, CALCIUM NITRATE, MAGNESIUM SULPHATE, AMMONIUM SULPHATE)

Introductory.—The results obtained with the four-salt solution type A [28] refer to nine different experimental series (series 14 to 22 inclusive, see Table 3) and to six different total concentrations. The numerical results will be presented after values, but the general appearance of the plants has been considered.

General appearance.—After five or six days in the culture

[28] A single set of salt proportions of this type of solution was used by Wolkoff; see Wolkoff, M. I., Effect of ammonium sulphate in nutrient solution on the growth of soy beans in sand cultures, Soil Sci. 5 (1918) 123–150.

solutions differences in the appearance of the plants generally began to be manifest and these differences became more striking as the cultures became older. With higher total concentrations these differences became pronounced sooner than with lower total concentrations. All of the cultures of series 14 to 22 inclusive gave better plants than were obtained in distilled-water cultures simultaneously carried out; the lowest total concentration tried (series 14, 0.0008 gram-molecule per liter, or 0.04 atmosphere) gave better growth in all of its salt proportions than did distilled water. Of the six total concentrations tested, it was generally true that the plants grew faster at first in the weaker solutions, but after about ten days of growth some of the cultures having the second or third total concentration (series 15 and 16, 0.0016 gram-molecule or 0.08 atmosphere, and series 17, 18, and 19, 0.0038 gram-molecule per liter, or 0.2 atmosphere) showed the most rapid growth.

Most of the cultures with the three weaker total concentrations gave good growth, and the best plants of these series were much better in appearance than were the best ones obtained in any of the 3-salt series with rice. There was generally some drying of the tips of the leaves, especially in the first half of the culture period, and this feature was developed more strongly as the total concentration was higher; but it appeared not to be related to salt proportions, for it was about the same for all. While the dead regions of the leaf tips were only about 0.5 centimeter long with the lowest total concentration used, they were two or three times as long with the fourth of the total concentrations (series 20, 0.0077 gram-molecule per liter, or 0.40 atmosphere). The best cultures of series 14 to 20 (with the four lower concentrations) showed good color and the plants were apparently normal in every way.

The highest two total concentrations (series 21 and 22, 0.0192 and 0.0384 gram-molecule per liter, or 1 and 2 atmospheres, respectively) gave poor growth with all salt proportions, the plants appearing markedly stunted, and the leaves drying badly at the tips or even so far as to affect nearly the whole blade. Chlorotic leaves were common with these two stronger total concentrations. For these two series no quantitative plant measurements were made, and they will not be considered in the sections that follow.

In connection with this observation that the highest two concentrations tested showed no sets of salt proportions at all suited to the growth of these plants, it is of interest to emphasize the fact that the lower one of these two highest total concentrations (series 21, 0.0192 gram-molecule per liter, or 1 atmosphere) was much less concentrated than Shive's best solution for young wheat plants. Whatever may be the details in this connection, it is safe to say that Shive's wheat grew excellently in solutions with osmotic values of 1.75 atmospheres, or even higher, while the rice of the present studies failed to develop even fairly well, with any set of salt proportions, if the osmotic value was greater than about 0.4 atmosphere. Turning to the other plants that have been studied in a systematic way by Shive (1917), by Shive and Martin,[29] and by Shive (soybeans, 1918), it will be seen that buckwheat gave about twice as much in dry yields of tops with the best sets of salt proportions for a total concentration of 1.75 atmospheres as it did with the best ones for a concentration of 0.1 or 4 atmospheres; so that it is evident that rice does not require nearly so high a total concentration for its best growth while young as does buckwheat. Also, Shive obtained excellent growth for soy beans with a total concentration value of 2.5 atmospheres, which indicates that this plant thrives best for the first few weeks in solutions much more concentrated than can well be borne by young rice plants. It may safely be said that rice differs remarkably from wheat, buckwheat, and soy bean, in that, in the case of these three plants, the total concentrations of the nutrient salt mixtures that show best growth in the young ones (when the salt proportions are properly arranged) have osmotic values well above 1 atmosphere, while this value is only about 0.5 atmosphere, or even lower, in the case of rice.

These considerations regarding the comparative ability of rice, wheat, buckwheat, and soy bean to withstand high total concentration of the culture solution, providing the salt proportions are properly arranged, will be still further emphasized when the quantitative data of the present studies are considered.

Throughout these series with the 4-salt solution type A, the yellowing of the leaves was generally more intense for the smaller plants; that is, chlorosis and stunted growth appeared to be controlled by the same sets of conditions. The more pronounced differences in size were paralleled by similar differences in dry yield.

[29] Shive, John W., and Martin, William H., A comparative study of salt requirements for young and for mature buckwheat plants in solution cultures, Journ. Agr. Res. 14 (1918) 151–175. Idem, A comparison of salt requirements for young and for mature buckwheat plants in water cultures and sand cultures, Am. Journ. Bot. 5 (1918) 186–191.

There was generally good agreement in the appearance of the six plants of any culture. Occasionally a seedling died, but this was rare. For such cases the quantitative data have been computed to represent six plants, although actually based on only five.

As to the different sets of salt proportions, the appearance of the plants became progressively poorer (especially with reference to chlorosis and size) with higher relative partial concentrations of monopotassium phosphate; that is, as the top apex of the tetrahedral diagram is approached, the plants are shown to have become more and more stunted and chlorotic. The best-appearing plants represent sets of salt proportions given in the lowest or the lowest two triangles of the diagram and the poorest plants represent the sets at or near the top apex.

Dry yield of tops.—The dry yield of tops from series 14 to 20 is shown in Table 5, all values being expressed in terms of the corresponding value for culture T1R1S1 of the same series. The actual value (fraction of a gram) for the last-named culture is given in parentheses beneath the value 1.00, in each case. Values marked H belong to the highest seven values obtained in the given series, those marked L belong to the lowest seven. These two groups of seven values (there are generally more than seven cultures included, on account of like values from two or more of them) will be called the high and the low groups. The date of beginning of each series is given beneath the series number.

Inspection of Table 5 brings out the fact that, where repetitions were made there are frequent discrepancies, a given solution giving a high relative value for one trial and a medium or low value for another trial. These discrepancies are attributable to unknown conditions (perhaps largely to the non-solution conditions called climatic). It will be remembered that these different trials were made at different seasons of the year, as indicated by the dates. It has been emphasized by other writers that the relative value of any solution must be expected to be different for different sets of non-solution conditions, providing, of course, that the latter differences are large enough to be effective. Whatever may have been the conditional differences that were at work in these cases of discrepancy, it is clear that comparisons between the physiological properties of the solutions here considered (as to whether they gave high, medium, or low yields of tops) must be made only in a broad and general way. It is to be supposed that, had series 14 and

20 been repeated, they also would have shown discrepancies similar to the ones shown for series 15 and 16 and for series 17 to 19. It is obvious that better control of non-solution conditions must be employed before such comparisons as the ones

TABE 5.—*Relative dry yields of tops (six plants), from series with 4-salt solution type A.*

[The value for culture T1R1S1 is always taken as unity and the others are expressed in terms of this. The actual value (grams) for this culture is given in parentheses below the assumed value of unity, in each case.]

Solution No.	Total concentration 0.0008 gram-molecule per liter, or 0.04 atmosphere.	Total concentration 0.0016 gram-molecule per liter, or 0.08 atmosphere.		Total concentration 0.0038 gram-molecule per liter, or 0.2 atmosphere.			Total concentration 0.0077 gram-molecule per liter, or 0.4 atmosphere.
	Series 14, June 19.	Series 15, May 24.	Series 16, June 19.	Series 17, May 1.	Series 18, May 24.	Series 19, June 19.	Series 20, June 19.
T1R1S1	1.00	H 1.00	H 1.00	H 1.00	H 1.00	H 1.00	H 1.00
	(0.198)	(0.416)	(0.239)	(0.354)	(0.420)	(0.243)	(0.226)
S2	0.98	H 0.98	H 0.98	H 1.02	H 0.97	0.86	0.73
S3	0.99	H 0.96	H 0.96	0.85	H 0.94	0.84	0.73
S4	0.74 L	0.90	0.95	H 0.89	H 0.91	0.79	0.69
S5	0.83 L	0.81 L	0.85	0.74	0.80	0.68 L	0.64
R2S1	1.04	H 0.98	H 1.02	H 0.96	H 0.96	H 0.91	H 0.82
S2	H 1.16	H 0.94	0.94	0.87	H 1.00	0.84	H 0.88
S3	H 1.09	H 0.92	0.87	H 0.93	0.77	0.82	0.71
S4	H 1.08	0.88	0.80 L	H 0.92	0.79	0.83	0.65
R3S1	H 1.08	H 0.93	H 1.00	0.82	0.82	0.89	H 1.04
S2	1.08	H 0.93	H 0.99	0.80	H 0.95	H 0.95	H 0.91
S3	0.94	0.80 L	0.87	0.74	0.88	H 0.95	0.71
R4S1	1.00	0.88	0.92	H 0.95	0.90	H 1.04	H 0.93
S2	H 1.14	0.80 L	0.87	H 0.92	H 0.94	H 0.92	0.74
R5S1	0.94	0.79 L	0.93	0.80	0.81	0.76	0.68
T2R1S1	1.01	H 0.97	0.92	0.81	H 0.96	H 0.97	H 0.85
S2	0.90 L	0.91	0.85	0.69	H 0.95	0.82	0.73
S3	0.86 L	0.86	0.83 L	0.77	0.74 L	0.86	0.65
S4	0.78 L	0.85	0.80 L	0.62 L	0.67 L	0.51 L	0.58 L
R2S1	0.93	0.89	H 0.96	0.84	0.79	0.87	0.63
S2	H 1.11	0.88	H 1.17	0.65 L	0.77	H 0.99	0.73
S3	0.92 L	0.84 L	0.68 L	0.68	0.73 L	0.72 L	0.61 L
R3S1	H 1.16	0.92	0.89	0.69	0.89	0.72 L	0.77
S2	H 1.08	0.87	0.91	0.66 L	0.87	0.75	0.72
R4S1	1.03	0.87	0.92	0.72	H 0.92	0.86	0.56 L
T3R1S1	1.02	0.90	0.90	0.75	0.79	0.47 L	0.70
S2	1.04	0.75 L	0.85	0.62 L	0.67 L	0.71 L	0.69
S3	0.86 L	0.80 L	0.74 L	0.54 L	0.67 L	0.58 L	0.35 L
R2S1	H 1.14	0.82 L	H 1.20	0.71	0.86	0.73 L	0.75
S2	1.03	0.87	0.72 L	0.62 L	0.88	0.71 L	0.53 L
R3S1	H 1.21	H 0.96	0.92	0.66 L	0.71 L	0.73 L	0.58 L
T4R1S1	0.94	0.87	0.72 L	0.61 L	0.70 L	0.79	0.60 L
S2	0.88 L	0.83 L	0.69 L	0.45 L	0.64 L	0.51 L	0.58 L
R2S1	H 1.10	0.87	0.81 L	0.56 L	0.76 L	0.75	0.53 L
T5R1S1	H 1.09	0.88	0.80 L	0.54 L	0.74 L	0 58 L	0.57 L

here made may be interpreted in any great degree of detail. Until such controls (especially of air and light conditions) become available, all that can be done is to make the survey for such problems as this rather superficial, to discuss the more- and the less-promising solutions for the uncertain range in the complex of non-solution conditions with which the whole investigation deals. This will be attempted in the present case, and the generalizations that are presented below are to be regarded as only tentatively established; they are meant to apply to such non-solution conditional complexes as were met with in the greenhouse here used, between May 1 and July 9.

It is seen from Table 5 that no set of salt proportions falls in the high group (H) for all series and that only two sets (T3R1S3 and T4R1S2) fall in the low group (L) for all series. Furthermore, no set of proportions falls in the medium group (unmarked in the table) for all series. Inspection of the actual top yields (from which the relative values of Table 5 have been computed) leads to the conclusion that the solutions of series 14 (the lowest total concentration dealt with) are in general too dilute to give the best growth of these plantlets, and, similarly, that those of series 20 (the highest total concentration studied) are too concentrated. This statement is supported by the data of Table 6, which shows the ranges of the actual top-yield values for the high and low groups, for the four series carried out simultaneously beginning June 19. A similar summary of the ranges for root-yield values is given in the same table.

TABLE 6.—*Highest and lowest yields of tops and of roots (milligrams) in the high and in the low groups for the four series carried out simultaneously beginning June 19.*

		Series 14 (lowest total concentration).		Series 16 (low-medium total concentration).		Series 19 (high-medium total concentration).		Series 20 (highest total concentration).	
		Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
Tops	High group	240	214	287	235	253	224	236	185
Do	Low group	184	154	192	163	176	115	138	80
Roots	High group	85	72	78	72	74	64	82	50
Do	Low group	65	54	62	52	53	42	45	36

From the upper part of Table 6 it appears that the maximum top yields from series 14 and 20 are both lower than either of the corresponding maxima for the two remaining series, and that the minimum top yields for the high group for series 14 and 20 are likewise lower than the corresponding minima for the two other series. For the low group the evidence is not so clear, but both minimum and maximum for series 16 are higher than the corresponding minima and maxima for series 14 and 20.

On the whole, it seems safe to conclude that the most promising solution for these young rice plants is to be looked for among solutions having total concentrations higher than the lowest and lower than the highest concentration here considered. For this reason attention will be mainly turned toward the series employing the two medium total concentrations (series 15 and 16, and series 17 to 19).

Before leaving the general subject of the comparison of the four different total concentrations, however, it may be remarked that both high and low yields are shown for all the triangles of the tetrahedral diagram (except the top one) for the lowest total concentration, but that the two groups become more and more sharply segregated with higher total concentrations, so that with the highest concentration (series 20) all the high values but one (T2R1S1, which has a comparatively low value for the high group) occur in the lowest triangle (T1), while no low values at all are shown for that triangle. This progressive segregation of the high values toward the lowest triangle of the diagram, with progressively higher total concentrations, may be considered to mean that the higher the total concentration the smaller must be the relative partial pressure of monopotassium phosphate, if excellent growth is to be expected. No segregation of this sort is apparent for series 14, with the lowest concentration studied, and the distribution of the low and high top-yield values in this series fails to suggest any definite relation between salt proportions and these values. This fact, together with other data for series 14, seem to indicate that the total concentration is here too low to produce the best growth of these plants and to bring out their salt relations as has been mentioned. Omitting this series, we may observe that just two solutions (T1R1S1 and T1R2S1) gave high values in all the remaining series, so that these two solutions appear, on the whole, to be most nearly balanced for these plants, for the whole range of total concentrations dealt with.

Turning now to a special study of the solutions having medium total concentration (series 15 to 19), the upper part of Table 6 indicates that the low-medium was generally better suited to the production of top yields than was the high-medium total concentration. Another comparison between these two total concentrations is possible, however, from the data of series 15 and 18, carried out simultaneously in the period beginning May 24, and data for this comparison are given in Table 7, which is planned like Table 6. For ready comparison, the data for series 16 and 19 are here repeated from the other table. For each series of each period the higher of the two comparable values is shown in bold-face type.

TABLE 7.—*Highest and lowest yields of tops and of roots (milligrams) in the high and in the low groups for the low-medium and high-medium total concentrations (series 15, 16, 18, and 19).*

		Period beginning May 24.				Period beginning June 19.			
		Series 15 (low-medium total concentration).		Series 18 (high-medium total concentration).		Series 16 (low-medium total concentration).		Series 19 (high-medium total concentration).	
		Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
Tops	High group	416	389	**420**	**394**	**287**	**235**	253	224
Do	Low group	**345**	**313**	309	267	**192**	**163**	176	115
Roots	High group	**128**	**118**	120	108	**78**	**72**	74	64
Do	Low group	**98**	71	90	**75**	**62**	**52**	53	42

It appears from the upper part of Table 7 that, in three cases out of four, both maximum and minimum top values for the high group, and also for the low group, are greater for the low-medium total concentration than for the high-medium, while preference is suggested for the high-medium total concentration in the fourth case, that of May 24, of the high group. In this case the differences are much smaller than in the others and they are too slight to be considered as significant (420 milligrams is not significantly greater than 416, nor 394 than 389). It may be added here that the evidence from root yields in the lower part of Table 7 points in the same direction, the agreement being actually better here than in the case of top yields, for the only comparison that gives preference to the high-medium total concentration on this basis is that between the two minima for the low group, 75 and 71 milligrams.

From these and other considerations it seems clear that the low-medium total concentration (0.0016 gram-molecule per liter, or 0.08 atmosphere) is to be regarded as generally more promising, for these plants and these non-solution conditions and for this 4-salt type of medium, than is the high-medium total concentration (0.0038 gram-molecule per liter, or 0.2 atmosphere). The differences are not generally relatively very great, however, and it may be safer to conclude from the limited data (and considering the discrepancies shown by the repetitions) that the most promising total concentration lies within the range between these two, perhaps nearer to the lower limit than the upper.

Reverting to Table 5 and taking up now the comparative physiological values for top yield of the various sets of salt proportions for the two medium total concentrations, it will be instructive to study the agreements and disagreements between

TABLE 8.—*Showing symbols for top and root yield of series 15 to 19.*

Solution No.	Top yields.		Root yields.	
	Low-medium total concentration. Series 15, 16.	High-medium total concentration. Series 17–19.	Low-medium total concentration. Series 15, 16.	High-medium total concentration. Series 17–19.
T1R1S1	H	H	H	H
S2	H	Hm	H	H
S3	H	Mh	H	H
S4	M	Hm	M	Mh
S5	LM	Ml	L	Ml
R2S1	H	H	H	H
S2	HM	Mh	H	Hm
S3	HM	Mh	M	Mh
S4	LM	Mh	L	HML
R3S1	H	M	HM	Mh
S2	HL	Hm	LM	Mh
S3	LM	Mh	L	HML
R4S1	M	Hm	L	Mh
S2	LM	H	L	H
R5S1	LM	M	L	M
T2R1S1	HM	Hm	H	H
S2	M	Mh	H	Hm
S3	LM	Ml	M	M
S4	LM	L	LM	L
R2S1	HM	M	HM	Hm
S2	HM	HML	H	Hm
S3	L	Lm	L	M
R3S1	M	Ml	HL	HML
S2	M	Ml	L	Ml
R4S1	M	Mh	HL	Mh
T3R1S1	M	Ml	H	Mh
S2	LM	L	M	Ml
S3	L	L	LM	L
R2S1	LH	Ml	HM	M
S2	LM	Lm	M	Mh
R3S1	HM	L	HM	Lm
T4R1S1	LM	Lm	HL	Lm
S2	L	L	LM	L
R2S1	LM	Lm	HM	Ml
T5R1S1	LM	L	HM	L

the two low-medium series and between the three high-medium series, also between the low-medium and the high-medium concentrations, as indicated by the groups (high, medium, and low) in which the various sets of salt proportions fall.

These agreements and disagreements are set forth in Table 8, which also includes the corresponding data for root yields. In this table the letters H, M, and L are employed to show in which group any given set of salt proportions fell for each trial. In the case of the lower of these two medium total concentrations there were two trials, and disagreement between the two is shown by the use of both letters (thus, HM denotes that one trial showed the solution in question as in the high group, while the other trial showed it as in the medium group). In the case of the higher total concentration there were three trials. When all were different in their indications all three letters are given in the table; when two of them agreed but the third was different, only two letters appear, but one is lower-case, to denote that only one trial is thus referred to. Thus, if the three trials call for L, L, and M respectively, the designation is Lm, etc.

Table 8 shows that solutions T1R1S1, T1R1S2, and T1R2S1 agree in giving high top yields, while solutions T2R2S3, T3R1S3, and T4R1S2 agree in giving low top yields, for both total concentrations. The other solutions show medium top yields or are more or less questionable, as far as the data go. It seems safe to conclude that the first three solutions just named may be expected to produce excellent top growth for this sort of plants, when the total concentration is between 0.0016 and 0.0038 gram-molecule per liter (0.08–0.2 atmosphere), while the last three mentioned may be taken as representing the poorly balanced sets of salt proportions of these series. The distribution of these and the other solutions on the tetrahedral diagram, together with the chemical interpretation of this, will be deferred till after the root yields have been presented.

Dry yields of roots.—The relative dry yields of roots from series 14 to 20 are presented in Table 9, in a manner quite like that followed for the top yields in Table 5.

From Table 9 it appears that disagreements are fully as frequent among the root yields as among those of tops, and the remarks made concerning the discrepancies in the other case will apply here also.

It appears that solution T1R1S1 and T2R1S1 agreed in giving high root yields for all series, and that no one of the thirty-five sets of salt proportions gave low root yields for all series.

TABLE 9.—*Roots, relative dry yields (six plants), from series with 4-salt solution type A.*

[The value for culture T1R1S1 is always taken as unity and the others are expressed in terms of this. The actual value (grams) for this culture is given in parentheses below the assumed value of unity, in each case.]

Solution No.	0.0008 gram molecule per liter, or 0.04 atmosphere.	0.0016 gram-molecule per liter, or 0.08 atmosphere.		0.0038 gram-molecule per liter, or 0.2 atmosphere.			0.0077 gram-molecule per liter, or 0.4 atmosphere.
	Series 14, June 19.	Series 15, May 24.	Series 16, June 19.	Series 17, May 1.	Series 18, May 24.	Series 19, June 19.	Series 20, June 19.
T1R1S1	H 1.00	H 1.00	H 1.00	H 1.00	H 1.00	H 1.00	H 1.00
	(0.185)	(0.128)	(0.078)	(0.098)	(0.120)	(0.074)	(0.068)
S2	0.81	H 0.98	H 0.94	H 1.02	H 0.93	H 0.92	H 0.75
S3	0.79	H 0.94	H 0.90	H 0.92	H 0.90	H 0.92	0.78
S4	0.71	0.89	0.85	H 0.95	0.87	0.76	0.68
S5	0.64 L	0.77 L	0.80 L	0.78	0.78	0.68 L	0.69
R2S1	0.79	H 0.98	H 1.00	H 1.01	H 0.96	H 0.91	H 0.75
S2	H 0.85	H 0.91	H 0.90	0.89	H 0.96	H 0.85	H 1.20
S3	0.84	0.84	0.86	H 0.95	0.78	0.84	H 0.75
S4	0.76	0.63 L	0.80 L	H 0.92	0.75 L	0.81	0.71
R3S1	H 0.85	0.79	H 0.91	0.84	0.83	H 0.85	H 0.87
S2	0.67 L	0.67 L	0.85	0.87	H 0.99	H 0.93	H 0.81
S3	0.78	0.64 L	0.71 L	0.67 L	0.88	H 0.92	H 0.74
R4S1	0.64 L	0.61 L	0.74 L	H 0.97	0.80	0.81	0.71
S2	0.74 L	0.56 L	0.67 L	H 0.92	H 0.92	H 0.91	0.65 L
R5S1	0.64 L	0.56 L	0.69 L	0.84	0.63	0.76	0.56 L
T2R1S1	H 0.91	H 0.95	H 0.94	H 0.95	H 0.95	H 0.95	H 0.85
S2	0.71 L	H 0.92	H 0.91	0.90	H 0.92	H 0.93	H 0.75
S3	0.66 L	0.90	0.87	0.89	0.80	0.84	0.73
S4	0.71 L	0.81	0.80 L	0.71 L	0.68 L	0.64	0.71
R2S1	0.68 L	0.83	H 0.90	H 0.95	0.84	H 0.89	0.66 L
S2	0.74 L	H 0.93	H 0.92	0.71 L	0.82	H 0.95	H 0.74
S3	0.73 L	0.77 L	0.74 L	0.83	0.80	0.78	H 0.75
R3S1	0.80	H 0.92	0.77 L	H 0.91	0.85	0.72	0.66 L
S2	0.77	0.67 L	0.74 L	0.90	0.73 L	0.87	0.72
R4S1	0.78	H 0.91	0.77 L	0.87	0.85	H 0.95	0.53 L
T3R1S1	H 0.94	H 0.98	H 0.95	0.74	H 0.90	0.76	H 0.75
S2	H 0.86	0.81	0.87	0.72 L	0.78	0.73	0.69
S3	0.80	0.78 L	0.85	0.68 L	0.72 L	0.69 L	0.53 L
R2S1	H 0.94	0.88	H 0.97	0.86	0.85	0.81	0.69
S2	H 0.88	0.84	0.81	0.80	H 0.93	0.77	0.63 L
R3S1	0.80	H 0.98	0.87	0.79	0.71 L	0.70 L	0.62 L
T4R1S1	H 0.88	H 0.92	0.78 L	0.73 L	0.76 L	0.82	0.65 L
S2	0.71 L	0.81	0.77 L	0.58 L	0.67 L	0.57 L	0.68
R2S1	H 0.89	H 0.92	0.89	0.67 L	0.79	0.81	0.54 L
T5R1S1	H 1.00	H 0.98	0.81	0.51 L	0.75 L	0.62 L	0.66 L

The range limits given in the lower part of Table 6 indicate a less marked distinction in favor of the two medium total concentrations (as compared with the lowest and highest, series 14 and 20) than is shown for top yields. Nevertheless, partly because the physiological meaning of the dry yield of roots is not at all understood and partly because the possible errors in cutting, weighing, etc., are much greater for roots than for tops, the same general plan will here be followed as was resorted to in the case of the top yields. Attention will be mainly restricted to the two medium total concentrations, series 15 and 19.

Before leaving the general subject of total concentration it may be remarked that the low and the high root yields are not in any case as clearly segregated as are the corresponding ones for tops; but, with the higher total concentrations, there is a marked tendency for low values to correspond especially to the third, fourth, and fifth triangles of the tetrahedral diagram; that is, to high relative partial concentrations of monopotassium phosphate. As in the case of top yields, the most certainly well-balanced sets of salt proportions have low relative partial concentrations of this salt.

In connection with Table 7 it has been noted that the limited information at hand appears to indicate that the lower of the two medium total concentrations may be appreciably better for root yields, as well as for top yields, than is the higher. Since the differences are not great, they require no emphasis at this time, however.

The agreements and disagreements between the similar series, with regard to root yields, are given in Table 8, the notation of which has already been explained. Reference to that table brings out the fact that the following five sets of salt proportions agreed in giving high root yields for all five trials: T1R1S1, T1R1S2, T1R1S3, T1R2S1, and T2R1S1. The first two and the fourth one of these have been noted as showing the same outstanding agreement for top yields. None of the solutions show this kind of agreement for low root yields.

TOP AND ROOT YIELDS IN RELATION TO SALT PROPORTIONS

The relations between yield and salt proportions may be brought out best by the use of the tetrahedral diagram. The symbols shown in Table 8, for tops and for roots, and for the low-medium and high-medium total concentrations, are plotted diagramatically in figs. 4 to 7. The only alteration made in entering the letters on the diagrams has been to change HL to M, on the supposition that a solution giving high yield in one trial and low yield in another trial should be represented as belonging to the medium group. The areas of the diagrams representing high yields and those representing low yields are distinguished by shading. In outlining these areas, combinations of letters—denoting uncertainty in the data—are treated as belonging to the medium group.

It seems undesirable, considering the discrepancies as to details, to attempt to combine these four diagrams into a single one, but the following remarks will draw attention to the main points on which such a combination might be based. We may begin by considering the two total concentrations separately, as to the degree of agreement between the data for tops and those for roots. For the lower of the two medium concentrations

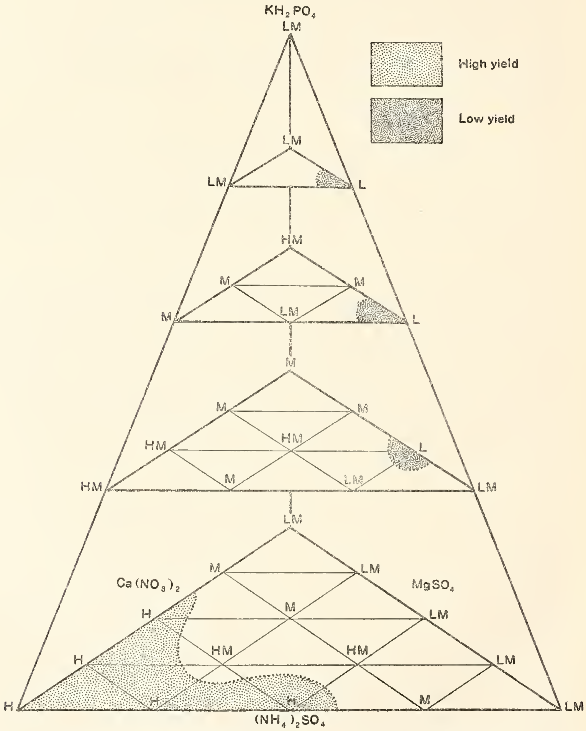

FIG. 4. Top-yield values for the thirty-five different sets of salt proportions, with low-medium total concentration.

considred (0.0016 gram-molecule per liter, or 0.08 atmosphere) the diagram for top yield (fig. 4) shows five sets of salt proportions as of the high group, all lying in the forward left portion of the lowest triangle. No set of proportions in the lowest triangle is indicated for the low group, but three sets are shown; one in the second, one in the third, and one in the fourth triangle, all at or adjacent to the forward right apex. The corresponding diagram for root yield (fig. 5) shows about the same low region in the lowest triangle as is shown for top yield, but here also there are three high sets of proportions; in the

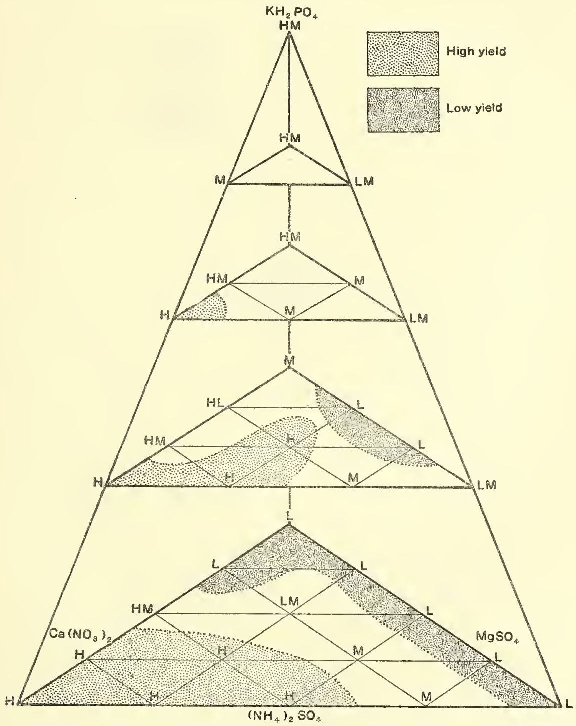

FIG. 5. Root-yield values for the thirty-five different sets of salt proportions, with low-medium total concentration.

middle, in the forward left portion of the second triangle, and at the forward left apex of the third triangle. On this root-yield diagram the low region occupies the whole right margin of the lowest triangle and a portion of the same margin of the second triangle. Just one set of proportions (T2R2S3) is set down as in the low group on both diagrams.

It is especially interesting to note that the yields of tops and of roots agree very well, a feature of these results that is different from what has been indicated for wheat and buckwheat by Shive's work; that writer frequently found low root yields

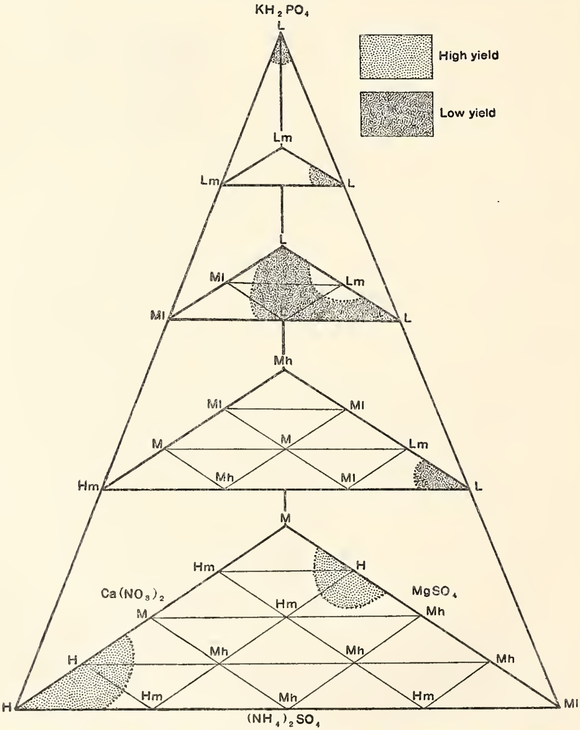

FIG. 6. Top-yield values for the thirty-five different sets of salt proportions, with high-medium total concentration.

accompanying high top yields and, conversely, it appears that the young rice plants generally show parallel, rather than opposite, effects upon top and root production.

Turning to the higher total concentration (0.0038 gram-molecule per liter, or 0.2 atmosphere), only two sets of salt proportions are indicated as of the high group of top yields (fig. 6) in the forward left region of the lowest triangle (the high designation given to solution T1R4S2 appears to be erratic in some way). On this top diagram the low region comprises six sets of salt proportions, lying at the forward right apices of the second,

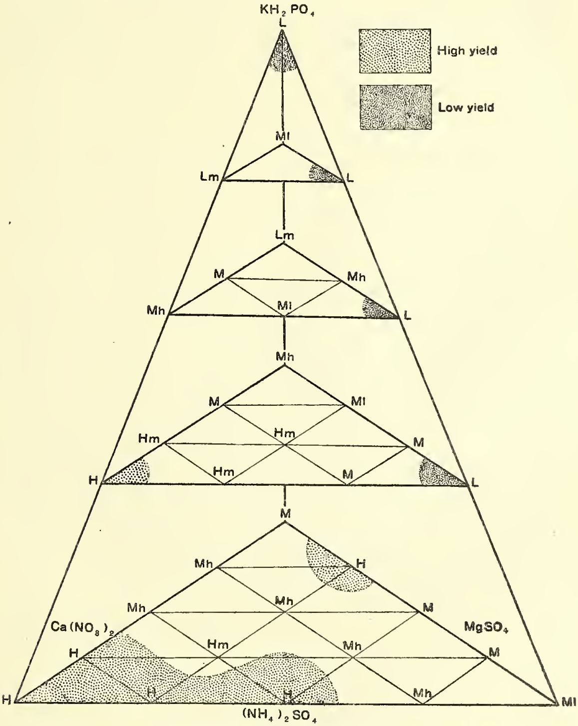

FIG. 7. Root-yield values for the thirty-five different sets of salt proportions, with high-medium total concentration.

third, and fourth triangles and the top apex of the whole tetrahedron, and at the rear apex and the forward central region of the third triangle. The corresponding diagram for root yield (fig. 7) shows a high region near the forward right apex of the lowest triangle (much as for the lower total concentration in regard to both tops and roots) and it agrees with the diagram for tops in giving a high designation to solution T1R4S2 (which may be erratic here also). The forward left apex of the second triangle is also indicated as of the high group, as in the case of the lower concentration and root yields (fig. 5).

The low region of this root diagram (fig. 7) occupies the forward right apices of the second, third, and fourth triangles and the top apex of the tetrahedron as a whole. It differs from the corresponding top diagram (fig. 6) only in that the low region is not here extended beyond the forward right apex in the third triangle.

With the higher of these two total concentrations it is again clear that top and root yields tend to be parallel, just as with the lower total concentration.

Finally, it should be noted that two sets of salt proportions, T1R1S1 and T1R2S1, are shown as of the high group on all four diagrams.

Study of the preceding pages and of the diagrams of figs. 4 to 7 leads to the following guarded generalizations. It appears that solutions T1R1S1, T1R1S2, and T1R2S1 are to be regarded as having about the best salt proportions for the development of these plants, with the other conditions involved in these studies, and it similarly appears that solutions T1R1S5, T2R1S4, T3R1S3, T4R1S2, and T5R1S1 are to be regarded as very unbalanced and injurious. Under the given non-solution conditions and with total concentrations lying between 0.0016 and 0.0038 gram-molecule per liter, these plants are found to give highest yields of both roots and tops when the culture solution contains relatively large proportions of magnesium sulphate, and relatively small proportions of the other three salts, themselves present in nearly equal proportions. The three solutions just indicated as best have the salt proportions shown below:

Solution No.	KH_2PO_4.	$(NH_4)_2SO_4$.	$Ca(NO_3)_2$.	$MgSO_4$.
T1R1S1	1	1	1	5
T1R1S2	1	1	2	4
T1R2S1	1	2	1	4

Perhaps a recommendation as to the best set of salt proportions for this solution type for these young rice plants, etc., might be obtained by averaging these proportions, thus obtaining solution T1R1$\frac{1}{3}$S1$\frac{1}{3}$, with molecular proportions 1:1$\frac{1}{3}$:1$\frac{1}{3}$:4$\frac{1}{3}$. It may even be desirable to leave the relative value for magnesium sulphate as it is in R1S2 and R2S1 and allow the hypothetically best solution to be T1R1$\frac{1}{2}$S1$\frac{1}{2}$, with molecular proportions 1:1$\frac{1}{2}$:1$\frac{1}{2}$:4. Judging from the information at hand, either T1R1$\frac{1}{3}$S1$\frac{1}{3}$ or T1R1$\frac{1}{2}$S1$\frac{1}{2}$ should give excellent results for both tops and roots. There seems to be no reason for increasing the molecular proportional value of monopotassium phosphate above unity (one-eighth of the total molecular concentration of all salts taken together) for the hypothetical best set of proportions.

From this generalization it appears that these young rice plants differ in their physiological salt requirements from many other plants, notably from wheat, buckwheat, and soy bean, especially in the fact that the former need relatively a very high partial concentration of magnesium sulphate, and about equal and relatively very low partial concentrations of monopotassium phosphate and calcium nitrate. As has been seen, these rice plants are also peculiar in that they cannot develop satisfactorily when supplied with monopotassium phosphate, calcium nitrate. and magnesium sulphate in any possible proportions, but do develop excellently in the 4-salt solution type here employed, containing the three salts just mentioned and also ammonium sulphate. It may be of interest to note that the hypothetically best sets of salt proportions suggested above, T1R1$\frac{1}{3}$S1$\frac{1}{3}$ and T1R1$\frac{1}{2}$S1$\frac{1}{2}$, are characterized by Ca:Mg ratio values of 1$\frac{1}{3}$: 4$\frac{1}{3}$ (1 : 3.25=0.308) and 1$\frac{1}{2}$: 4 (1 : 2.67=0.375), respectively. If we adopt the quite undesirable method of considering such ratio values as derived by considering the two metals as their oxides and employing the ratio of the weights of the oxides rather than the atomic or molecular ratio, it may be said that the atomic ratio Ca:Mg=0.308 is equivalent to the molecular ratio CaO:MgO =0.308, or the weight ratio CaO:MgO=0.375. The complete sets of atomic and ionic ratio values for the hypothetically best set of salt proportions T1R1$\frac{1}{3}$S1$\frac{1}{3}$ are as follows (neglecting the H-ion):

$$K : Ca : Mg : N : P : S = 1 : 1\tfrac{1}{3} : 4\tfrac{1}{3} : 5\tfrac{1}{3} : 1 : 5\tfrac{2}{3}.$$
$$K : Ca : Mg : NH_4 : NO_3 : PO_4 : SO_4 = 1 : 1\tfrac{1}{3} : 4\tfrac{1}{3} : 2\tfrac{2}{3} : 2\tfrac{2}{3} : 1 : 5\tfrac{2}{3}.$$

With reference to what sets of molecular salt proportions constitute bad physiological balance for these plants, it has been mentioned that, in general, progressively higher relative partial concentrations of monopotassium phosphate give progressively poorer yields. At the same time it is to be noted that bad physiological balance generally accompanies low relative partial concentrations of magnesium sulphate. Perhaps the worst solution of this 4-salt type may, as here tested, be represented by T3R1S3 or by T4R1S2. These have the molecular salt proportions shown below:

Solution No.	KH_2PO_4.	$(NH_4)_2SO_4$.	$Ca(NO_3)_2$.	$MgSO_4$.
T3R1S3	3	1	3	1
T4R1S2	4	1	2	1

They are characterized by high relative proportions of monopotassium phosphate and calcium nitrate, and by low proportions of ammonium sulphate and magnesium sulphate. But the best solutions for top and root yields are also characterized by low relative proportions of the ammonium salt, as has been seen, so that the distinguishing characters of these very poorly balanced solutions are high proportions of monopotassium phosphate and calcium nitrate and low proportions of magnesium sulphate. From the nature of the results that have been presented and from the nature of the problem itself, it is undesirable to attempt to fix upon any one of the sets of salt proportions as most poorly balanced; to attempt this would lead to discussion of the general problem of toxicity and starvation.

Referring to the studies of earlier students of rice culture and of the salt nutrition of the rice plant, the conclusions just brought forth appear to substantiate the more general ones that have been expressed in the literature; namely, that young rice plants require ammonium and cannot thrive with nitrate as the only source of nitrogen, and that rice needs relatively little potassium and relatively much magnesium, while it cannot generally bear much calcium. An additional point, not emphasized in the literature, is that the best growth of young rice is not to be expected with anything but comparatively low proportions of the ammonium salt, although the present studies suggest that ammonium sulphate is not so injurious in higher proportions as is monopotassium phosphate. Perhaps it may be said to be about as injurious as calcium nitrate.

Lengths of tops and roots.—As has been said, the approximate average length of tops and of roots was obtained at the end of the culture period, for each culture of series 14 to 20. Discrepancies between the different trials of the same series, as to the relative physiological values of the various sets of salt proportions, are more pronounced in top length than in dry yield, and in root length than in top length, and the general consistency of the whole array of values for top and root length is of a low order. This may be considered as indicating that these length values are not as good criteria as are the dry yields, for bringing out differences in growth in the various cultures as here studied. It should be noted, however, that the method used in obtaining these approximate values involved considerable personal judgment and was not based on precision measurements and mathematical treatment. All things considered, it seems unnecessary to present all these length values here, although some samples for tops will be shown below. In spite of the discrepancies and inconsistencies of this mass of data, it generally appears that sets of salt proportions that appear most satisfactory by the criterion of dry yield also appear very satisfactory by the criterion of top length, and the solutions that appear to be badly balanced according to the one criterion also exhibit very poor growth according to the other.

Table 10 shows the actual and relative top-length values for the three sets of salt proportions chosen as the most promising, and for the two sets chosen as least promising on the basis of dry yields. The relative value is placed in parenthesis after the actual value in each case.

TABLE 10.—*Approximate mean length of tops for selected solution of 4-salt solution type A.*

Solution No.	Series 14, June 19.	Series 15, May 24.	Series 16, June 19.	Series 17, May 1.	Series 18, May 24.	Series 19, June 19.	Series 20, June 19.
	cm.	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
T1R1S1	30.0(1.00)	40.0(1.00)	35.0(1.00)	38.5(1.00)	36.0(1.00)	33.4(1.00)	31.3(1.00)
T1R1S2	29.5(0.98)	38.3(0.96)	34.4(0.97)	39.0(1.01)	35.0(0.97)	30.0(0.90)	27.7(0.89)
T1R2S1	31.5(1.05)	39.5(0.99)	32.6(0.93)	38.0(0.99)	38.2(1.06)	30.0(0.90)	29.0(0.93)
T3R1S3	26.3(0.88)	30.6(0.77)	27.0(0.77)	26.0(0.68)	29.8(0.83)	23.8(0.71)	17.0(0.54)
T4R1S2	28.5(0.95)	33.5(0.84)	26.6(0.76)	23.0(0.60)	29.3(0.81)	23.0(0.69)	20.3(0.65)

It is clear that the best three sets of salt proportions of Table 10 agree in showing the two medium total concentrations as about alike and markedly better than either the lowest or the highest total concentration here considered, thus supporting the conclusion derived from the data of dry yield. This is not so clear for the two badly balanced sets of salt proportions in this table, for the values for series 14 are both higher than the corresponding ones for series 19 and one of them is higher than the corresponding one for series 16. It is to be remembered that series 14, 16, 19, and 20 were simultaneously carried out, as also were series 15 and 18. The highest total concentration (series 20) gave top length values much lower than the corresponding ones of any other concentration. As to the comparison between the two medium total concentrations, these two badly balanced sets of salt proportions agree, by both trials, in showing higher values for the low-medium concentration than for the other. Finally, there is no doubt, from the data in Table 10, that the first three solutions belong to the high or well-balanced group, while the last two belong to the low or badly balanced group. On the whole, the indications of these data for top length agree very well with those derived from the dry-yield data for tops and roots.

Green weight and water content of tops.—For the four series carried out in the period beginning June 19, the green weights of tops were determined, and these are shown in Table 11. There were just four series (14, 16, 19, and 20) and each had a different total concentration, so that there are no repetitions to be considered in regard to green weight, but these four series were carried out simultaneously so that they should be comparable as far as non-solution conditions are concerned. In Table 11 the letters H and L are fixed to the values belonging to the high and low groups, respectively, as in the cases of dry yields (Tables 5 and 9).

Considering the comparative physiological values of the four different total concentrations, as shown in Table 11, it is seen that for the lowest total concentration all but one (T4) of the five triangles of the tetrahedral diagram have one or more high green-weight values, and that all but one (T5) have one or more low values also. On the other hand, for the highest total concentration the lowest triangle of the diagram has seven values of the high group and none of the low group, the second triangle has one high value and two low values, and the remaining three triangles have one or more low values each, but no high value. As in the case of the dry yields of tops, the higher the total concentration the more segregated the high values in the lower part of the diagram and the low values in the upper part. As the total concentration is progressively higher the ability of the plants to withstand the higher partial concentration of monopotassium phosphate becomes markedly diminished. For the highest total

TABLE 11.—*Green weight of tops (six plants), actual values, from series with 4-salt solution type A, for culture period June 19 to July 9.*

Solution No.	Total concentration 0.0008 gram-molecule per liter, or 0.04 atmosphere (series 14).	Total concentration 0.0016 gram-molecule per liter, or 0.08 atmosphere (series 16).	Total concentration 0.0038 gram-molecule per liter, or 0.2 atmosphere (series 19).	Total concentration 0.0077 gram-molecule per liter, or 0.4 atmosphere (series 20).
	grams.	*grams.*	*grams.*	*grams.*
T1R1S1	1.24	H 1.78	H 1.68	H 1.39
S2	1.22	H 1.69	1.42	H 1.12
S3	1.23	1.51	1.36	1.00
S4	1.19	1.45	1.29	0.85
S5	1.00 L	1.27	1.07	0.84
R2S1	1.20	H 1.56	1.43	H 1.12
S2	H 1.41	1.31	1.35	H 1.24
S3	1.28	1.35	1.33	0.96
S4	1.27	1.25 L	1.35	0.91
R3S1	1.24	1.47	H 1.46	H 1.43
S2	1.23	1.47	H 1.53	H 1.27
S3	1.28	1.32	H 1.57	0.97
R4S1	1.26	1.37	H 1.65	H 1.26
S2	H 1.36	1.28	1.45	1.02
R5S1	1.16 L	1.37	1.14	0.86
T2R1S1	1.22	1.45	H 1.55	H 1.17
S2	1.12 L	H 1.61	1.06	1.02
S3	1.11 L	1.30	1.01 L	0.92
S4	1.02 L	1.28	0.82 L	0.78 L
R2S1	1.19	1.48	1.39	0.87
S2	H 1.43	H 1.80	H 1.58	1.02
S3	1.18 L	1.02 L	1.13	0.79 L
R3S1	H 1.40	1.32	1.04 L	H 1.08
S2	1.35	1.42	1.18	0.96
R4S1	1.28	1.42	1.31	0.82
T3R1S1	1.27	H 1.52	1.02 L	0.99
S2	H 1.38	1.30	1.10	0.93
S3	1.15 L	1.21 L	0.94 L	0.45 L
R2S1	H 1.42	H 1.55	1.13	1.06
S2	1.29	1.09 L	1.06	0.72 L
R3S1	H 1.54	1.44	1.14	0.76 L
T4R1S1	1.16 L	1.14 L	1.26	0.82
S2	1.11 L	1.05 L	0.75 L	0.76 L
R2S1	1.35	1.23 L	1.10	0.57 L
T5R1S1	H 1.40	1.21 L	0.84 L	0.75 L

concentration, no high value occurs for any set of salt proportions in which monopotassium phosphate makes up more than two-eighths of the total molecular concentration. For the lowest total concentration this salt may make up five-eighths of the total and a high green-weight value may be produced.

Furthermore, low values shown in the lower two or three triangles of the diagram correspond to relatively low partial concentration of magnesium sulphate, and to high ones of calcium nitrate, and the high values in these triangles correspond to high partial concentrations of magnesium sulphate and low ones of the calcium salt.

Considering each set of salt proportions singly, it is seen from Table 11 that the highest green weight most generally occurs with the low-medium total concentration (series 16); this is true for 20 out of the 35 sets of salt proportions tested. Of the remaining 15 sets, 7 show the highest green weight for the high-medium total concentration (series 19), and in all other cases (8) the highest value occurs for the lowest total concentration (series 14); in no case does the highest total concentration (series 20) give the highest green-weight value. This supports the conclusion reached from the study of the dry yields of tops and roots, that both of the medium concentrations are to be considered relatively good for these plants, but that the low-medium total concentration is probably to be regarded as more nearly optimal than the high-medium. The last point is more strongly emphasized here than in the case of dry yields.

Green weight of tops has frequently been employed as a criterion for comparing the physiological efficiencies of different environmental complexes, although it does not appear to have been used by earlier workers with solution cultures arranged for a thorough study of salt proportions. Since green weight consists, in any case, of the corresponding dry weight plus the corresponding water content, it is quite possible that the green-weight criterion (or the water content per weight unit of dry yield, or per weight unit of green weight itself) may bring out other physiological relations than those shown by the dry-yield criterion. For example, with a given total concentration, one set of salt proportions may give a higher dry-yield value than is given by another set, or the two sets may give equal values, and at the same time the first set may give a percentage of water content either less, equal to, or greater than that given by the other set. The salt proportions may influence not only the dry-yield production but also (possibly in an entirely different manner) the power of the plant to retain water. Two plants may have the same dry weight but may be markedly different physiologically (and in regard to commercial value), according to the amount of water retained in their tissue; one might be much more succulent than the other, etc. Such possibilities are suggested in the literature.

On account of these considerations it will be valuable to make a comparison between the indications of the dry-yield and of the green-weight criteria for these four simultaneous series with young rice plants; for these cultures the dry yields of tops are also available, as has been shown. For the sake of this comparison Table 12 has been prepared. On account of the numerous discrepancies among the indications from repeated series it seems best not to consider any dry yield data here excepting those of the four simultaneous series in question, where the proposed comparisons may be made directly and without any complications introduced by differences in climatic and other non-

TABLE 12.—*Comparison between dry yield and green weight of tops, as to the indications from the four simultaneous series (14, 16, 19, and 20), beginning June 19.*

Solution No.	Lowest total concentration (series 14).			Low-medium total concentration (series 16).			High-medium total concentration (series 19).			Highest total concentration (series 20).		
	Dry.		*Green.*	*Dry.*		*Green.*	*Dry.*		*Green.*	*Dry.*		*Green.*
T1R1S1	M		M	H		H	H		H	H		H
S2	M		M	H		H	M		M	M	X	H
S3	M		M	H	X	M	M		M	M		M
S4	L	X	M	M		M	M		M	M		M
S5	L		L	M		M	L	X	M	M		M
R2S1	M		M	H		H	H	X	M	H		H
S2	H		H	M		M	M		M	H		H
S3	H	X	M	M		M	M		M	M		M
S4	H	X	M	L		L	M		M	M		M
R3S1	H	X	M	H	X	M	M	X	H	H		H
S2	M		M	H	X	M	H		H	H		H
S3	M		M	M		M	H		H	M		M
R4S1	M		M	M		M	H		H	H		H
S2	H		H	M		M	H	X	M	M		M
R5S1	M	X	L	M		M	M		M	M		M
T2R1S1	M		M	M		M	H		H	H		H
S2	L		L	M	X	H	M		M	M		M
S3	L		L	L	X	M	M	X	L	M		M
S4	L		L	L	X	M	L		L	L		L
R2S1	M		M	H	X	M	M		M	M		M
S2	H		H	H		H	H		H	M		M
S3	L		L	L		L	L	X	M	L		L
R3S1	H		H	M		M	L		L	M	X	H
S2	H	X	M	M		M	M		M	M		M
R4S1	M		M	M		M	M		M	L	X	M
T3R1S1	M		M	M	X	H	L		L	M		M
S2	M	X	H	M		M	L	X	M	M		M
S3	L		L	L		L	L		L	L		L
R2S1	H		H	H		H	L	X	M	M		M
S2	M		M	L		L	L	X	M	L		L
R3S1	H		H	M		M	L	X	M	L		L
T4R1S1	M	X	L	L		L	M		M	L	X	M
S2	L		L	L		L	L		L	L		L
R2S1	H	X	M	L		L	M		M	L		L
T5R1S1	H		H	L		L	L		L	L		L

solution conditions. For the same reason, the detailed values need not be considered, attention being confined to the group designations only, for both dry yield and green weight. Table 12 shows the group designations (high, medium, or low) for dry yield and green weight of tops, for each set of salt proportions and for each of the four different total concentrations. In this table each series has a double column, the first for the dry yield and the second for the green weights. Where the group designations are different in the two cases the letter X is placed in the space between the two values; this brings out the frequency of discrepancies and shows for what sets of salt proportions and total concentrations they occur.

Inspection of Table 12 leads to the impression that dry yield and green weight are generally in agreement as far as placing the various culture solutions in the low, medium, or high group is concerned. Out of one hundred forty comparisons between the indications given by these two criteria only thirty-one, or 22 per cent of the total number, fail to show agreement. This means that the two criteria agree in 78 per cent of the cases; and, since these cases of agreement represent the whole range of environmental complexes here studied, it may be concluded that the two criteria are generally both influenced in about the same way, by total concentration, salt proportions, and nonsolution conditions. It should be emphasized that this conclusion is to be regarded as holding only for the plants and environments dealt with in these experiments; such a generalization is not warranted for the whole plant kingdom or for other solution types, etc. It may or may not hold for these other conditional complexes, for other plants (or for lowland rice plants in later developmental stages), etc.

With this warning as to the danger of attempting to generalize beyond the limits of the field actually investigated (a danger that seems not always to be appreciated fully in biological writing), attention may be turned more specifically to the cases that show disagreement in the indications of the two criteria here considered. In the first place, it may be inquired whether these discrepancies are any more or any less frequent with one total concentration than with another. Table 12 shows nine disagreements for the lowest total concentration, eight for the low-medium, ten for the high-medium and only four for the highest total concentration; it therefore appears that, with higher total concentrations than are well suited to the development of this plant with this type of solution, the agreement between dry yield and green weight of tops may be expected to be better than occurs for what may be termed the optimal range of total concentration. The three less concentrated series nearly agree with one another in this regard, but the series with highest concentration shows less than half the number of discrepancies that any one of the other three shows. This fact may or may not be important; of course it is to be understood that, if the total concentration were made high enough to injure the plants seriously, each of the various dry yields must approach the

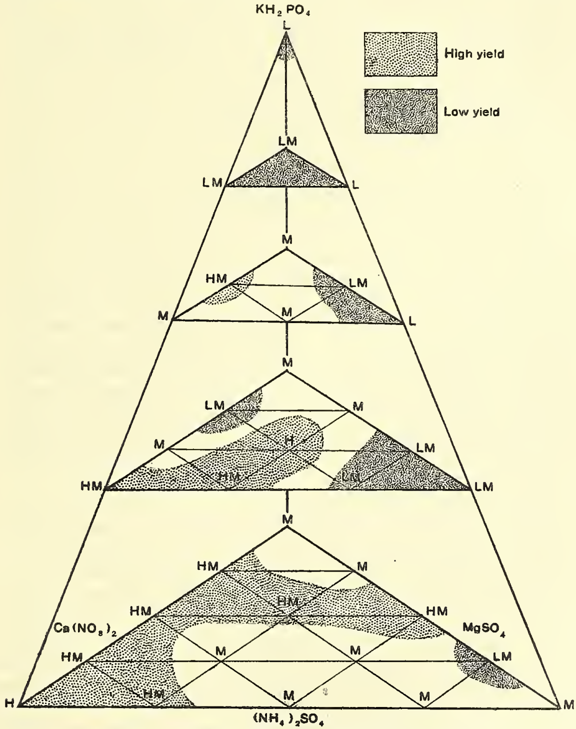

FIG. 8. Distribution of low, medium and high green-weight values for series 16 and 19 combined.

corresponding green weight, as both approached the zero value where all growth was inhibited.

Turning next to the relation between the discrepancies shown in Table 12 and the various sets of salt proportions, it may be remarked that there are just three cases in which a discrepancy is recorded for two or more total concentrations of the same set of salt proportions. One of these cases refers to solution T1R3S1, for which disagreement between the two criteria is shown for the lowest three total concentrations, but not for the highest. The second case refers to solution T2R1S3, for which disagreement is recorded for the two medium total concentrations. The third case refers to solution T4R1S1, for which there is disagreement for the lowest and for the highest total concentration. Altogether, it appears that there is no evident relation between salt proportions, which supports the generalization stated on page 508, to the effect that these two criteria generally agree in their indications, and that (for the present study) one is to be regarded as about equivalent to the other.

Considering only the two medium total concentrations, the distribution of the low, medium, and high values of the green weight of tops, with reference to salt proportions, may be brought out diagrammatically as in the case of the dry yields. This is done by fig. 8, which is constructed in a manner similar to that followed for figs. 4 to 7. The letter designations shown for green weight and for the two medium total concentrations (series 16 and 19) in Table 12 have been placed on the tetrahedral diagram (HL being replaced by M, as for the dry-yield diagrams) and the high and low areas have been demarked and distinguished by shading. For this particular diagram the HM-points are included in the high regions, and the LM-points are included in the low regions.

From this diagram it appears at once that this sort of summary of the green-weight data leads to the same general conclusions as were reached from the study of the dry-yield data. It appears that the most promising set of salt proportions on this basis is T1R1S1, and the least promising ones are T2R1S4, T3R1S3, T4R1S2, and T5R1S1 (the top apex). It seems safe, however, to allow the general conclusions derived from dry yields to stand as they are, and merely to remark that the points there emphasized are supported and substantiated by the indications derived from green weight of tops.

It is clear from what precedes that the thirty-five sets of salt proportions and the four total concentrations here dealt with did not differ significantly in their influence upon the ability of the plant tops to retain water. Calculating the water content as percentage of the corresponding green-weight value the result shows that the total range of these values is only from 79 to 87.5 per cent, and most of the values lie between 83 and 86. It may be said that these tops were sensibly equally succulent for all cultures, irrespective of the total concentration or of the salt proportions. It is also clear that these tops were uniformly re-

TABLE 13.—*Water absorption (cubic centimeters per six plants) during the culture period, for series 14, 16, 19, and 20, beginning June 19.*

Solution No.	Total concentration 0.0008 gram-molecule per liter, or 0.04 atmosphere (series 14).	Total concentration 0.0016 gram-molecule per liter, or 0.08 atmosphere (series 16).	Total concentration 0.0038 gram-molecule per liter, or 0.2 atmosphere (series 19).	Total concentration 0.0077 gram-molecule per liter, or 0.4 atmosphere (series 20).
	cc.	*cc.*	*cc.*	*cc.*
T1R1S1	188	H 228	H 197	H 168
S2	185	H 196	168	H 154
S3	185	188	165	137
S4	174	187	157	127
S5	155 L	163 L	142 L	124
R2S1	190	H 205	H 177	143
S2	H 206	188	164	H 163
S3	H 194	183	170	134
S4	H 198	162 L	160	129
R3S1	192	190	173	H 176
S2	H 204	189	H 184	H 155
S3	H 206	170	H 191	134
R4S1	192	187	H 204	H 163
S2	H 206	178	H 180	H 150
R5S1	169 L	183	154	136
T2R1S1	181	189	H 184	142
S2	145 L	190	155	139
S3	153 L	166	170	131
S4	146 L	161 L	120 L	123
R2S1	167 L	H 191	173	128
S2	H 199	H 217	H 194	142
S3	160 L	143 L	142 L	123
R3S1	H 201	174	153	H 145
S2	186	183	158	138
R4S1	175	176	169	113 L
T3R1S1	176	H 193	138 L	134
S2	181	166	146	136
S3	160 L	162 L	128 L	91 L
R2S1	H 194	H 194	152	135
S2	176	153 L	144 L	120 L
R3S1	H 210	190	150	119 L
T4R1S1	173	150 L	161	115 L
S2	153 L	145 L	108 L	109 L
R2S1	191	162 L	154	105 L
T5R1S1	H 199	167	126 L	109 L

latively very dry, as compared with active plant tissues in general, and that the drying of leaf tips that occurred in many of the poorer cultures was without marked effect upon the percentage of water content.

In considering the green weight as a criterion for comparing the physiological efficiency of different cultures, etc., it should be remembered that there is probably a more or less pronounced daily fluctuation in the water content of leaves and small stems, as has been emphasized by Livingston and Brown,[30] by Renner,[31] by Edith B. Shreve,[32] by Yuncher,[33] and by others.

Water absorption.—The four simultaneous series carried out in the period beginning June 19 (series 14, 16, 19, and 20) also furnished comparative data on water absorption, which are presented in Table 13. These values are the amounts of water, in cubic centimeters, absorbed during the entire culture period.

Considering the very small amount of water retained by the plants (see the green weights and dry yields of tops), the absorption values clearly represent the amounts of water transpired, which, as Livingston [34] has shown, may be generally considered as an approximate index of the leaf area, at least for young wheat plants. In studies like the present one the use of the total amount of water transpired during the growth period, as a criterion for comparing the plants of different cultures, seems to have been inaugurated by Whitney and Cameron,[35] and it has been continued by Livingston, Britton, and Reid,[36] and by many other later workers. It appears that Shive (1915) was the first, at least among those who have been engaged in the recent systematic study of salt relations by the method of solution cultures, to employ water absorption instead of transpirational water loss. Since this gives another quantitative criterion by which plants

[30] Livingston, B. E., and Brown, W. H., Relation of the daily march of transpiration to variation in water content of leaves, Bot. Gaz. **53** (1912) 309–330.

[31] Renner, O., Beiträge zur Physik der Transpiration, Flora **100** (1910) 451–547.

[32] Shreve, Edith B., The daily march of transpiration in a desert perennial, Pub. Carnegie Inst. Washington (1914) No. **149**.

[33] Yuncher, T. G., A study of the relation of soil moisture to transpiration and photosynthesis in the corn plant, Plant World **19** (1916) 151–161.

[34] Livingston, B. E., Relation of transpiration to growth in wheat, Bot. Gaz. **40** (1905) 178–195.

[35] Whitney, M., and Cameron, F. K., Investigation in soil fertility, Bull. U. S. Dept. Agr., Bur. Soils **23** (1904).

[36] Livingston, B. E., Britton, J. C., and Reid, F. R., Studies on the properties of an unproductive soil, Bull. U. S. Dept. Agr., Bur. Soils **28** (1905) 39.

may be compared, and especially since the amount of water absorption is much more easily determined for solution cultures than is any other quantitative plant value, it seemed desirable to make these water-absorption determinations in the present study.

The data in Table 13 show that the highest values are not generally found for the two medium total concentrations as was the case for dry yield and green weight. It is commonly understood that, except in special cases, the lower the total concentration the higher the rates of water absorption and transpiration, providing that the plants to be compared are all fairly healthy, and that all have been exposed to the same set of non-solution conditions. In spite of this consideration, however, the very highest water-absorption values for the one hundred forty simultaneous cultures here dealt with are for the low-medium total concentration (solutions T1R1S1 and T2R2S2). The highest total concentration here considered generally gives values lower than the corresponding ones of the other three total concentrations. Without trying to determine which one of the solutions may be expected to show the highest absorption rates, we may turn to the two medium total concentrations and make a comparison between their group designations (H and L) and those obtained from these two total concentrations in terms of dry yield and green weight of tops.

Such a comparison may be instituted by means of Table 14, which is a reproduction of Table 12 with the water-absorption designations added as a third column for each series. The method followed is the same as was used for Table 12, and the notation is the same throughout.

Examination of Table 14 shows that the group designations for water absorption generally agree with those for green weight, and in the majority of cases agreement is perfect for all three criteria. In each of these four series there are from five to eight discrepancies between the evidence from green weight and that from water absorption, but there seems to be no relation between the number of discrepancies and the total concentration, unless such evidence may be suggested by the fact that series 16 (with the low-medium concentration) shows only five disagreements of this kind, while series 14 and 20 show seven each, and series 19 shows eight. It may be concluded immediately that water absorption is apparently just as satisfactory in discriminating between the different cultures of any series as is either dry yield or green weight. All three criteria appear to be about equally valuable.

TABLE 14.—*Comparison between dry and green weight of tops and water absorption, as to the indications from the four simultaneous series (14, 16, 19, and 20), beginning June 19.*

Solution No.	Lowest total concentration (series 14).			Low-medium total concentration (series 16).			High-medium total concentration (series 19).			Highest total concentration (series 20).		
	Dry yield.	*Green wt.*	*Abs.*	*Dry yield.*	*Green wt.*	*Abs.*	*Dry yield.*	*Green wt.*	*Abs.*	*Dry yield.*	*Green wt.*	*Abs.*
T1R1S1	M	M	M	H	H	H	H	H	H	H	H	H
S2	M	M	M	H	H	H	M	M	M	M X	H	H
S3	M	M	M	H X	M	M	M	M	M	M	M	M
S4	L X	M	M	M	M	M	M	M	M	M	M	M
S5	L	L	L	M	M X	L	L X	M	X L	M	M	M
R2S1	M	M	M	H	H	H	H X	M X	H	H	H X	M
S2	H	H	H	M	M	M	M	M	M	H	H	H
S3	H X	M X	H	M	M	M	M	M	M	M	M	M
S4	H X	M X	H	L	L	L	M	M	M	M	M	M
R3S1	H X	M	M	H X	M	M	M X	H X	M	H	H	H
S2	M	M X	H	H X	M	M	H	H	H	H	H	H
S3	M	M X	H	M	M	M	H	H	H	M	M	M
R4S1	M	M	M	M	M	M	H	H	H	H	H	H
S2	H	H	H	M	M	M	H X	M X	H	M	M X	H
R5S1	M X	L	L	M	M	M	M	M	M	M	M	M
T2R1S1	M	M	M	M	M	M	H	H	H	H	H X	M
S2	L	L	L	M X	H X	M	M	M	M	M	M	M
S3	L	L	L	L X	M	M	M X	L X	M	M	M	M
S4	L	L	L	L X	M X	L	L	L	L	L	L X	M
R2S1	M	M X	L	H X	M X	H	M	M	M	M	M	M
S2	H	H	H	H	H	H	H	H	H	M	M	M
S3	L	L	L	L	L	L	L X	M X	L	L	L X	M
R3S1	H	H	H	M	M	M	L	L X	M	M X	H	H
S2	H X	M	M	M	M	M	M	M	M	M	M	M
R4S1	M	M	M	M	M	M	M	M	M	L X	M X	L
T3R1S1	M	M	M	M X	H	H	L	L	L	M	M	M
S2	M X	H X	M	M	M	M	L X	M	M	M	M	M
S3	L	L	L	L	L	L	L	L	L	L	L	L
R2S1	H	H	H	H	H	H	L X	M	M	M	M	M
S2	M	M	M	L	L	L	L X	M X	L	L	L	L
R3S1	H	H	H	M	M	M	L X	M	M	L	L	L
T4R1S1	M X	L X	M	L	L	L	M	M	M	L X	M X	L
S2	L	L	L	L	L	L	L	L	L	L	L	L
R2S1	H X	M	M	L	L	L	M	M	M	L	L	L
T5R1S1	H	H	H	L	L X	M	L	L	L	L	L	L

Looking further into this matter of disagreements between the indications of green weight and those of water absorption, it is seen that where this kind of discrepancy occurs along with a disagreement between the indications of dry yield and those of green weight, the three designations (L, M, and H) never occur together; there are always two like designations and one different one. A similar statement holds for the entire series of disagreements shown in Table 14; wherever a discrepancy occurs it is between two contiguous groups, H and M, or M and L. These considerations constitute still further evidence in favor of the conclusion that all these plant criteria are about the same in their indications as to the relative physiological values of the various sets of salt proportions.

As in previous cases, it is instructive to place the water-absorption designations for the two medium total concentrations on the tetrahedral diagram and then indicate the regions of high and low values. Such a diagram is shown in fig. 9, which is markedly like the diagrams, figs. 4 to 8. The experi-

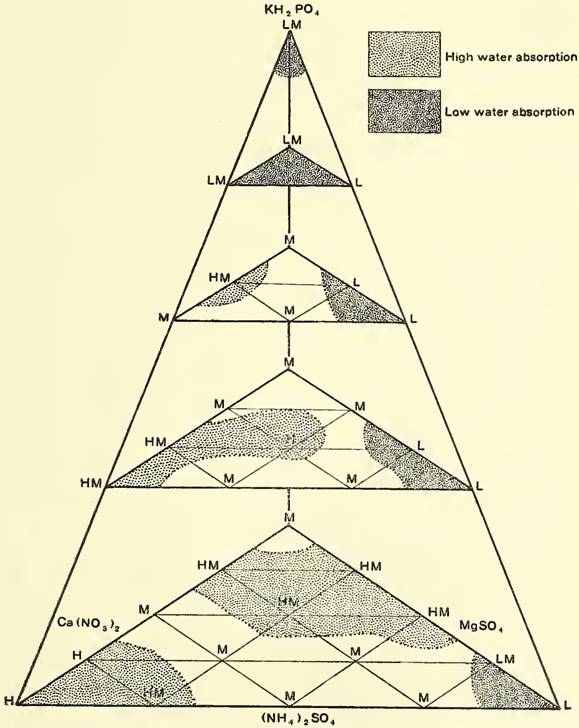

FIG. 9. Distribution of low, medium and high water-absorption values for series 16 and 19.

mental data are so limited that detailed discussion of the differences is not warranted. It is clear, from the yield data, that the three sets of salt proportions selected as most generally promising are shown as most promising by the water-absorption data, as well as by the data for green weight. Also the two sets of salt proportions selected to represent badly balanced cultures are shown as belonging to the low group in fig. 9.

FOUR-SALT TYPE B (MONOPOTASSIUM PHOSPHATE, MONOCALCIUM PHOSPHATE, MAGNESIUM SULPHATE, AMMONIUM SULPHATE)

As has been mentioned, the tests with the four-salt solution type B were carried out to determine whether the nitrate ion in the solutions of type A might be unnecessary, or even harmful. The lowest section of Table 3 shows the six experimental series that were carried out with this type of solution, three total concentrations (0.0008, 0.0016, and 0.0038 gram-molecule per liter, or 0.04, 0.08, and 0.2 atmosphere) being simultaneously employed for the period beginning August 3 (series 23, 25, and 27), and again for that beginning September 9 (series 24, 26, and 28).

The better cultures of each series showed very satisfactory growth, excepting that the plants were always markedly affected in the latter part of the three-week period by a characteristic drying of the leaves backward from the tips. This was so pronounced and so characteristic of these type B solutions that it must be regarded as a serious form of physiological injury. The dry yields of tops and of roots gave values not markedly lower than the corresponding ones obtained with solution type A, but the presence of the injury just mentioned made it impossible to regard even the best sets of salt proportions of type B as in any way approaching physiological equality with the best ones of type A. For this reason the data of series 23 to 28 will not be presented in the present paper. It may be noted further, however, that the highest total concentration here used (corresponding to the high-medium of solution type A) proved to be too high for the best growth, and that the lowest one here used seemed to be somewhat too low. The most promising solutions of this type had what was termed in the preceding discussions the low-medium total concentration (0.0016 gram-molecule per liter, or 0.08 atmosphere). It will be recalled that this total concentration seemed to be somewhat more promising than the others for type A. For type B, however, emphasis appears to be placed on the lowest and the low-medium total concentration rather than on the low-medium and the high-medium.

On account of the pronounced leaf injury present even in the best cultures of solution type B, it is concluded that this type is not at all well suited to the growth of these young rice plants, at least under the non-solution conditions here dealt with. A direct and simultaneous comparison between some of the best sets of salt proportions for type B with some of the best ones for type A will be considered in the following section of this paper.

It should be remembered that 4-salt solution type B represents only one of many possible ways by which the ions potassium, calcium, magnesium, ammonium, phosphate, and sulphate might be brought together in solutions, without any nitrate, and the failure of any of these sets of salt proportions to give satisfactory growth in the plants here used is not to be regarded as definite proof that young rice plants actually require the nitrate ion. All that may be said is that these plantlets grew excellently well with certain sets of salt proportions of the 4-salt solution type with both ammonium and nitrate, while no set of proportions tried with ammonium but without nitrate gave passable development, on account of the generally present leaf injury.

FINAL COMPARISON BETWEEN THE THREE DIFFERENT SOLUTION TYPES

After the experiments whose results have thus far been considered had been completed and after the data given by them had been studied to some extent, but before the method of basing conclusions on agreement in group designations had been hit upon, the apparently best three sets of salt proportions were selected from each of the three solution types, for each of the lowest two total concentrations, and these were employed in a set for simultaneous test. In this lot there were thus six solutions of 4-salt type A, six of 4-salt type B, and three of 3-salt type I (increments of one-seventh). To these were added two different total concentrations of Shive's best solution for young wheat plants (3-salt type I, osmotic proportions, increments of one-tenth). Four like cultures, of 6 plants each, were employed in each case. The methods and treatment were the same as for the preceding larger series, and the culture period was from March 13 to April 3, 1919. The solution characteristics and the dry-yield data for tops, roots, and entire plants (each representing 6 plants but each derived as an average from four like cultures of 6 plants each) are presented in Table 15. The numerical data are all expressed in terms of the corresponding yield value for solution AT1R2S1 (0.0016 gram-molecule per liter, or 0.08 atmosphere), taken as unity, the actual value for this solution being given in parentheses beneath the value 1.00.

TABLE 15.—*Relative yields of tops, roots, and entire plants for selected solutions of 4-salt type A, 4-salt type B, and 3-salt type I, final comparative series.*

[Data are for six plants, being averages from four cultures of six plants each.]

Solution No.	Total concentration.		Dry yield.		
	Gram-molecule per liter.	Atmosphere.	Tops.	Roots.	Entire plants.
AT1R2S1	0.0016	0.08	[a]1.00 (0.169 g.)	[a]1.00 (0.079 g.)	[a]1.00 (0.996 g.)
AT1R2S2	0.0008	0.04	0.94	1.05	0.98
AT2R3S1	0.0008	0.04	0.93	0.94	0.98
AT3R3S1	0.0008	0.04	0.83	1.00	0.88
AT2R1S1	0.0016	0.08	0.81	1.02	0.88
AT2R2S2	0.0016	0.08	0.72	0.94	0.79
BT2R1S1	0.0016	0.08	0.97	1.02	0.99
BT1R2S1	0.0008	0.04	0.87	1.04	0.98
BT2R1S2	0.0016	0.08	0.85	1.03	0.91
BT1R2S2	0.0008	0.04	0.84	1.02	0.90
BT3R1S1	0.0016	0.08	0.81	1.00	0.87
BT3R2S1	0.0008	0.04	0.84	1.04	0.87
IR2S1[b]	0.0022	0.10	0.44	0.89	0.59
IR3S1[b]	0.0022	0.10	0.40	0.90	0.57
IR4S1[b]	0.0022	0.10	0.40	0.87	0.55
IR5S2[c]	0.0022	0.10	0.44	0.94	0.60
IR5S2[c]	0.0382	1.75	0.47	0.92	0.62

[a] All values are expressed in terms of the corresponding one for solution AT1R2S1 and the actual value for this solution is given in parentheses beneath the relative value 1.00.

[b] Increment one-seventh.

[c] Increment of one-tenth osmotic proportions.

Although the data in Table 15 are derived from twenty-four plants grown simultaneously in four cultures of six plants each, as has been stated, and although it may be assumed that the aërial complex of conditions was practically the same for all, yet it seems necessary to disregard all minor differences brought out in the table. With this consideration in view, we may allow a plus or minus variation of 0.05 as negligible, so that 0.95 in the table becomes equivalent to all values from 0.95 to 1.05, inclusive. In other words, the values from 0.95 to 1.05 may be considered as practically alike, all lying within the best group. On the basis of this agreement it is seen that just two solutions agree in belonging to the best group for all three criteria (yields of tops, roots, and entire plants), and that these two solutions are AT1R2S1 and BT2R1S1. It must be remarked, however, that the second of these solutions, and all of the B type in this series, produced the characteristic form of leaf injury noted above, so that this solution is not to be regarded as nearly so well balanced as is AT1R2S1. The last-named solution is undoubtedly the most promising of the present series, and it is the only one of the three previously selected as representing good physiological balance, that was included in the present series. The data of Table 15 therefore support the conclusion reached from the more thorough study of type A; namely, that T1R1S1, T1R2S1, and T2R1S1 are to be regarded as about equal and as very well balanced for these plants. This conclusion is especially strengthened by the fact that the solutions tested in the present series were selected because they showed high values in earlier tests, but before the analysis by agreements and disagreements had been completed. It is unfortunate that solutions AT1R1S1 and AT1R1S2 were not included in the final series.

It is of interest to emphasize that solution type B is shown to be capable of giving yield values of the best group, in spite of the fact that these solutions always produced marked leaf injury.

With regard to the 3-salt solutions of the final series, Table 15 shows that the representative of this type gave entire plant yields of 0.62 or below, and top yields of 0.47 or below, while their root yields approach very nearly to being included in the best group, their values being from 0.87 to 0.94. It may be suggested that the best sets of salt proportions of the 3-salt type I series of solutions, with the two low total concentrations as well as with the single higher one found to be nearly optimal for wheat plantlets (Shive), are very well balanced for the production of dry root yields, although they are very badly balanced according to the criteria of top yields or entire plants. This suggestion may possibly be of importance at some later time when the relations between the physiology of roots and that of tops is better understood and attracts more attention than is now the case.

It is obvious enough from Table 15 that none of these best 3-salt solutions is at all well suited for young rice plants; they all belong in the poor group of this series, on the basis of yields both of tops and of whole plants. This result of the final series supports that reached on the basis of appearance of the plants, as stated in an earlier section of this paper.

The last two solutions shown in Table 15 deserve special attention. These have the salt proportions of Shive's best solution for young wheat plants (IR5S2); they are based on the scheme of osmotic (instead of molecular) proportions and on the triangular diagram with increments of one-tenth (instead of one-seventh, as in the case of the other 3-salt solutions here considered). It is a noteworthy fact that, although these rice plantlets have shown themselves very sensitive to total concentration for the well-balanced solutions (best ones of types A and B), yet the yield values shown in Table 15 are practically the same for both total concentrations here included. This set of salt proportions is badly balanced for young rice plants but it gives equally good yields whether the total concentration has an osmotic value of 0.1 or of 1.75 atmospheres. This equality was not shown, however, by the appearance of the plants; those with more concentrated solution were much more stunted than those with the weaker one (see Plate 1).

As to general appearance, all the plants with solution type A looked about alike; the differences brought out by the dry yields were not apparent. Also, the plants with solution type B were like those with type A in appearance, excepting for the leaf injury characteristic of the former group. On the other hand, the plants with 3-salt solution type I were all obviously much stunted and the leaves were yellowish rather than of the deep green color found in the case of types A and B in this series. Comparison of the two Shive solutions (0.1 and 1.75 atmospheres) shows that the one with the higher concentration exhibited much smaller and more stunted plants than did the other, in spite of the similar dry-yield values from these two solutions, as has been remarked. An idea of the general appearance of these plants may be gained from the photographs given in Plate 1, which requires no further description than that given by its legend.

To summarize, this final comparative series still further emphasizes and supports the conclusions reached before; namely, that 3-salt solution type I (with nitrate but without ammonium) offers no promise, with any possible set of salt proportions, for good growth of lowland rice plants; that 4-salt solution type A (with both ammonium and nitrate) gives excellent growth of these plants with salt proportions about like those of solution T1R1S1, and with total concentrations between 0.0008 and 0.0016 gram-molecule per liter (0.04 and 0.08 atmosphere); and that 4-salt solution type B (with ammonium but without nitrate) may give excellent dry yields with properly selected sets of salt proportions (as T2R1S1), but is nevertheless badly balanced for the successful growth of rice plants on account of leaf injury.

SUMMARY

The studies here reported deal with the mineral nutrition of lowland rice plants in solution cultures, for the phase of their development represented by the three-week period following germination. They involve experimental data on the growth of the plants in three different types of solutions: 3-salt solution type I comprising, besides a trace of ferric phosphate, the three salts monopotassium phosphate, calcium nitrate, and magnesium sulphate; 4-salt solution type A comprising, besides a trace of ferric phosphate, the three salts just mentioned together with ammonium sulphate; and 4-salt solution type B comprising, besides a trace of ferric phosphate, the four salts monopotassium phosphate, monocalcium phosphate, magnesium sulphate, and ammonium sulphate. Each type was studied with reference to a large number of different sets of salt proportions and several different total salt concentrations. The experiments were carried out in the spring and summer in a greenhouse in Baltimore, and the results are to be considered as applicable to the climatic conditions prevailing there.

For each solution type the various sets of salt proportions were arranged on the basis of molecular proportions, instead of on osmotic proportions, as was done in several previous studies dealing with salt proportions and physiological balance in nutrient media. With this improvement in the method of planning and preparing the numerous solutions to be tested it is possible to make up a single, somewhat highly concentrated stock solution for any given set of molecular salt proportions and, by simple dilution of portions of this stock solution, to obtain solutions with the same set of salt proportions but with lower concentrations.

The following are the main generalizations derived from the experimental data:

1. No set of salt proportions of 3-salt type I gave even fair growth.

2. Excellent growth was obtained with proper sets of salt proportions of 4-salt solution type A. This suggests that these plants require the ammonium ion, thus apparently differing from many other plant forms.

3. It appears highly improbable that young rice plants could thrive with any 3-salt type of solution; there is no doubt that rice requires the kations potassium, calcium, and magnesium (as well as a little ferrum) like other plants, and the ammonium-ion cannot be introduced into a 3-salt solution without its being the

kation of one of the three salts used, which means that its introduction can be accomplished (in a 3-salt solution) only by omitting either potassium, calcium, or magnesium.

4. With 3-salt solution type I the nearest approach toward good growth was obtained. With solutions in which not more than one-eighth of the molecular total is due to calcium nitrate, the proportions of the other two salts seem to have been without influence in determining which sets of salt proportions were least badly balanced.

5. The best sets of salt proportions of 4-salt solution type A gave the most satisfactory growth that was obtained.

6. The best solutions of type B gave about as good growth as did the best ones of type A, by the criteria of size, yield, and water-absorption; but even these best solutions of type B always produced a marked and characteristic leaf injury, so that no solution of this type is to be regarded as at all suited to the growth of these plants. This suggests that these young rice plants require (at least within the range of these experiments) not only the ammonium ion but also the nitrate ion.

7. The best solution for these plants is one that has a total concentration of 0.0016 or 0.0038 gram-molecule per liter (of all salts taken together), or an osmotic value of about 0.08 or about 0.2 atmosphere. It may be said that the most promising total concentration for these plants lies between these limits, probably nearer the lower one. The best total concentration for young rice plants is thus very much lower than that for any other form of plant hitherto studied by these general methods. (Wheat thrives best with a total concentration represented by an osmotic value of between 1.5 and 2.5 atmospheres.)

8. For the range of total concentration just mentioned (0.08 to 0.2 atmosphere) the best solutions (4-salt type A) are characterized by having very high relative molecular partial concentrations of magnesium sulphate. They generally have comparatively low relative molecular partial concentrations of monopotassium phosphate and calcium nitrate. The most promising solution for these plants may be stated as having about 0.002 gram-molecule per liter (of all salts), the salts being present in about the following molecular proportions:

$$KH_2PO_4 : (NH_4)_2SO_4 : Ca(NO_3)_2 : MgSO_4 = 1 : 1\tfrac{1}{2} : 1\tfrac{1}{2} : 4.$$

It is safe to say that one very excellent solution would have the potassium, ammonium, and calcium salts in about the same proportions, while the molecular partial concentration of the magnesium salt should be four or five times as great as that of any one of the others. The tolerance of these plants for magnesium sulphate is especially remarkable.

9. The results of these experiments led to the conclusion that good growth of tops was generally accompanied by good growth of roots, a feature with regard to which these plants seem to differ from wheat.

10. Dry yield of tops, dry yield of roots, green weight of tops, and the amount of water absorbed during the three-week period, all appear to furnish valuable criteria for comparing growth in these different solutions, and all four criteria are in good general agreement.

ILLUSTRATIONS

Plate 1

TEXT FIGURES

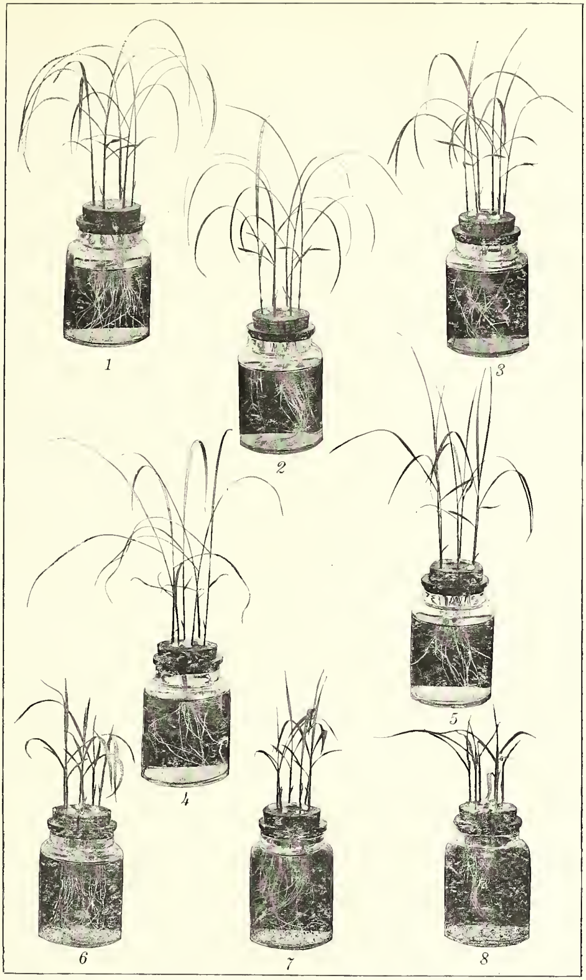

PLATE 1. REPRESENTATIVE CULTURES OF THE FINAL COMPARATIVE SERIES, AT THE END OF THE CULTURE PERIOD.

HIGHER BASIDIOMYCETES FROM THE PHILIPPINES AND THEIR HOSTS, III

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The following list is a continuation of determinations of Philippine wood-destroying fungi collected on Mount Maquiling, in the vicinity of Los Baños, Laguna Province, Luzon, in Mindanao, and in Sulu as indicated in the text. The collections have been made either by me, or by my students under my direction. All identifications as herein given were made by N. Patouillard, of Neuilly-sur-Seine, France.

The species are grouped, in so far as is possible, according to the classification of Engler and Prantl, with the host and the collector under each species of fungus. The numbers refer to the College of Agriculture fungus herbarium.

AURICULARIACEAE

AURICULARIA Bulliard

AURICULARIA MESENTERICA (Dicks.) Fr.

Mount Maquiling, *Collado 129,* on decaying log.

AURICULARIA POLYTRICHA (Mont.) Sacc. (*A. purpurascens* Jungh.).

Bambusa, Jolo, *Reinking 2429,* on dead stem.

Columbia serratifolia (Cav.) DC., Mount Maquiling, *Reinking 2621,* on dead wood.

Ficus benjamina Linn., Mount Maquiling, *Divinagracia 2474,* on dead wood.

Gliricidia sepium (Jack.) Steud., Mount Maquiling, *Reinking 2619,* on dead wood.

Theobroma cacao Linn., Mount Maquiling, *Marajas 1521,* on dead branches.

AURICULARIA RUGOSISSIMA Lév.

Mindanao, Davao, Pantucan, *Reinking 2434,* on dead wood.

AURICULARIA TENUIS Lév.

Bambusa, Jolo, *Reinking 2430,* on dead stem.

Zea mays Linn., Los Baños, *Reinking 1918,* on dead leaves.

TREMELLACEAE

HETEROCHAETE Patouillard

HETEROCHAETE TENUICULA (Lév.) Pat.

Citrus, Davao, *Reinking 2291*, on dead twigs.

TREMELLA Dillenius

TREMELLA.

Mount Maquiling, *Santos 2496*, on dead wood.

THELEPHORACEAE

STEREUM Persoon

STEREUM AFFINE Lév.

Mount Maquiling, *Collado 1852*, on decaying wood.

STEREUM HIRSUTUM Fr.

Parkia javanica (Lam.) Merr. (*Parkia roxburghii* G. Don), Mount Maquiling, *Leaño 1014*, on dead wood.

STEREUM INVOLUTUM Kl.

Mount Maquiling, *Collado 1381*, on dead wood.

STEREUM LOBATUM (Kze.) Fr.

Ficus religiosa Linn., Mount Maquiling, *Pañganiban 311*, on dead wood.

Ficus, Mount Maquiling, *Collado 1363*, on dead wood.

STEREUM LOBATUM K. var. CONCOLOR Pat.

Mount Maquiling, *Collado 150, 1467*, on decaying wood.

CLAVARIACEAE

PHYSALACRIA Peck

PHYSALACRIA ORINOCENSIS Pat. et Gaett. (*Physalacria langlosii* Ellis).

Psidium guajava Linn., Mount Maquiling, *Lontoc 1022*, on dead wood.

POLYPORACEAE

FOMES Fries

FOMES APPLANATUS Pers.

Citrus, Mount Maquiling, *Pañganiban 2351*, on dead branches.

Parashorea plicata Brandis, Mount Maquiling, *Daproza 460*, on dead wood.

FOMES CALIGNOSUS Berk.

Ficus Mount Maquiling, *Collado 2347*, on dead wood.

FOMES FASTUOSUS Lév.

Parashorea plicata Brandis, Mount Maquiling, *Catalan 2350*, on dead wood.

FOMES PULLUS Mont.

Croton, Mount Maquiling, *Collado 1428*, on dead wood.

Tabernaemontana pandacaqui Poir, Mount Maquiling, *Collado 1835*, on living stem.

GANODERMA Karsten

GANODERMA APPLANATUM Pers.

Parashorea plicata Brandis, Mount Maquiling, *Daproza 460*, on dead wood.

GANODERMA AUSTRALE (Fr.) Pat.

Citrus, Mount Maquiling, *Pañganiban 2351*, on dead wood.

GANODERMA LUCIDUM (Leyn.) var BAMBUSAE Pat.[1]

Bambusa spinosa Roxb. (*Bambusa blumeana* Schultes), Mount Maquiling, *Reyes 2514*, *Nantes 522*, *Pañganiban 968*, on dead stem.

Bambusa vulgaris Schrad. var. *striata* (Lodd.) Gamble, Mount Maquiling, *Marquez 307*, on dead stem.

POLYPORUS Micheli

POLYPORUS ADUSTUS Fr.

Mount Maquiling, *Baybay 2527*, on dead wood.

POLYPORUS AFFINIS Nees.

Quercus sp., Mount Maquiling, *Collado 1364*, on dead wood.

POLYPORUS ANEBUS Berk. (*vulneratus* Lév. = *sanguinarius*, etc.).

Ficus benjamina Linn., Mount Maquiling, *Nantes 1015*, on dead wood.

Ficus religiosa Linn., Mount Maquiling, *Divinagracia 919*, on dead wood.

POLYPORUS BADIUS Jungh. (*Polyporus vinosus* Berk.).

Nauclea, Mount Maquiling, *Collado 114*, on decaying wood.

POLYPORUS BICOLOR Jungh.

Mount Maquiling, *Baybay 964*, *Pañganiban 747*, on dead wood.

[1] *Ganoderma lucidum* Leyn. var. *bambusae* Pat., *2514*, *968*, *522*, *307* are forms found especially on bamboo; they are characterized by a slender stipe and a smaller pileus.

POLYPORUS DICHROUS Fr.

Eugenia calubcob C. B. Rob., Mount Maquiling, *Collado 1873*, on dead wood.

Leucaena glauca (Linn.) Benth., Mount Maquiling, *Collado 1880*, on dead wood.

Parashorea plicata Brandis, Mount Maquiling, *Collado 1484*, on dead wood.

Polyalthia, Mount Maquiling, *Collado 1477*, on dead wood.

POLYPORUS GALLOPAVONIS Berk.

Aporosa sphaeridophora Merr., Mount Maquiling, *Collado 1375*, on dead wood.

Ficus, Mount Maquiling, *Collado 1449*, on dead wood.

POLYPORUS GRAMMOCEPHALUS Berk.

Mount Maquiling, *Collado 1345, 1491, Reyes 2552*, on dead wood.

POLYPORUS HEMICAPNODES Berk.

Mount Maquiling, *Nantes 2537*, on dead wood.

POLYPORUS HIRSUTUS Pers.

Castilloa elastica Cerv., Isabela, Basilan, *Reinking 2082*, on dead log.

Celtis, Mount Maquiling, *Collado 77*, on dead wood.

Cordia myxa Linn., Mount Maquiling, *Collado 68*, on dead wood.

Croton tiglium Linn., Mount Maquiling, *Reinking 3084*, on dead wood.

Leucaena glauca (Linn.) Benth., Mount Maquiling, *Collado 1495*, on dead wood.

Macaranga tanarius (Linn.) Muell.-Arg., Mount Maquiling, *Santos 2448*, on dead wood.

Manihot glaziovii Muell.-Arg., Lanao Province, Saguiaran, *Reinking 2079*, on dead wood.

Mount Maquiling, *Collado 98*, on dead grass.

POLYPORUS LIGNOSUS Kl.

Erythrima indica Linn., Mount Maquiling, *Marquez 981*, on dead wood.

POLYPORUS MICROLOMA Lév.

Terminalia comintana (Blanco) Merr., Mount Maquiling, *Collado 1388*, on dead wood.

POLYPORUS OBTECTANS Berk.

Bambusa spinosa Roxb. (*Bambusa blumeana* Schultes), Mount Maquiling, *Reyes 1164,* on dead stem.

POLYPORUS POLYZONUS Pers.

Leucaena glauca (Linn.) Benth., Mount Maquiling, *Collado 1850,* on dead wood.

POLYPORUS RIGIDUS Lév.

Mount Maquiling, *Collado 157, 1487, 1799,* on dead wood.

POLYPORUS RUGULOSUS Lév.

Annona glabra Linn., Mount Maquiling, *Quisumbing 263,* on living trunk.

Areca catechu Linn., Mount Maquiling, *Pañganiban 2477,* on dead trunk.

Artocarpus, Mount Maquiling, *Pañganiban 387,* on living trunk.

Bambusa spinosa Roxb. (*Bambusa blumeana* Schultes), Mount Maquiling, *Cazeñas 1082, 2554,* on dead stem.

Bambusa spinosa Roxb. (*Bambusa blumeana* Schultes), Jolo, *Reinking 2147,* on dead stem.

Ficus benjamina Linn., Mount Maquiling, *Divinagracia 2472,* on dead wood.

Gliricidia sepium (Jack.) Steud., Mount Maquiling, *Nantes 974,* on dead wood.

"Malungay," Mount Maquiling, *Santos 414,* on dead wood. Mount Maquiling, *Collado 1890,* on soil.

POLYPORUS SANGUINEUS Fr.

Bambusa spinosa Roxb. (*Bambusa blumeana* Schultes), Mount Maquiling, *Pañganiban 344, 740, Baybay 2568,* on dead stems.

Livistona rotundifolia Mart., Mount Maquiling, *Collado 1895,* on dead parts.

POLYPORUS SCRUPOSUS Fr.

Mangifera indica Linn., Mount Maquiling, *Marquez 272,* on dead wood.

POLYPORUS SQUAMAEFORMIS Berk.

Mount Maquiling, *Nantes 2532,* on dead wood.

POLYPORUS SULFUREUS Fr.

Mount Maquiling, *Mendoza 2519,* on dead wood.

POLYPORUS VELLEREUS Berk.

Aleurites moluccana (Linn.) Willd., Mount Maquiling, *Collado 69*, on dead wood.

POLYPORUS VINOSUS Berk.

Ficus, Mount Maquiling, *Catalan 2347*, on dead wood.

Parashorea plicata Brandis, Mount Maquiling, *Divinagracia 2487*, on dead wood.

POLYPORUS WILLIAMSIANUS Murr.

Parashorea plicata Brandis, Mount Maquiling, *Catalan 2350*, on dead wood.

POLYPORUS XANTHOPUS Fr.

Eugenia, Mount Maquiling, *Collado 107*, on dead wood.

Psidium guajava Linn., Los Baños, college grounds, *Collado 80, 1828*, on dead wood.

CORIOLUS Quelet

CORIOLUS HIRSUTUS (Fr.) Quelet.

Mount Maquiling, *Cazeñas 1005*, on dead wood.

TRAMETES Fries

TRAMETES ASPERA (Jungh.) Bres.

Mallotus, Mount Maquiling, *Collado 1383*, on dead wood.

Mangifera indica Linn., Mount Maquiling, *Hernandez 956*, on dead wood.

Parashorea plicata Brandis, Mount Maquiling, *Baybay 2582*, on dead wood.

TRAMETES MEYENII Fr. (OBSTINATUS Cooke).

Mount Maquiling, *Collado 1472*, on dead wood.

TRAMETES PERSOONII Mont.

Allaeanthus luzonicus F.-Vill., Mount Maquiling, *Reinking 3036*, on dead petiole.

Durio zibethinus Murr., Jolo Provincial Nursery, *Reinking 2105*, on bark of living tree.

Ficus benjamina Linn., Mount Maquiling, *Pañganiban 248*, on dead wood.

Ficus ulmifolia Miq., Mount Maquiling, *Navera 917*, on dead branches.

Rottboellia exaltata Linn., Mount Maquiling, *Reinking 188*, on dead wood.

TRAMETES SCOPULOSA Berk.

Mount Maquiling, *Cazeñas 2481*, *Nantes 2486*, on dead wood.

TRAMETES VELLEREUS Berk.

Alstonia macrophylla Wall., Mount Maquiling, *Collado 88*, on dead wood.

LENZITES Fries

LENZITES APPLANATA Fr.

Ficus, Mount Maquiling, *Divinagracia 2460*, on dead wood.

LENZITES PALISOTII Fr.

Mount Maquiling, *Reyes 1157*, on decaying log.

HEXAGONA Fries

HEXAGONA ALBIDA Berk.

Mount Maquiling, *Cazeñas 2502*, on dead wood.

HEXAGONA THWAITESII Berk.

Ficus nota (Blanco) Merr., Mount Maquiling, *Collado 74*, on dead wood.

FAVOLUS Fries

FAVOLUS SPATHULATUS (Jungh.) Bres.

Mount Maquiling, *Nantes 1025*, *Divinagracia 2536*, on dead wood.

MICROPORUS

MICROPORUS XANTHOPUS (Fr.) Pat.

Mount Maquiling, *Collado 1492*, on dead wood.

AGARICACEAE

SCHIZOPHYLLUM Fries

SCHIZOPHYLLUM COMMUNE Fr.

Acacia farnesiana (Linn.) Willd., Mount Maquiling, *Reinking 1887*, on dead wood.

Areca catechu Linn., Mount Maquiling, *Collado 1841*, on dead leaves.

Bambusa vulgaris Schrad., Mount Maquiling, *Collado 2157*, on dead stem.

Citrus, Los Baños, college grounds, *Lago 1248*, on dead leaves.

Cocos nucifera Linn., Los Baños, college grounds, *Pañganiban 712*, *Nantes 2475*, *2476*, on dead trunk.

Gliricidia sepium (Jack.) Steud., Mount Maquiling, *Collado 1830*, on dead wood.

Macaranga tanarius (Linn.) Muell.-Arg., Los Baños, college grounds, *Santos 417*, on dead branches.

LENTINUS Fries

LENTINUS CONNATUS Berk.

Mount Maquiling, *Collado 1804*, on dead wood.

LENTINUS LEUCOCHROUS Lév.

Bauhinia, Mount Maquiling, *Collado 1881*, on decaying wood.

Koordersiodendron pinnatum Merr., Mount Maquiling, *Collado 1429*, on dead wood.

Mangifera indica Linn., Mount Maquiling, *Marquez 283*, on dead wood.

Mount Maquiling, *Mendoza 1095*, on soil.

LENTINUS SQUARROSULUS Mont.

Leucaena glauca (Linn.) Benth., Mount Maquiling, *Collado 1823, 1877*, on dead stump.

Sapium merrillianum Pax et K. Hoffm., Mount Maquiling, *Dario 1173*, on base of living tree.

LYCOPERDACEAE

LYCOPERDON Tournefort

LYCOPERDON CEPIFORME Bull.

Mount Maquiling, *Collado 1824*, on decaying wood.

LYCOPERDON ROSEUM Zoll.[2]

Mount Maquiling, *Collado 1885*, on decaying wood; *Reyes 2556*, on dead wood.

GEASTER (Micheli) Fries

GEASTER MIRABILIS Mont.

Mount Maquiling, *Marquez 2491*, on dead wood.

NIDULARIACEAE

CYATHUS Haller

CYATHUS MONTAGNEI Tul.[3]

Bambusa, Jolo, *Reinking 2431*, on dead stem.

Citrus, Mount Maquiling, *Lago 862*, on dead stem.

CYATHUS POEPPIGI Tul. (*C. sulcatus* Kalch.).

Manihot glaziovii Muell.-Arg., Lanao, *Reinking 2087*, on dead branches.

Sesamum orientale Linn. (*Sesamum indicum* Linn.), Mount Maquiling, *Reyes 860*, on living weakened pods.

[2] *Lycoperdon* spp. *1885* and *2556* are most probably *Lycoperdon roseum* Zoll., but the specimens sent were too few and in too poor condition to be identified with accuracy.

[3] On number *2431*, Mr. Patouillard noted a typical example, with good fruiting bodies, of *Hypocrea citrina* var. *fungicola* Karst. He states that it was his impression that this parasite was described on *Cyathus*.

CALOSTOMATACEAE

ASTRAEUS Morgan

ASTRAEUM HYGROMETRICUS (Pers.) Morgan.[4]

Mount Maquiling, *Santos 2561*, on dead fruit.

FUNGI LISTED ACCORDING TO HOSTS

ACACIA FARNESIANA (Linn.) Willd.
Schizophyllum commune Fr. dead wood.

ALEURITES MOLUCCANA (Linn.) Willd.
Polyporus vellereus Berk., dead wood.

ALLAEANTHUS LUZONICUS F.-Vill.
Trametes persoonii Mont., dead wood.

ALSTONIA MACROPHYLLA Wall.
Trametes vellereus Berk., dead wood.

ANNONA GLABRA Linn.
Polyporus rugulosus Lév., living trunk.

APOROSA SPHAERIDOPHORA Merr.
Polyporus gallopavonis Berk., dead wood.

ARECA CATECHU Linn.
Polyporus rugulosus Lév., dead trunk.
Schizophyllum commune Fr., dead leaves.

ARTOCARPUS.
Polyporus rugulosus Lév., living trunk.

BAMBUSA.
Auricularia polytricha (Mont.) Sacc., dead stem.
Auricularia tenuis Lév., dead stem.
Cyathus montagnei Tul., dead stem.

BAMBUSA SPINOSA Roxb. (*Bambusa blumeana* Schultes).
Ganoderma lucidum (Leyn.) var. *bambusae* Pat., dead stem.
Polyporus obtectans Berk., dead stem.
Polyporus rugulosus Lév., dead stem.
Polyporus sanguineus Fr., dead stem.

BAMBUSA VULGARIS Schrad.
Schizophyllum commune Fr., dead stem.

BAMBUSA VULGARIS Schrad. var. STRIATA (Lodd.) Gamble.
Ganoderma lucidum (Leyn.) var. *bambusae* Pat., dead stem.

BAUHINIA.
Lentinus leucochrous Lév., decaying wood.

CASTILLOA ELASTICA Cerv.
Polyporus hirsutus Pers., dead log.

CELTIS.
Polyporus hirsutus Pers., dead wood.

CITRUS.
Cyathus montagnei Tul., dead stem.
Fomes applanatus Pers., dead branches.
Ganoderma australe (Fr.) Pat., dead wood.
Heterochaete tenuicula (Lév.) Pat., dead twigs.
Schizophyllum commune Fr., dead leaves.

[4] *Astraeus hygrometricus* (Pers.) Morgan, *2561*, was a determination from a poor specimen and consequently is questionable.

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COCOS NUCIFERA Linn.
Schizophyllum commune Fr., dead trunk, also dead leaf.
COLUMBIA SERRATIFOLIA (Cav.) D.C.
Auricularia polytricha (Mont.) Sacc., dead wood.
CORDIA MYXA Linn.
Polyporus hirsutus Pers., dead wood.
CROTON.
Fomes pullus Mont., dead wood.
CROTON TIGLIUM Linn.
Polyporus hirsutus Pers., dead wood.
DURIO ZIBETHINUS Murr.
Trametes persoonii Mont., bark of living tree.
ERYTHRINA INDICA Linn.
Polyporus lignosus Kl., dead wood.
EUGENIA.
Polyporus xanthopus Fr.
EUGENIA CALUBCOB C. B. Rob.
Polyporus dichrous Fr., dead wood.
FICUS.
Fomes calignosus Berk., dead wood.
Lenzites applanatus Fr., dead wood.
Polyporus gallopavonis Berk., dead wood.
Polyporus vinosus Berk., dead wood.
Stereum lobatum (Kze.) Fr., dead wood.
FICUS BENJAMINA Linn.
Auricularia polytricha (Mont.) Sacc., dead wood.
Polyporus anebus Berk., dead wood.
Polyporus rugulosus Lév., dead wood.
Trametes persoonii Mont., dead wood.
FICUS NOTA (Blanco) Merr.
Hexagona thwaitesii Berk., dead wood.
FICUS RELIGIOSA Linn.
Polyporus anebus Berk., dead wood.
Stereum lobatum (Kze.) Fr., dead wood.
FICUS ULMIFOLIA Miq.
Trametes persoonii Mont., dead branches.
GLIRICIDIA SEPIUM (Jack.) Steud.
Auricularia polytricha (Mont.) Sacc., dead wood.
Polyporus rugulosus Lév., dead wood.
Schizophyllum commune Fr., dead wood.
KOORDERSIODENDRON PINNATUM Merr.
Lentinus leucochrous Lév.
LEUCAENA GLAUCA (Linn.) Benth.
Lentinus squarrosulus Mont., dead stump.
Polyporus dichrous Fr., dead wood.
Polyporus hirsutus Pers., dead wood.
Polyporus polyzonus Pers., dead wood.
LIVISTONA ROTUNDIFOLIA Mart.
Polyporus sanguincus Linn., dead parts.
MACARANGA TANARIUS (Linn.) Muell.-Arg.
Polyporus hirsutus Pers., dead wood.
Schizophyllum commune Fr., dead branches.

MALLOTUS.
Trametes asper (Jungh.) Bres., dead wood.
"MALUNGAY."
Polyporus rugulosus Lév., dead wood.
MANGIFERA INDICA Linn.
Lentinus leucochrous Lév., dead wood.
Polyporus scruposus Fr., dead wood.
Trametes aspera (Jungh.) Bres., dead wood.
MANIHOT GLAZIOVII Muell.-Arg.
Cyathus poeppigi Tul., dead branch.
Polyporus hirsutus Pers., dead wood.
NAUCLEA.
Polyporus badius Jungh., decaying wood.
PARASHOREA PLICATA Brandis.
Fomes applanatus Pers., dead wood.
Fomes fastuosus Lév., dead wood.
Ganoderma applanatum Pers., dead wood.
Polyporus dichrous Fr., dead wood.
Polyporus vinosus Berk., dead wood.
Polyporus williamsianus Murr., dead wood.
Trametes aspera (Jungh.) Bres., dead wood.
PARKIA JAVANICA (Lam.) Merr. (*Parkia roxburghii* G. Don).
Stereum hirsutum Fr., dead wood.
POLYALTHIA.
Polyporus dichrous Fr., dead wood.
PSIDIUM GUAJAVA Linn.
Physalacria orinocensis Pat. et Gaett., dead wood.
Polyporus xanthopus Fr., dead wood.
QUERCUS.
Polyporus affinis Nees., dead wood.
ROTTBOELLIA EXALTATA Linn.
Trametes persoonii Mont., dead wood.
SAPIUM MERRILLIANUM Pax et K. Hoffm.
Lentinus squarrosulus Mont., base of living tree.
SESAMUM ORIENTALE Linn. (*Sesamum indicum* Linn.).
Cyathus poeppigi Tul., living weakened pods.
TABERNAEMONTANA PANDACAQUI Poir.
Fomes pullus Mont., fresh stem.
TERMINALIA COMINTANA (Blanco) Merr.
Polyporus microloma Lév., dead wood.
THEOBROMA CACAO Linn.
Auricularia polytricha (Mont.) Sacc., dead branches.
ZEA MAYS Linn.
Auricularia tenuis Lév., dead leaves.

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 16 JUNE, 1920 No. 6

NOTES ON PHILIPPINE EUPHORBIACEAE, III

By ELMER D. MERRILL

Director and Botanist, Bureau of Science, Manila

In this series,[1] including the present paper, about one hundred previously undescribed species of Euphorbiaceae have been characterized, while a number of others have been considered either because of their being new to the Philippine flora or because of questions of nomenclature involved. The present paper contains the descriptions of thirty-eight presumably new species and the records of several others not previously recorded from the Philippines. The genera *Wetria*, *Megistostigma*, and *Plukenetia* are new to the Archipelago, *Megistostigma* being of special interest, the genus having been previously a monotypic one known only from the Malay Archipelago. It is of considerable interest to note the continued increase in the number of Philippine species in the small or comparatively small genera *Blumeodendron*, *Trigonostemon*, *Excoecaria*, *Omphalea*, and *Codiaeum*.

PHYLLANTHUS Linnaeus

PHYLLANTHUS PANAYENSIS sp. nov.

Frutex dioicus, ramulis exceptis glaber; foliis numerosis, plerumque lanceolatis, chartaceis, 1.2 ad 3 cm longis, nitidis, basi leviter inaequilateralibus, late rotundatis et plus minusve cordatis, sursum angustatis, acutis vel acuminatis, nervis utrinque circiter 10, tenuibus; floribus circiter 2.8 mm diametro, perianthii segmentis 6, ellipticis ad oblongo-ellipticis, 1.2 mm longis,

[1] Notes on Philippine Euphorbiaceae, Philip. Journ. Sci. 7 (1912) Bot. 379–410; 9 (1914) Bot. 461–493.

obtusis; filamentis 3, liberis, antheris verticaliter dehiscentibus, floribus ♀ plerumque solitariis, pedicillatis, pedicello usque ad 12 mm longo.

A dioecious shrub, glabrous except the branchlets, the branches slender, terete, grayish-brown. Leaves very numerous, mostly lanceolate, chartaceous, 1.2 to 3 cm long, 4 to 10 mm wide, somewhat olivaceous, shining, the base usually more or less inequilateral, broadly rounded and often slightly cordate, narrowed upward to the acute or somewhat acuminate apex; lateral nerves slender, about 10 on each side of the midrib, spreading, not prominent, anastomosing; petioles 1 mm long or less; stipules slenderly acuminate, from a broadened base, about 2 mm long. Staminate flowers fascicled, axillary, but one or few flowers appearing at the same time, each fascicle with numerous, crowded, small bracteoles, the pedicels slender, 6 to 8 mm long, the perianth 2.8 mm in diameter, the segments 6, equal, elliptic to oblong-elliptic, obtuse, 1.2 mm long. Disk glands 6, prominent. Filaments 3, about 1 mm long, free, the anthers dehiscing vertically, 0.2 mm long. Pistillate flowers axillary, mostly solitary, their pedicels in fruit up to 12 mm long, the perianth similar to that of the staminate flowers. Styles 6, free, 1 mm long. Fruit globose, about 4 mm in diameter, composed of three dehiscent cocci.

PANAY, Capiz Province, Mount Bulilao, *Bur. Sci. 35655, 35679 Martelino & Edaño*, June 20, 1919, in forests near the summit, altitude about 650 meters.

The alliance of this species is manifestly with *Phyllanthus lancifolius*, Merr., from which it is especially distinguished by its smaller leaves, its pubescent branchlets, and much shorter pedicels of the pistillate flowers.

PHYLLANTHUS APICULATUS sp. nov.

Frutex glaber, ramis ultimis circiter 7 mm diametro, cicatricibus magnis instructis, ramulis confertis, tenuibus, usque ad 40 cm longis; foliis numerosis, chartaceis, nitidis, oblongo-ellipticis, 3 ad 4.5 cm longis, basi acutis, apice acuminatis et plerumque apiculatis; floribus fasciculatis, breviter pedicellatis, circiter 4 mm diametro, segmentis 6, elliptico-oblongis, 1.8 ad 2 mm longis, staminibus 3, filamentis liberis, antheris verticaliter dehiscentibus.

A glabrous shrub, the ultimate branches terete, about 7 mm in diameter, marked with large scars, these subtended by several small, broadly ovate, stipule-like bracts, the tip and uppermost axils supplied with small, dense rosettes of oblong-lanceolate, acuminate scales; branchlets crowded toward the tips of primary ones, slender, up to 40 cm in length, somewhat simulating pinnate leaves, 2 mm in diameter or less, terete or somewhat angular near the nodes, the apical portion distinctly angular. Leaves numerous, chartaceous, the upper surface dark brown and shining when dry, the lower paler, oblong-elliptic, 3 to 4.5 cm long, 1.3 to 2 cm wide, subequilateral, narrowed to the acute base and to the distinctly acuminate and often apiculate apex; lateral nerves slender, about 9 on each side of the midrib, anastomosing, the reticulations rather close, distinct; petioles 2 mm long or less; stipules lanceolate to ovate-lanceolate, acuminate, about 3 mm long. Staminate flowers axillary, fascicled, their pedicels about 5 mm long, the perianth about 4 mm in diameter, the lobes 6, equal, elliptic-oblong, rounded or obtuse, 1.8 to 2 mm long. Disk glands 6, globose, conspicuous. Stamens 3, their filaments erect, free, 1.5 mm long, the anthers longitudinally dehiscing, 0.5 mm long.

LUZON, Camarines Province, Paracale, *Bur. Sci. 33813 Ramos & Edaño,* November 29, 1919, in damp forests at low altitudes, indicated by the collectors as 2 meters high.

This species may be as closely allied to *Phyllanthus securinegoides* Merr. as to any other species, although it is radically different from the latter in its somewhat thickened ultimate branches bearing the elongated, slender branchlets more or less crowded at the apices.

PHYLLANTHUS INDICUS (Dalz.) Muell.-Arg. in Linnaea 32 (1863) 52, DC. Prodr. 16^2 (1866) 417.

Prosorus indicus Dalz. in Hook. Kew Journ. Bot. 4 (1852) 346.

LUZON, Camarines Province, Mapid, *For. Bur. 22655 Alvarez,* November, 1911. PALAWAN, Aborlan, *Bur. Sci. 15589 Fénix,* July, 1912. MINDANAO, Agusan Province, Tipgon River, *Weber 1195,* July, 1911, with the Visayan name *bungas.* In forests and thickets at low altitudes.

The numbers cited are all in fruit, but they agree perfectly with a full series of Javan specimens representing this species. It has not previously been reported from the Philippines. India and Ceylon to Java.

GLOCHIDION Forster

GLOCHIDION PHYLLANTHOIDES sp. nov. § *Hemiglochidion.*

Arbor parva, glabra, vel partibus junioribus leviter pubescens; foliis oblongo-ellipticis, chartaceis, 2 ad 3 cm longis, apice rotundatis, basi acutis vel leviter rotundatis, nervis utrinque circiter

5, tenuibus; floribus ♂ perianthii segmentis oblongo-ellipticis, obtusis, usque ad 3 mm longis, antheris 3; floribus ♀ breviter pedicellatis, ♂ simillimis, ovario glabro, stylis continuis, cylindraceis, haud constrictis.

A small glabrous tree or the younger parts very slightly pubescent, the branches dark-colored when dry, lenticellate, the branchlets slender, reddish-brown. Leaves oblong-elliptic, chartaceous, 2 to 3 cm long, 1 to 1.5 cm wide, the apex rounded, base broadly acute or somewhat rounded, nearly equilateral; lateral nerves about 5 on each side of the midrib, slender, the reticulations indistinct; petioles 2 to 3 mm long; stipules lanceolate, acuminate, 1.5 to 2 mm long. Flowers axillary, fascicled, the staminate ones with pedicels up to 9 mm in length, the perianth segments oblong-elliptic, obtuse, up to 3 mm long, anthers 3, about 1 mm long, united. Pistillate flowers with pedicels about 2 mm long, the perianth segments similar to those of the staminate flowers. Ovary and style about 2 mm long, cylindric, glabrous, the latter about as thick as the ovary and not at all constricted.

LUZON, Batangas Province, Mount Batulao, *Bur. Sci. 22358 Ramos*, July 30, 1914, on dry slopes, altitude about 190 meters.

This species is apparently most closely allied to *Glochidion breynioides* C. B. Rob., from which it is easily distinguishable by its rounded or obtuse leaves.

GLOCHIDION FALCATILIMBUM sp. nov. § *Hemiglochidion.*

Frutex glaber, circiter 2 m altus; foliis subcoriaceis, falcatis, valde inaequilateralibus, oblongis, usque ad 5 cm longis, apice obtusis vel rotundatis, basi acutis vel acuminatis, nervis utrinque circiter 8, tenuibus; floribus ♀, segmentis 6, oblongo-obovatis ad oblongo-spatulatis, 2 ad 2.5 mm longis; ovario glabro, columno stylari quam ovario duplo longioribus, continuo; staminibus, 3.

A glabrous shrub about 2 m high, the branches brownish, the branchlets slender, reddish-brown. Leaves subcoriaceous, oblong, conspicuously falcate and very inequilateral, 4 to 5 cm long, 1 to 2 cm wide, rather pale and slightly shining when dry, the lower surface often slightly glaucous, the apex obtuse to rounded, the base acute to acuminate, one side very much narrower than the other; primary lateral nerves about 8 on each side of the midrib, slender, not prominent; petioles about 3 mm long; stipules lanceolate to ovate-lanceolate, acuminate, falcate, 2 to 2.5 mm long. Flowers axillary, one or two in each axil opening at the same time, their pedicels 2 to 3 mm long. Pistillate perianth segments 6, oblong-obovate to oblong-spatulate, 2 to 2.5 mm long, obtuse. Ovary about 1 mm high, glabrous, the style cylindric, not constricted below, continuous with and as wide as the ovary, about 1.8 mm long and 1.2 mm in diameter. Staminate flowers few, their anthers 3, about 1 mm long. Fruits depressed-globose, about 8 mm in diameter, obscurely sulcate, usually 3-celled, 6-seeded.

LUZON, Pangasinan Province, Mount San Isidro, Labrador, *Bur. Sci. 30059 Fénix*, November 13, 1917, on grassy and rocky slopes, altitude about 60 meters, with the Pampangan name *malapalin.*

A species well characterized by its small, strongly inequilateral, obtuse, falcate, pale leaves. In appearance it more nearly resembles *Glochidion triandrum* (Blanco) C. B. Rob. than any other Philippine species, but differs totally from that form in its style characters.

GLOCHIDION BRACHYSTYLUM sp. nov. § *Hemiglochidion.*

Frutex vel arbor parva, monoica, ramis hirsutis, valde elongatis; foliis chartaceis, oblongis, tenuiter acuminatis, glabris, usque ad 25 cm longis, nervis utrinque circiter 10, supra impressis, subtus valde prominulis, floribus ♂ longe et tenuiter pedicellatis, sepalis oblongis, 3 mm longis, ♀ breviter pedicellatis, perianthii segmentis recurvatis, utrinque hirsutis; ovario pubescente, columna stylari crassa cylindrica, pubescens, circiter 1 mm diametro, truncata, quam ovario paullo longioribus.

A shrub or small tree, the ultimate branches greatly elongated, spreading-hirsute with short, stiff, dark-brown hairs. Leaves chartaceous, oblong, slenderly acuminate, base rounded to subacute, 20 to 25 cm long, 7 to 8 cm wide, brownish-olivaceous and shining when dry; lateral nerves about 10 on each side of the midrib, impressed on the upper surface, very prominent on the lower surface, curved, anastomosing, the reticulations lax, prominent; petioles about 5 mm long. Staminate flowers up to 25 in a fascicle, their pedicels slender, sparingly spreading-hirsute, 10 to 12 mm long. Perianth segments oblong, 3 mm long, glabrous or the outer ones with a very few, short, spreading hairs. Anthers 3, united, about 1 mm long. Pistillate flowers axillary, fascicled, on the more distal parts of the same branches bearing the staminate ones, 5 to 20 in a fascicle, their pedicels hirsute, about 2 mm long. Perianth segments oblong, recurved, 3 mm long, spreading-hirsute on both surfaces. Ovary pubescent, about 10-celled, shorter than wide; stylar column cylindric, entire, not contracted at the base, nearly as wide as the ovary, pubescent, about 1 mm long and wide, truncate, hollow.

PANAY, Capiz Province, Jamindan, *Bur. Sci. 31374 Ramos & Edaño,* May 22, 1918, in forests along small streams.

In leaf venation this species resembles *Glochidion dolichostylum* Merr. but differs radically from that species in its longer, slenderly acuminate, more numerously nerved, glabrous leaves, and is entirely different in its floral characters.

GLOCHIDION HUMILE sp. nov. § *Hemiglochidion.*

Frutex parvus, ramis usque ad 30 cm longis e radicibus incrassatis; foliis ellipticis, subcoriaceis, 4 ad 10 cm longis, utrinque plerumque rotundatis, nervis utrinque circiter 6, cum reticulis perspicuis, subtus ad costa nervisque pubescens; floribus fasciculatis, ♂ tenuiter pedicellatis, perianthii segmentis ellipticis, 3 mm longis, exterioribus pubescens; staminibus 3; floribus ♀ breviter pedicellatis, pubescens, ovario pubescente, columna stylari pubescente, quam ovario duplo longiore, cylindrica, sursum leviter angustata, basi haud constricta.

A shrub or undershrub consisting of short, simple branches produced from the much-thickened roots, these branches varying in length from 7 to 30 cm, slender, terete, up to 3 mm in diameter, the older ones glabrous, the younger parts pubescent. Leaves elliptic to somewhat oblong-elliptic, subcoriaceous, 4 to 10 cm long, 2.5 to 5 cm wide, base rounded, apex usually rounded, sometimes obtuse, the upper surface glabrous or nearly so, usually pale when dry, the lower surface distinctly pubescent on the midrib, nerves, and reticulations; lateral nerves about 6 on each side of the midrib, distinct, the reticulations lax, evident. Male and female flowers fascicled, mostly in separate axils, male flowers with pedicels up to 11 mm long, slightly pubescent, the outer three perianth-segments elliptic, obtuse, about 3 mm long, somewhat pubescent, the inner three somewhat smaller, glabrous or slightly pubescent on the medium portion. Stamens 3, the staminal mass cylindric, about 1.5 mm long. Female flowers with pedicels about 3 mm long, pubescent. Sepals oblong to narrowly oblong, obtuse, pubescent, 2 mm long. Ovary and style pubescent, the styles forming an almost entire or slightly lobed column which is nearly as broad as the ovary, not at all constricted at the base, slightly narrowed upward, and about twice as long as the ovary. Capsules usually about 8-celled, depressed-globose, prominently sulcate, about 1.3 cm in diameter, brown when dry, sparingly pubescent with short hairs.

MINDANAO, Bukidnon Subprovince, near Tanculan, *Bur. Sci. 26112 Fénix,* July 17, 1916, in open grasslands.

This species is apparently dwarfed due to its habitat. Like several forms in other genera which occur in open cogon areas, the root becomes more or less thickened and produces few to many shoots which endure but one or two years, as all but the subterranean parts of the individual plants are destroyed by the annual grass fires. In habit it is quite different from any other species known to me.

GLOCHIDION CAULIFLORUM sp. nov. § *Euglochidion.*

Arbor parva; foliis subcoriaceis, oblongis ad oblongo-ovatis, usque ad 25 cm longis, plus minusve pubescens vel vetustioribus subglabris, breviter acuminatis, basi latissime et abrupte subtruncato-rotundatis admodum leviter cordatis, nervis utrinque 9 ad 11, perspicuis; inflorescentiis caulinis, racemosis, racemis solitariis vel fasciculatis, 3 ad 12 cm longis, floribus fasciculatis, floribus ♂ campanulatis, circiter 4 mm longis, segmentis parcissime ciliatis, staminibus 5; fructibus obovoideis, 10- ad 12-locellatis, circiter 3 cm longis, leviter pubescens, valvis sublignosis.

A small tree 5 to 6 m high, the younger branches densely pubescent. Leaves subcoriaceous, oblong to oblong-ovate, 13 to 25 cm long, 5 to 9 cm wide, the apex shortly acuminate, the base broadly and abruptly rounded, sometimes shallowly cordate, brownish or olivaceous when dry, more or less pubescent on both surfaces or in age the upper surface nearly glabrous; lateral nerves 9 to 11 on each side of the midrib, prominent, the reticulations very distinct on the lower surface; petioles stout, up to 4 mm in length. Inflorescence from the trunk and perhaps from the larger branches, solitary or two or three from a tubercle, racemose, 3 to 12 cm long, pubescent, the male and female flowers borne on the same raceme, fascicled at the leafless nodes of the racemes. Pedicels of the male flowers 5 to 6 mm long, glabrous or very slightly ciliate, the perianth campanulate, about 4 mm long, the lobes elliptic or elliptic-ovate, obtuse, sparingly ciliate with few, long, scattered, spreading hairs. Stamens 5, the staminal mass ellipsoid including the somewhat produced connectives, about 1.7 mm long. Female flowers apparently few, sometimes in separate inflorescences, sometimes in the same fascicles with the male flowers. Sepals oblong-lanceolate, pubescent, about 3.5 mm long and somewhat accrescent. Fruit obovoid, 10- to 12-celled, about 3 cm long, white when fresh, somewhat pubescent, when mature the valves somewhat woody.

MINDANAO, Lanao District, near Camp Vickers, *For. Bur. 25183 Alvarez* (type), March 17, 1916, in dipterocarp forests, altitude about 900 meters. LEYTE, Dagami, *Bur. Sci. 15352 Ramos*, August 12, 1912, said to be from the mossy forest, Mount Buraui.

Both specimens cited above were originally identified by me as *Glochidion weberi* C. B. Rob., as they distinctly resemble the latter species in vegetative characters. The most remarkable character of the present species and one that distinguishes it from all representatives of the genus known to me is its cauline, solitary or fascicled, racemose inflorescence, the racemes varying in length from 3 to 12 cm and having the flowers either solitary or fascicled at their leafless nodes.

APOROSA Blume

APOROSA ACUMINATISSIMA sp. nov.

Arbor glabra, circiter 7 m alta; foliis subcoriaceis, lanceolatis, tenuiter caudato-acuminatis, integris, usque ad 10 cm longis, pallide olivaceis, nitidis, nervis utrinque circiter 5, distinctis, anastomosantibus, adscendentibus; infructescentiis axillaribus et e axillis defoliatis, racemosis, 2 ad 4 cm longis, glabris vel parcissime pubescentibus; fructibus ovoideis vel ellipsoideo-ovoideis, circiter 1 cm longis.

A glabrous tree about 7 m high, the branches and branchlets reddish-brown, slender. Leaves lanceolate, subcoriaceous, pale-olivaceous when dry, somewhat shining, 6 to 10 cm long, 1.5 to 3 cm wide, base acute or acuminate, apex slenderly caudate-acuminate, the acumen usually falcate, margins entire; lateral nerves about 5 on each side of the midrib, slender, distinct, ascending, anastomosing; petioles about 5 mm long; stipules none or minute and caducous. Fruiting racemes axillary and from the axils of fallen leaves, solitary, 2 to 4 cm long, glabrous or very slightly pubescent, each with from two to five fruits; fruits ovoid or ellipsoid-ovoid, about 1 cm long, pale-brownish when dry; stigmas 2.

LUZON, Laguna Province, Cavinti, Palasan, *For. Bur. 26185 Amarillas*, September 9, 1916, on forested slopes, altitude about 465 meters.

A species similar, and manifestly allied, to *Aporosa sphaeridophora* Merr., from which it is readily distinguished by its much narrower, lanceolate, prominently caudate-acuminate leaves.

APOROSA STIPULOSA sp. nov.

Arbor, inflorescentiis exceptis glabra; foliis coriaceis, oblongis vel late oblongo-lanceolatis, nitidis, apice acuminatis, basi rotundatis et leviter cordatis, usque ad 24 cm longis; stipulis usque ad 3 cm longis, late falcato-acinaciformibus, acuminatis; spicis ♂ fasciculatis, sessilibus vel breviter pedunculatis, 1 ad 2 cm longis, cylindraceis, floribus sessilibus, staminibus 2 vel 3; inflorescentiis masculinis axillaribus, fasciculatis, floribus 5-meris, racemose dispositis; ovario vestito.

A tree, glabrous or nearly glabrous except the inflorescences. Branches stout, terete, dark colored when dry. Leaves oblong to broadly oblong-lanceolate, 15 to 24 cm long, 5 to 6 cm wide, coriaceous, shining, the base rounded, slightly cordate, the apex prominently acuminate; nerves about 14 on each side of the midrib, very prominent beneath, curved-ascending, anastomosing, the reticulations rather dense, distinct; petioles 1 to 1.5 cm long, pubescent when young, ultimately glabrous; stipules of the same texture as the leaves, large and prominent, broadly falcate-acinaciform, 2 to 3 cm long, the base broad and rounded, the apex acuminate. Staminate inflorescences fasciculate, the flowers arranged in dense cylindric spikes 1 to 2 cm long, which are sessile or very shortly peduncled, their rachises pubescent. Calyx segments 3 or 4, slightly pubescent; stamens 2 or 3, their filaments 2 mm long. Pistillate inflorescences axillary, fascicled, the flowers 5-merous, racemosely arranged, the rachis densely fulvous-pubescent, about 2.5 cm long; pedicels stout, about 1.5 mm long, each subtended by a small, ovate bracteole. Ovary densely fulvous-pubescent. Fruit narrowly ovoid, glabrous, narrowed upward, 1.5 cm long.

BILIRAN, *Bur. Sci. 18642 McGregor*, June, 1914. LEYTE, *Wenzel 637*, March, 1917. MINDANAO, Agusan Province, *Elmer 13474, 14042*, August and October, 1912: Lanao District, *Mrs. Clemens 968* (type), March and May, 1907, *For. Bur. 22029 Sherfesee, Cenabre & Ponce*, April, 1914. In forests at low altitudes, ascending to 800 meters.

This species belongs in the group with *Aporosa lunata* Kurz, *A. benthamiana* Hook. f., and *A. falcifera* Hook. f. together with three Bornean species, *A. hosei* Merr., *A. grandistipula* Merr., and *A. euphlebia* Merr. It seems to be closest, however, to a Celebes form represented by *Koorders 16801* and identified by him, with doubt, as representing *Antidesma auriculatum* Teysm. & Binn. I have not been able to locate any published description of the latter, but in any case *Koorders 16801* is safely an *Aporosa,* not an *Antidesma.*

ANTIDESMA Burman

ANTIDESMA IMPRESSINERVE sp. nov.

Frutex vel arbor parva, partibus junioribus inflorescentiisque exceptis glaber; foliis chartaceis, oblongis ad elliptico-oblongis, usque ad 30 cm longis, tenuiter subcaudato-acuminatis, nervis utrinque circiter 18, supra cum reti venarum impressis, subtus valde prominulis; inflorescentiis ♀ et ♂ spicatis, simplicibus, tenuibus, valde elongatis, ♀ usque ad 50 cm longis, floribus 5-meris, dispersis; ovario dense pubescente; stylis terminalibus; fructibus oblique ovatis, leviter compressis, valde reticulato-rugosis, circiter 7.5 mm longis, breviter pedicellatis.

A shrub or small tree, glabrous except the very young parts and inflorescences. Leaves chartaceous, oblong to elliptic-oblong, 18 to 30 cm long, 7 to 10 cm wide, brownish or olivaceous and shining when dry, the base rounded to obtuse, apex slenderly subcaudate-acuminate and long-apiculate, the nerves and reticulations impressed on the upper surface, very prominent on the lower surface; lateral nerves about 18 on each side of the midrib, arched-anastomosing, the reticulations lax, distinct; petioles 5 to 8 mm long, glabrous; stipules narrowly lanceolate, long-acuminate, pubescent, 1 to 1.5 cm long. Staminate spikes axillary, solitary or in pairs, slender, densely ferruginous-pubescent, up to 20 cm long, the flowers widely scattered, sessile, about 2 mm in diameter, their subtending bracteoles pubescent, oblong-ovate, about 0.8 mm long. Calyx lobes usually 5, oblong-ovate, pubescent, 1 mm long, free nearly to the base. Disk glabrous. Stamens usually 4, their filaments 1 mm long. Pistillate inflorescences very slender, apparently pendulous, up to 50 cm long, more or less pubescent, the lower part naked, the upper part with usually widely scattered sessile flowers. Calyx lobes ovate, about as large as those of the staminate flowers. Ovary ovoid, densely ferruginous-pubescent; stigmas three, terminal, about 1 mm long, cleft nearly to the middle. Fruits obliquely ovate, somewhat compressed, base rounded, 7 to 8 mm long, 6 mm wide, prominently reticulate-rugose when dry, slightly pubescent when young, soon becoming glabrous; styles terminal.

PANAY, Capiz Province, Jamindan, *Bur. Sci. 31409* (type), *31268*, *31020 Ramos & Edaño,* April and May, 1918, in forests along small streams.

This species is manifestly allied to *Antidesma cumingii* Muell.-

Arg. from which it is at once distinguished by its conspicuously impressed nerves and reticulations, and by its very slender, greatly elongated inflorescences, both the staminate and pistillate flowers even in young inflorescences being widely scattered and not densely crowded as in *A. cumingii.*

ANTIDESMA ILOCANUM sp. nov.

Frutex vel arbor parva, ramulis inflorescentiisque castaneo-pubescentibus; foliis lanceolatis, chartaceis, 15 ad 20 cm longis, subtus ad costa nervisque leviter pubescentibus, acuminatis, basi plerumque obtusis, nervis utrinque circiter 12, perspicuis; stipulis linearis vel lineari-lanceolatis, 6 ad 8 mm longis; racemis ♀ axillaribus, solitariis, circiter 20 cm longis; fructibus inaequilateraliter ovoideis, glabris, 9 mm longis, obtusis, stigmate terminale.

A shrub or small tree, the young branchlets and inflorescences castaneous-pubescent. Leaves lanceolate, chartaceous, 15 to 20 cm long, 3 to 4.5 cm wide, pale-olivaceous and shining when dry, the lower surface brownish and sparingly castaneous-pubescent on the midrib and nerves, ultimately glabrous or nearly so, somewhat narrowed upward to the acuminate apex, the acumen with a short mucro, base slightly narrowed, rounded to obtuse; lateral nerves about 12 on each side of the midrib, prominent on the lower surface, arched, anastomosing, the reticulations distinct; petioles stout, 5 to 7 mm long, when young castaneous-pubescent, soon becoming glabrous; stipules linear or linear-lanceolate, acuminate, 6 to 8 mm long. Pistillate racemes axillary, simple, about 20 cm long, the rachis rather stout, castaneous-pubescent, marked with numerous scars of fallen pedicels, the pedicels pubescent, 2 to 3 mm long. Sepals 5, pubescent, about 1 mm long. Fruits ovoid, inequilateral, glabrous, somewhat compressed, about 9 mm long, the base broadly rounded, apex obtuse, when dry prominently reticulate-rugose; stigmas terminal.

LUZON, Ilocos Norte Province, between Bangui and Claveria, *Bur. Sci. 32998 Ramos,* August 12, 1918, in thickets and forests at low altitudes.

The alliance of this species is manifestly with *Antidesma cumingii* Muell.-Arg., from which it is readily distinguished by its relatively much-narrowed leaves and its very narrow stipules.

ANTIDESMA CATANDUANENSE sp. nov.

Arbor parva, inflorescentiis parce pubescentibus exceptis glabra; ramis ramulisque griseis, teretibus; foliis chartaceis, ellipticis, usque ad 11 cm longis et 7 cm latis, breviter acuminatis, basi acutis ad subrotundatis, supra olivaceis, nitidis, subtus pallidioribus, nervis utrinque 5, perspicuis, reticulis laxis, distinctis; infructescentiis axillaribus terminalibusque, usque ad 5 cm longis, breviter pedunculatis vel e basi ramosis, tri- vel quadripinnatim paniculatis, multifloris; fructibus subovoideis, racemose dispositis, leviter inaequilateralibus, in siccitate nigris, leviter reticulatis, circiter 3 mm longis, stigmate terminale; calycis subulatis, truncatis.

A small tree, 6 m high fide Ramos, entirely glabrous except the sparingly pubescent infructescences. Branches and branchlets smooth, terete, gray. Leaves chartaceous, olivaceous and shining when dry, the lower surface paler than the upper, elliptic, 8 to 11 cm long, 4.5 to 7 cm wide, the apex rather abruptly and shortly acuminate, base rounded to acute; primary lateral nerves 5 on each side of the midrib, rather prominent on the lower surface, curved and somewhat ascending, anastomosing, the reticulations distinct, rather lax; petioles 1 to 1.5 cm long. Infructescences axillary and terminal, shortly peduncled or branched from the base, tri- or quadripinnately paniculate, many flowered, up to 5 cm in length. Fruits racemosely disposed on the ultimate branchlets, subovoid, slightly compressed, black when dry, somewhat rugose, about 3 mm long, slightly inequilateral, the stigmas terminal; pedicels 1.5 to 2 mm long, the subtending bracteoles 0.5 mm long or less. Persistent calyx cup-shaped, about 1 mm long and wide, truncate.

CATANDUANES, Mount Mariguidon, along streams in forests, *Bur. Sci. 30515 Ramos,* November 13, 1917.

This species is well characterized by its elliptic, shortly and rather abruptly acuminate, few-nerved leaves, and its many-flowered paniculate inflorescences. It is perhaps as closely allied to *Antidesma microcarpum* Elm. as to any other species.

ANTIDESMA SANTOSII sp. nov.

Arbor parva, subglabra; foliis oblongo-ellipticis, olivaceis, nitidis, usque ad 12 cm longis, caudato-acuminatis, basi acutis, nervis utrinque 7 vel 8, subtus perspicuis, obliquis; infructescentiis terminalibus, pauciramosis, 5 ad 6 cm longis, leviter griseo-puberulis; fructibus pedicellatis, oblongo-ellipticis, utrinque acutis vel leviter acuminatis, aequilateralibus, leviter compressis, glabris, in siccitate reticulatis.

A small tree about 7 m high, subglabrous, or the younger parts sparingly pubescent. Branches grayish-brown, terete, smooth. Leaves chartaceous, oblong-elliptic, olivaceous, shining, subequally narrowed to the acute base and to the prominently subcaudate-acuminate apex, the acumen blunt, up to 2 cm in length, sparingly pubescent on the midrib on both surfaces or ultimately glabrous; lateral nerves 7 or 8 on each side of the midrib, prominent on the lower surface, anastomosing, ascending; petioles about 1 cm long; stipules apparently minute, caducous. Infructescences terminal, 5 to 6 cm long, sparingly grayish-puberulent, usually with 2 or 3 branches, the branches 3 to 4 cm long. Fruits racemosely arranged, their pedicels 1 to 1.5 mm long, the subtending bracteoles ovate, acute, somewhat pubescent, 0.6 mm long, the fruits brown when dry, shining, glabrous, rugose, oblong-ellipsoid, equilateral, about 4 mm long, subequally narrowed to the acute or slightly acuminate base and apex, the stigma terminal. Calyx cup-shaped, about 1.2 mm long, the teeth 4, broad, shallow, obtuse, somewhat ciliate.

LUZON, Laguna Province, Mount Banahao, *For. Bur. 26300 Santos*, August 28, 1916, on slopes along small streams, altitude about 600 meters.

A species well characterized by its obliquely nerved, subcaudate-acuminate leaves; its branched inflorescences; racemosely arranged, shining, equilateral, 4 mm long, glabrous fruits; and 4-merous flowers. It is apparently most closely allied to *Antidesma obliquinervium* Merr., of Palawan, but is at once distinguished from it by its much longer petioles.

ANTIDESMA MEGALOPHYLLUM sp. nov.

Species *A. cumingii* affinis, differt foliis majoribus, usque ad 33 cm longis et 13 cm latis, stipulis longioribus, circiter 2.5 cm longis, et fructibus majoribus, circiter 13 mm longis.

A tree about 7 m high, glabrous except the younger branchlets. Branches terete, brownish, smooth, glabrous. Leaves firmly chartaceous, oblong to oblong-elliptic, 20 to 33 cm long, 9 to 13 cm wide, base rounded, cordate, apex usually prominently acuminate, entirely glabrous or when young sparingly pubescent on the midrib beneath, subolivaceous, shining and of about the same color on both surfaces when dry; lateral nerves about 15 on each side of the midrib, prominent, arched-anastomosing, the reticulations lax; petioles stout, 5 to 10 mm long, pubescent when young, ultimately glabrous; stipules linear-lanceolate, slightly falcate, acuminate, about 2.5 cm long and 3 mm wide. Pistillate racemes greatly elongated in fruit, pendulous, 30 to 40 cm in length, bearing fruit only in the upper part, the rachis and peduncle sparingly pubescent. Fruits strongly inequilateral, ovoid, obtuse, rounded at the base, prominently and laxly reticulate-rugose, glabrous, pale and somewhat shining when dry, about 13 mm long and 1 cm wide, the pedicels about 5 mm long; persistent calyx-lobes 5, lanceolate, acuminate, pubescent, about 1.5 mm long.

BABUYAN ISLANDS, Calayan, *For. Bur. 26642 Velasco,* June 6, 1917, in forests, altitude about 40 meters.

A species manifestly closely allied to *Antidesma cumingii* Muell.-Arg., differing in its larger leaves, longer stipules, and larger fruits.

DAPHNIPHYLLUM Blume

DAPHNIPHYLLUM OBTUSIFOLIUM sp. nov.

Frutex glaber, ramulis brunneis, laevis, teretibus; foliis ellipticis ad oblongo-ellipticis, coriaceis, usque ad 9 cm longis, in siccitate nitidis, utrinque olivaceis et concoloribus vel subtus admodum brunneis, apice late rotundatis, interdum brevissime apiculatis, nervis utrinque 6 ad 9, distinctis; infructescentiis circiter 5 cm longis, fructibus ovoideis, laevis, in siccitate nigris, circiter 12 mm longis.

A glabrous shrub about 3 m high, the branches terete, brownish, slightly wrinkled, the branchlets smooth, brown or reddish-brown. Leaves numerous, elliptic to oblong-elliptic, 6 to 9 cm long, 3 to 4 cm wide, olivaceous and shining on both surfaces when dry, coriaceous, usually of the same color beneath as above, sometimes somewhat brownish, never glaucous, entire, the apex broadly rounded and sometimes minutely apiculate, base acute and obscurely 3-nerved or 3-plinerved; lateral nerves 6 to 9 on each side of the midrib, somewhat curved, distinct on both surfaces as are the reticulations; petioles brown, 2.5 to 3.5 cm long. Infructescences axillary, about 5 cm long. Fruits ovoid, black, somewhat fleshy, about 12 mm long, the pericarp somewhat wrinkled when dry, the styles less than 1 mm long, spreading or recurved.

LUZON, Tayabas Province, Mount Binuang, *Bur. Sci. 28705* (type), *28662 Ramos & Edaño,* May, 1917, in forests near the summit of the mountain, altitude about 1,000 meters.

This species is perhaps as closely allied to *Daphniphyllum glaucescens* Blume as to any other species, but is readily distinguished by its leaves being broadly rounded at their apices, not acuminate, but at most minutely apiculate. It likewise differs from *Daphniphyllum borneense* Stapf in the same leaf characters and in having much longer petioles.

AGROSTISTACHYS Dalzell

AGROSTISTACHYS LEPTOSTACHYA Pax & K. Hoffm. in Engl. Pflanzenreich 57 (1912) 102.

LUZON, Camarines Province, Paracale, *Bur. Sci. 33688 Ramos & Edaño,* November 30, 1918, in forests near small streams at low altitudes.

This species has previously been known only from Borneo. The Philippine material is an exact match for our series of Bornean specimens including *Hose 162,* cited in the original description.

CLAOXYLON Jussieu

CLAOXYLON ELLIPTICUM sp. nov. § *Indica.*

Frutex vel arbor parva, ramulis inflorescentiisque adpresse hirsutis; foliis ellipticis, chartaceis, usque ad 14 cm longis, basi rotundatis ad subobtusis, apice abrupte acuminatis, nervis utrinque 5, subtus valde prominulis, margine minute et distanter glanduloso-denticulatis; inflorescentiis ♂ axillaribus solitariis, petiolo subaequantibus; floribus circiter 7 mm diametro; staminibus circiter 30, glandulis elongatis, oblongis, supra perspicue albido-ciliatis.

A shrub or small tree, the branches and inflorescences rather prominently appressed-hirsute, the indumentum on the younger parts fulvous. Leaves chartaceous, elliptic to oblong-elliptic, 9 to 14 cm long, 4.5 to 7.5 cm wide, base rounded to subobtuse, apex rather abruptly acuminate, the acumen broad, acute, margins distantly and minutely glandular-serrulate, greenish-olivaceous when dry, shining, both surfaces minutely papillate-scaberulous; lateral nerves 5 on each side of the midrib, curved-ascending, arched-anastomosing, very prominent, primary nerves and larger reticulations more or less pubescent; petioles 1.5 to 3 cm long, appressed-pubescent, eglandular. Staminate inflorescences axillary, solitary, equaling or shorter than the petioles, simple, flowers white, short-pedicelled, in bud fulvous-hirsute as are other parts of the inflorescences. Flowers about 7 mm in diameter. Sepals 3, oblong-obovate, narrowed below, 4 to 5 mm long. Stamens about 30; filaments 2.5 mm long, glabrous, the interstaminal glands narrowly oblong, 2 mm long, conspicuously ciliate at their apices, the cilia white, about 1 mm long.

PANAY, Antique Province, Culasi, *Bur. Sci. 32303 McGregor,* May 18, 1918, on forested slopes, altitude 800 meters.

This species belongs in the group with *Claoxylon longifolium* Miq. and *C. subviride* Elm. and is distinctly more closely allied to the latter, from which it differs in its very minutely glandular-serrulate leaves, eglandular petioles and much fewer stamens. In this connection I am of the opinion that all of the Philippine specimens referred by Pax to *C. longifolium* are referable to *C. subviride* on account of their short inflorescences and their biglandular petioles.

BLUMEODENDRON (Muell.-Arg.) Kurz

This group was first characterized by Muell.-Arg. in 1866 as a subgenus of *Mallotus,* and raised by Kurz to generic rank in 1873, although Bentham and Hooker f. retained it as a subgenus of *Mallotus* as originally placed by Mueller. The type is the Javan species originally described by Blume as *Elateriospermum tokbrai* Blume. J. J. Smith [2] has justly reinstated the group as of generic rank, in which he has been followed by Pax.[3] The two known Malayan species are *Blumeodendron tokbrai* (Blume) Kurz (quoad syn. Blume) and *B. kurzii* (Hook. f.) J. J. Sm.; the former known from Java and Borneo, the latter from Tenasserim, the Andaman Islands, Malay Peninsula, Sumatra, and Java. *Blumeodendron kurzii* J. J. Sm. is the form thought by Kurz to represent *Elateriospermum tokbrai* Blume, and which was later redescribed by Hooker f. as *Mallotus kurzii.* To this genus in 1912 I referred the Philippine species described two years earlier by Mr. Elmer as *Sapium rotundifolium.*

In a note prepared at Kew and supplied to me in 1911 by the late Dr. C. B. Robinson he indicates that both he and Mr. R. A. Rolfe were of the opinion that the Kew material from the Indo-Malayan region then available represented at least four distinct species. In the Philippines I find the genus to be represented by at least five distinct species, and possibly by seven, as a sterile specimen from Leyte is somewhat different from the forms enumerated below, while two fruiting specimens from Basilan, *Bur. Sci. 16138 Reillo* and *For. Bur. 18906 Miranda* can scarcely be referred to described species. The genus *Blumeodendron* is then considerably larger than the current literature would indicate.

[2] Meded. Dept. Landbouw 10 (1910) 460.
[3] Engl. Pflanzenreich 63 (1914) 47.

Key to the Philippine species of Blumeodendron.

a^1. Fruits globose or subglobose, terete, not compressed or angled.
  b^1. Reticulations conspicuous.. 1. **B. paucinervium.**
  b^2. Reticulations not conspicuous.
    c^1. Leaves mostly alternate.
      d^1. Staminate and pistillate inflorescences axillary, peduncled, the flowers subumbellately arranged........................ 2. **B. philippinense.**
      d^2. Flowers solitary or fascicled, chiefly on leafless branches and on the trunks.. 3. **B. subcaudatum.**
    c^2. Leaves all verticillate; flowers fascicled in the axils of fallen leaves, on the larger branches, and on the trunks...... 4. **B. verticillatum.**
a^2. Fruits conspicuously compressed and keeled, or distinctly 3-angled, borne on tubercles along the larger branches and on the trunks.
5. **B. subrotundifolium.**

1. **BLUMEODENDRON PAUCINERVIUM** (Elm.) comb. nov.

Elateriospermum paucinervium Elm.. Leafl. Philip. Bot. 2 (1908) 484; Pax in Engl. Pflanzenreich 44 (1910) 102.

LUZON, Tayabas Province, Mount Banahao, *Elmer 7416*, (type), May, 1906: Bataan Province, Mount Mariveles, *For. Bur. 758 Borden*, May, 1904. SIBUYAN, *Elmer 12367*, April, 1910, in primary forests.

Of this species fruiting specimens only are known, yet I am now convinced that it is referable to *Blumeodendron*, and among the known species of this genus that it is most closely allied to *B. tokbrai* (Blume) Kurz. I had previously [4] expressed the opinion that it might be referable to *Cheilosa* or *Alcinaeanthus*. It is distinguished from the other Philippine species of *Blumeodendron* by the prominently reticulate leaves, in this character resembling *B. tokbrai* (Bl.) Kurz, of which I now have seven specimens from Java available for comparison.

2. **BLUMEODENDRON PHILIPPINENSE** Merr. & Rolfe sp. nov.

Arbor glabra, usque ad 25 m alta; foliis alternis, vel superioribus rariter verticillatis, coriaceis, in siccitate brunneis, nitidis, oblongis ad oblongo-ellipticis, 8 ad 20 cm longis, basi plerumque acutis, apice perspicue acuminatis, nervis utrinque 6 vel 7, adscendentibus, perspicuis; inflorescentiis axillaribus, ♂ fasciculatis, 1 ad 1.5 cm longis, floribus subumbellatim dispositis, staminibus circiter 35, ♀ plerumque solitariis, pedunculatis, floribus 4 vel 5; capsulis subglobosis, 3 ad 4 cm diametro, 1- vel 2-locellatis, seminibus 1 vel 2.

A glabrous tree, up to 25 m high, branchlets brownish.

[4] Philip. Journ. Sci. 7 (1912) Bot. 382.

Leaves all alternate, or the uppermost ones occasionally opposite or rarely in whorls of 3, coriaceous, usually brownish when dry, oblong to oblong-elliptic, 8 to 20 cm long, 4 to 10 cm wide, the base acute, sometimes rounded, the apex rather abruptly and conspicuously acuminate, the acumen 1 to 2 cm long; lateral nerves usually 6 or 7 on each side of the midrib, prominent, ascending, the reticulations slender, subparallel, not prominent; petioles 3 to 7 cm long. Staminate inflorescences, axillary, fascicled, 1 to 1.5 cm long, the flowers subumbellately arranged near the apices of the peduncles, the buds globose, glutinous, the pedicels up to 8 m long. Sepals 3, elliptic-ovate, obtuse, 4.5 mm long. Stamens about 35, the filaments up to 4 mm long. Pistillate inflorescences axillary, usually solitary, 1 to 1.5 cm long, the flowers usually 4 or 5, subumbellate, the pedicels stout, 2 to 3 m long. Calyx 1.5 to 2 mm long, 3- or 4-toothed. Ovary narrowly ovoid, 2-celled; style very short; stigmas 2, stout, recurved. Fruit globose, usually 1- or 2-seeded, 3 to 4 cm in diameter, the pericarp brown, rather brittle, ultimately dehiscent, the sutures obscure.

LUZON, Bataan Province, Mount Mariveles, *For. Bur. 630, 2377 Borden, For. Bur. 2401 Meyer, For. Bur. 7511, 7228 Curran, For. Bur. 12962 Alvarez, For. Bur. 20054 Topacio* (type), *For. Bur. 24782 Sulit, Williams 699, Whitford 339:* Laguna Province, San Antonio, *Bur. Sci. 16549 Ramos*, pistillate flowers. In primary forests at low altitudes, ascending to 700 meters, flowering in January, September, and October.

Although much of the material representing this species was collected between the years 1903 and 1905 no description of it has yet been published. Female flowers were not secured until 1912 and from the staminate flowers and fruits it was impossible for me to place it in its proper genus in Manila. In November, 1911, Dr. C. B. Robinson and Mr. R. A. Rolfe made a critical examination of the Philippine material available in the Kew Herbarium, resulting in Mr. Rolfe's placing the species in the genus *Blumeodendron*. In a note supplied by Doctor Robinson at that time he intimated that both he and Mr. Rolfe were in agreement that four distinct species were represented by the Indian and Malayan material then available at Kew. The present species I believe to be most closely allied to *Blumeodendron kurzii* J. J. Sm., of the Andaman Islands, Tenasserim, Malay Peninsula, and Java.

3. BLUMEODENDRON SUBCAUDATUM sp. nov.

Arbor glabra, usque ad 25 m alta; foliis omnibus alternis, coriaceis, ellipticis ad elliptico-ovatis, nitidis, in siccitate brunneis vel brunneo-olivaceis, 8 ad 12 cm longis, subcaudato-acuminatis, nervis utrinque plerumque 4, tenuibus, reticulis obscuris. Floribus ♂ solitariis vel fasciculatis, plerumque in ramis defoliatis dispositis, staminibus circiter 35; capsulis solitariis, lateralibus, subglobosis, 3 ad 3.5 cm diametro, obscure 2-valvis, seminibus 1 vel 2.

A glabrous tree, at least 25 m high, the branches brown or reddish-brown, shining. Leaves all alternate, coriaceous, elliptic-ovate, usually brownish or brownish-olivaceous when dry, shining, 8 to 12 cm long, 3.5 to 7 cm wide, the base usually rounded, the apex subcaudate-acuminate, the acumen slender, blunt, up to 2 cm long; lateral nerves usually 4 on each side of the midrib, rather slender, distinct, the reticulations not prominent, sometimes subobsolete; petioles 2.5 to 4 cm long. Staminate flowers solitary or fascicled, chiefly on the branches below the leaves, the buds globose, glutinous, their pedicels up to 8 mm long. Sepals 3, elliptic-ovate, obtuse, 4.5 mm long. Stamens about 35. Pistillate flowers unknown. Capsules ellipsoid or subglobose, solitary, on the branches below the leaves, 3 to 3.5 cm in diameter, ultimately 2-valved, the sutures obscure, 1- or 2-seeded, the pericarp brown, smooth, shining; stigmas 2.

LUZON, Sorsogon Province, *For. Bur. 10598 Curran,* June 16, 1908. SAMAR, *For. Bur. 21075* (type), *21069 Sherfesee, Cenabre & Cortes* (type), April, 1914, *Bur. Sci. 17407 Ramos,* April, 1914, *For. Bur. 24643 Phasis.* PANAY, Capiz Province, *For. Bur. 23928 Cortes & Knapp,* May, 1915. In primary forests at low altitudes, known in Samar as *sabunotan, dancalan,* and *salgnan,* and in Panay as *lindog.*

This species is distinguished from *Blumeodendron philippinense,* described above, by its constantly smaller, fewer-nerved, somewhat caudate-acuminate leaves and by its solitary or fascicled flowers, the rachises of the inflorescences not being at all produced. The field note with one of the Samar specimens cited above indicates that the flowers also grow along the trunk as well as on the branches.

4. BLUMEODENDRON VERTICILLATUM sp. nov.

Arbor glabra, usque ad 12 m alta; foliis omnibus verticillatis, coriaceis, subolivaceis vel pallidis, ellipticis ad obovato-ellipticis, usque ad 15 cm longis, basi acutis, apice abrupte acuminatis, nervis utrinque 5 vel 6, distinctis, reticulis subtus distinctis; floribus ♂ axillaribus, fasciculatis, pedicellatis, resinosis, staminibus circiter 35. Capsulis globosis, 3 ad 3.5 cm diametro, tarde 2-valvis.

A glabrous tree up to 12 m high, the branches and branchlets terete, slender, internodes 6 to 10 cm long. Leaves all verticillate, 3 or 4 at each node, coriaceous, subolivaceous or pale when dry, slightly shining, elliptic to obovate-elliptic, 10 to 15 cm long, 5 to 8 cm wide, base acute, apex rather abruptly acuminate, the acumen blunt, up to 1 cm long; lateral nerves 5 or 6 on each side of the midrib, distinct, somewhat ascending, the reticulations rather lax, evident on the lower surface; petioles 2.5 to 3 cm long. Staminate flowers axillary, fascicled, mostly from leafless branches and on the trunk, the axis of the inflorescences not produced. Pedicels 4 to 5 mm long. Sepals 3, broadly ovate, rounded or obtuse, about 4 mm long. Stamens about 35. Buds globose, glutinous. Pistillate flowers unknown. Capsules globose, 3 to 3.5 cm in diameter, ultimately 2-valved, but the sutures scarcely visible on nearly mature fruits, the pericarp smooth, brown; stigmas 2, short, recurved.

LUZON, Bataan Province, Mount Mariveles, *For. Bur. 2603 Meyer,* February, 1905 (type), *For. Bur. 1190 Borden,* June, 1904, *For. Bur. 1515 Ahern's collector,* July, 1904, *Whitford s. n.* In primary forests, altitude about 600 meters.

A species characterized by its constantly verticillate leaves and fascicled flowers, the latter being for the most part borne at leafless nodes and on the trunk and larger branches.

5. **BLUMEODENDRON SUBROTUNDIFOLIUM** (Elm.) Merr. in Philip. Journ. Sci. 7 (1912) Bot. 384; Pax & Hoffm. in Engl. Pflanzenreich 63 (1914) 49.

Sapium subrotundifolium Elm. Leafl. Philip. Bot. 3 (1910) 930.

This species is as yet represented by only the type collection, *Elmer 12349* from Sibuyan, the specimen having very immature fruits. Pax and Hoffmann state regarding it: "species quoad genus incerta." To my mind there is not the slightest doubt that this species is properly placed as to the genus. It differs radically from the other described forms in its fruits being either compressed or 3-angled and further in their being borne on tubercles on the larger branches and apparently also on the trunks.

MALLOTUS Loureiro

MALLOTUS CONFUSUS sp. nov. § *Echinus.*

Mallotus barbatus Merr. in Philip. Journ. Sci. 7 (1912) Bot. 397, non Muell.-Arg.

Frutex dioicus, ad 7 m altus, ramulis junioribus densissime et molliter barbato-papillosis, papillae elongatae, stellato-tomentosae; foliis alternis, longe petiolatis, late ovatis, usque ad 36 cm longis, basi rotundatis, alte peltatis, apice perspicue caudato-acuminatis, margine irregulariter dentatis vel subintegris, subtus densissime griseo- ad ferrugineo-tomentosis; inflorescentiis ♂ circiter 20 cm longis, parce ramosis, floribus pedicellatis, ♀ pedunculatis, spiciformibus, densis, cylindraceis, 1 ad 1.5 cm diametro, floribus sessilibus; infructescentiis densis, cylindraceis, circiter 10 cm longis et 3.5 ad 4 cm diametro, capsulis echinis mollibus incurvis subulato-filiformibus stellato-tomentosis densissime obtectis.

A dioecious shrub up to 7 m in height, prominently stellate-tomentose. Branches terete, rather stout, 5 to 10 mm in diameter, the leaf-bearing parts densely covered with pale-brownish, soft, stout, densely stellate-tomentose papillae about 5 mm in length, the younger petioles often with similar papillae. Leaves alternate, broadly ovate, long-petioled, chartaceous, 13 to 36 cm long, 10 to 25 cm wide, the base broadly rounded and peltate, the petiole inserted 1.5 to 5 cm from the margin, the apex prominently caudate-acuminate, the margins subentire to irregularly dentate, the teeth never large, usually minute, the upper surface eventually glabrous, or the nerves somewhat stellate-tomentose, pale-olivaceous or brownish-olivaceous, the lower surface very densely stellate-tomentose with grayish to subferruginous, short hairs; petioles up to 18 cm in length, those of the smaller leaves very much shorter, sometimes but 3 to 4 cm in length, uniformly and densely stellate-tomentose, the younger ones with projecting stellate-tomentose papillae. Staminate inflorescences about 20 cm long, densely stellate-tomentose, sparingly branched, the branches 3 cm long or less. Pedicels about 3 mm long. Sepals 4, oblong-elliptic, 2.5 mm long. Stamens about 70, their filaments 2 mm long. Pistillate inflorescences solitary, simple, peduncled, the flower-bearing part dense, cylindric, spiciform, 4 to 5 cm long, 1 to 1.5 cm in diameter, the peduncles densely stellate-tomentose and often papillose. Calyx-lobes lanceolate, acuminate, 3 mm long. Ovary densely tomentose; styles stout, densely bearded, about 4 mm long. Infructescences dense, cylindric, about 10 cm long and 3.5 to 4 cm in diameter, the individual capsules, including the thick indumentum, about 1.5 cm long, densely covered with filiform, densely stellate-tomentose, weak, variously incurved and intertwined, slender processes.

LUZON, Tayabas Province, Mount Tulaog, *Bur. Sci. 29153 Ramos & Edaño* (type), May, 1917; Atimonan, *Whitford 711,* August, 1904. SAMAR, Yabong, *Phil. Pl. 1650 Merrill,* March, 1914, with fruits. MINDANAO, Davao District, *DeVore & Hoover,* May, 1903.

The alliance of this species is manifestly with *Mallotus barbatus* Muell.-Arg., to which I previously referred *Whitford 711,* a specimen with pistillate flowers. Pax & Hoffmann [5] have already indicated that Whitford's specimen apparently represented a distinct species. Now that complete material is available, presenting staminate and pistillate flowers and fruits, it is clearly evident that this Philippine form is distinct from *Mallotus barbatus* Muell.-Arg.

MALLOTUS PAPUANUS (J. J. Sm.) Pax & K. Hoffm. in Engl. Pflanzenreich 63 (1914) 202.

Mallotus hookerianus Muell.-Arg. var. *papuanus* J. J. Sm. in Nova Guinea 8 (1912) 787, *t. 137.*

MINDANAO, Surigao Province, *Bur. Sci. 34549 Ramos & Pascasio,* April 30, 1919, in damp forests at low altitudes.

A species previously known only from New Guinea but scarcely distinguishable from *Mallotus hookerianus* Muell.-Arg. from southern China. The specimen is with mature fruits and agrees very closely with a cotype before me, *Gjellerup 316!,* staminate specimen.

MALLOTUS LONGISTYLUS sp. nov. § *Axenfeldia.*

Frutex vel arbor parva, glabra, vel partibus junioribus leviter pubescens; foliis alternis, oblongis, subcoriaceis, nitidis, penninerviis, eglandulosis, 25 ad 30 cm longis, basi rotundatis, apice tenuiter acuminatis, integris, nervis utrinque circiter 15; stipulis ovatis ad oblongo-ovatis, coriaceis, 7 ad 15 mm longis; racemis ♀ solitariis, circiter 10 cm longis, plerumque 3-floris, sepalis anguste lanceolatis, circiter 6 mm longis, capsulis subglobosis, leviter pubescens, haud glandulosis, spinis paucis tenuibus usque ad 2 mm longis, armatis.

[5] Engl. Pflanzenreich 63 (1914) 165.

A nearly glabrous shrub or small tree, the branchlets terete, brownish, glabrous, about 2 mm in diameter, the very young parts slightly pubescent. Leaves alternate, oblong, subcoriaceous, shining, eglandular, 25 to 30 cm long, 6 to 8 cm wide, the base rounded, without glands, apex rather slenderly acuminate, margins entire; lateral nerves about 15 on each side of the midrib, curved, prominent; petioles 2 to 3 cm long, thickened at base and apex; stipules ovate to oblong-ovate, coriaceous, somewhat acuminate, 7 to 15 mm long, 5 to 8 mm wide, attached by their broad bases. Pistillate racemes solitary, leaf-opposed, slightly pubescent, about 10 cm long, usually about 3-flowered, the pedicels 5 mm long or less. Sepals narrowly lanceolate, acuminate, about 6 mm long, somewhat appressed-pubescent. Capsules subglobose, sparingly pubescent, not glandular, armed with rather slender, spreading, scattered spines up to 2 mm in length, the individual cocci about 7 mm in diameter; styles densely papillate, up to 4 cm in length.

DINAGAT, *Bur. Sci. 35173 Ramos & Pascasio*, May 11, 1919, in forests at low altitudes.

This characteristic species apparently belongs in the section *Axenfeldia* and is perhaps most closely allied to *Mallotus calvus* Pax & Hoffm. The elongated, entire, eglandular, alternate leaves, and the persistent, coriaceous stipules are characteristic.

WETRIA Baillon

WETRIA MACROPHYLLA (Blume) J. J. Sm. in Meded. Dept. Landbouw 10 (1910) 471; Pax & Hoffm. in Engl. Pflanzenreich 63 (1914) 219.

Trewia macrophylla Blume Bijdr. (1825) 612.
Wetria trewioides Baill. Étud. Gén. Euphorb. (1858) 409.
Pseudotrewia macrophylla Miq. Fl. Ind. Bat. 1 [2] (1859) 414.
Alchornea blumeana Muell.-Arg. in Linnaea 34 (1865) 167, DC. Prodr. 15 [2] (1866) 900.
Agrostistachys pubescens Merr. in Philip. Journ. Sci. 4 (1909) Bot. 274; Pax in Engl. Pflanzenreich 57 (1912) 99.

LUZON, Bataan Province, *For. Bur. 5940 Curran*, January, 1907, *For. Bur. 23450 Sherfesee & Alambra*, January, 1915. NEGROS, *For. Bur. 23871 Cardona*, April, 1915. BANCALAN, *Weber*, September, 1916. In bamboo thickets and in forests at low altitudes. A monotypic genus previously known from Borneo, Sumatra, and Java.

This species is a very characteristic one and, although our available Philippine material is all in fruit, I have not the slightest hesitancy in referring it to the Malayan *Wetria macrophylla* (Blume) J. J. Sm., it agreeing closely with our series of but the other specimens cited, including one from near the type of *Agrostistachys pubescens* Merr. has rather pubescent leaves, but the other specimens cited, including one from near the type locality, have glabrous or nearly glabrous leaves.

MACARANGA Thouars

MACARANGA OVATIFOLIA sp. nov.

Arbor parva, inflorescentiis ramulisque exceptis glabra, ramis circiter 1 cm diametro; foliis ovatis, chartaceis, integris, usque ad 25 cm longis, acuminatis, basi late rotundatis et distincte cordatis, subtus glandulosis, nervis utrinque 10 ad 12, perspicuis, petiolo usque ad 16 cm longo; infructescentiis lateralibus, paniculatis, solitariis, e axillis defoliatis, 6 ad 9 cm longis, pubescens; coccis solitariis, globosis, laevis, glabris, circiter 4 mm diametro.

A small tree, glabrous except the tips of the branchlets and the inflorescences, branches brown when dry, terete, the ultimate ones up to 1 cm in diameter, marked with large scattered petiolar scars, the leaf axils and the very tips of the branchlets ferruginous-pubescent. Leaves ovate, chartaceous, 20 to 25 cm long, 16 to 18 cm wide, entire, apex distinctly acuminate, base broadly rounded and distinctly cordate, the upper surface greenish-olivaceous, shining, the lower somewhat paler, with numerous pale-yellowish glands; lateral nerves 10 to 12 on each side of the midrib, prominent, the basal pair with about 10 secondary nerves on the lower side, the reticulations subparallel, distinct; petioles reddish brown, slender, up to 16 cm long. Infructescences paniculate, solitary, in the axils of fallen leaves, spreading, 6 to 9 cm long, ferruginous-pubescent, the branches few, the primary ones 4 cm long or less. Pedicels about 1.5 cm long, the bracteoles pubescent, oblong-obovate, somewhat toothed, up to 3 mm long. Fruit consisting of a single, globose, smooth, ultimately glabrous coccus, about 4 mm in diameter.

MINDANAO, Surigao Province, *Bur. Sci. 34583 Ramos & Pascasio*, June 15, 1919, along streams at low altitudes at the iron deposit on the northeast coast.

This species belongs in the group with *Macaranga noblei* Elm. and *M. piperi* Merr. but is at once distinguishable from both by its leaves being glabrous on the lower surface. It is less closely allied to *M. amplifolia* Merr., from which it is easily distinguished by its cordate leaves, its shorter inflorescences, and its entirelv glabrous leaves and petioles.

MEGISTOSTIGMA Hooker f.

MEGISTOSTIGMA CORDATUM sp. nov.

Herbacea, scandens, partibus junioribus inflorescentiisque exceptis glabra; foliis ovatis, chartaceis, profunde cordatis, acuminatis, longe petiolatis; inflorescentiis racemosis, axillaribus, pedunculatis, usque ad 16 cm longis, floribus inferioribus ♀, superioribus ♂, sepalis ♀ lanceolatis, acuminatis, 6 mm longis.

A scandent, apparently herbaceous vine, nearly glabrous except the inflorescences and very young vegetative parts. Leaves ovate, chartaceous, 8 to 14 cm long, 6 to 9 cm wide, entire, base prominently cordate, apex acuminate, shining when dry, the upper surface olivaceous, the lower paler; lateral nerves above the basal pair 3 or 4 on each side of the midrib, distinct; petioles 3 to 5 cm long. Inflorescences racemose, axillary, solitary, long-peduncled, up to 16 cm in length, the flower-bearing portion 3 to 5 cm long, the lower flowers in each raceme pistillate, the upper ones staminate. Staminate flowers about 6 mm in diameter, their pedicels about 6 mm long, sparingly pubescent, the calyx-lobes 3, orbicular-ovate, obtuse to acute, 3 to 4 mm in diameter; bracteoles lanceolate, acuminate, somewhat pubescent, 4 to 5 mm long, usually hastate-lobed at the base. Pistillate flowers in the lower part of the same raceme as the staminate ones and fewer in number, yellowish-green. Sepals lanceolate, acuminate, about 6 mm long, pubescent on both surfaces, somewhat inflated at the base. Ovary subglobose, somewhat 3-lobed, pubescent, 3-celled; style pubescent, 2 to 3 mm long; stigma subglobose, obscurely 3-lobed, glabrous, fleshy, about 6 mm in diameter.

SAMAR, Mount Canislagan, *Bur. Sci. 17591 Ramos*, April 3, 1914, in dry forests.

The genus *Megistostigma* has previously been known from the Malay Peninsula where it is represented by a single species, *M. malaccense* Hook. f., the type of the genus. The present species differs radically from *M. malaccense* in its ovate, cordate, long-petioled leaves and in its very much larger flowers, the staminate and pistillate ones being borne in the same racemes, not in separate racemes as in Hooker's species. In essential floral characters, by which the genus is distinguished, both the staminate and pistillate flowers conform entirely to those of *Megistostigma*.

PLUKENETIA Linnaeus

PLUKENETIA CORNICULATA Smith in Nov. Act. Soc. Sci. Upsal. 6 (1799) 4.

LUZON, Rizal Province, Barrio of Pulong, *Bur. Sci. 24086 Ramos*, November 25, 1915, in dry places, old clearings.

The genus is new to the Philippines. While the specimen cited above differs in some details from Smith's species, as described, I can detect no differences, in the absence of named material for purposes of comparison, that would warrant me in distinguishing the Philippine form as specifically or varietally distinct. According to Hooker the species extends from the Himalayan region to Java; it extends at least as far to the southeast as Amboina, as it was figured by Rumphius, Herb. Amb. 1 (1741) 194, *t. 79, f. 2*, as *Sajor volubilis*.

TRAGIA Linnaeus

TRAGIA LUZONIENSIS sp. nov.

Scandens, ramulis plus minusve pubescentibus; foliis oblongis, chartaceis, usque ad 9 cm longis, acuminatis, basi leviter cordatis et minute peltatis, margine irregulariter undulatis, nervis utrinque 6 vel 7, patulis, distinctis, anastomosantibus; inflorescentiis ♂ axillaribus, spicatis, tenuibus, 5 ad 7 cm longis, puberulis, solitariis vel fasciculatis; floribus 2 mm diametro, 4-meris, sepalis oblongis, acuminatis, 1 mm longis; staminibus 4, quam sepalis brevioribus; bracteolis anguste oblongis, 0.5 mm longis.

A slender vine, the branches terete, 1 to 1.5 mm in diameter, brownish when dry, the younger ones more or less pubescent, the older ones glabrous. Leaves chartaceous, subolivaceous when dry, shining, oblong, 6 to 9 cm long, 2.5 to 3 cm wide, somewhat narrowed to the rounded, slightly cordate, and minutely peltate base, the apex acuminate, margins irregularly undulate, the upper surface glabrous, the lower surface with rather numerous short, stiff stinging hairs from bulbous bases 1 mm long or less; petioles 5 to 10 mm long, sparingly hirsute, ultimately glabrous; lateral nerves 6 or 7 on each side of the midrib, distinct, spreading, anastomosing, the reticulations lax. Staminate inflorescences spicate, slender, axillary, solitary or fascicled, puberulent, 5 to 7 cm long, the bracteoles narrowly oblong, 0.5 mm long, usually curved and persisting after the flowers fall. Flowers sessile, 2 mm in diameter, 4-merous. Sepals oblong, acuminate, 1 mm long. Stamens 4, rarely 3, shorter than the sepals; rudimentary ovary none. Pistillate flowers and fruits unknown.

LUZON, Ilocos Norte Province, Burgos, *Bur. Sci. 32854 Ramos,* July 26, 1918, in dry forests at low altitudes.

This species is entirely different from the other two known from the Philippines and probably belongs in the alliance with *Tragia involucrata* Linn. It is well characterized by its oblong, somewhat undulate leaves, which are rounded, slightly cordate, and minutely peltate at the base, and by its spicately arranged staminate flowers. In this genus the pistillate flowers are usually found at the base of the staminate inflorescences; but none of the specimens of *Tragia luzoniensis* shows any indication whatever of pistillate flowers, so that apparently the present species is dioecious. The stinging hairs of the present species are very short and are apparently confined to the lower surface of the leaves.

TRAGIA PHILIPPINENSIS sp. nov.

Scandens, ramulis, foliis et fructibus pilis numerosis urentibus instructis; foliis oblongo-ovatis ad oblongo-lanceolatis, usque ad 10 cm longis, basi late truncato-subcordatis, leviter hastatis, sursum gradatim angustatis, tenuiter acute acuminatis; sepalis ♀ 3, accrescentibus, subcoriaceis, ovatis, circiter 10 mm longis, obtusis ad leviter acuminatis, integris; coccis circiter 7 mm diametro, perspicue hispidis, pilis urentibus.

A scandent, herbaceous or subherbaceous vine, the branchlets, leaves, and other parts prominently hispid with scattered, white, stiff, stinging hairs 2 to 3 mm in length. Leaves membranaceous, oblong-ovate to oblong-lanceolate, 7 to 10 cm long, 2.5 to 4 cm wide at the truncate-subcordate and slightly hastate base, gradually narrowed upward to the slenderly and sharply acuminate apex, often with 2 or 3 coarse teeth or shallow lobes on each side near the base, otherwise entire, both surfaces with scattered, stiff, stinging hairs, the upper surface brown or castaneous when dry, the lower greenish; lateral nerves 4 or 5 on each side of the midrib, prominent, anastomosing; petioles about 3 cm long. Staminate flowers 3-merous, the buds triangular, the sepals reniform-ovate, about 3 mm long and 4 mm wide. Disk much thickened; stamens 3, about 2 mm long. Pistillate sepals in fruit 3, subcoriaceous, spreading, entire, ovate, obtuse to somewhat acuminate, about 10 mm long and 7 mm wide. Fruits depressed, about 12 mm in diameter, brown, the cocci globose, about 7 mm in diameter, prominently hispid with white, stiff, spreading, stinging hairs.

LUZON, Abra Province, Mount Posuey, *Bur. Sci. 27013 Ramos*, February 4, 1917, on damp forested slopes.

The third species to be found in the Philippines, and one readily distinguished from *Tragia irritans* Merr. in its leaves being truncate-cordate and somewhat hastate, the sinus very broad and shallow, and the basal lobes not rounded; its three, accrescent, pistillate sepals; and its numerous, very prominent, stinging hairs. It differs notably from the polymorphous *Tragia involucrata* Linn. in its three entire sepals.

TRIGONOSTEMON Blume

TRIGONOSTEMON MACGREGORII sp. nov. § *Pycnanthera.*

Frutex circiter 2 m altus, ramulis inflorescentiisque plus minusve adpresse hirsutis; foliis membranaceis, oblongis, perspicue acuminatis, integris, usque ad 14 cm longis, basi rotundatis vel obtusis, 3-nerviis; paniculis axillaribus, pedunculis, foliis subaequantibus; floribus ♂ circiter 9 mm diametro, sepalis apice perspicue glandulosis, antheris 3, ellipsoideis, integris, ♀ sepalis perspicue ciliato-hirsutis; ovario glabro, stylis 3, brevibus, integris.

A shrub about 2 m high, the branchlets and inflorescences more or less appressed-hirsute. Leaves membranaceous, oblong, prominently acuminate, entire, 10 to 14 cm long, 3 to 5 cm wide, base rounded to obtuse, distinctly 3-nerved; lateral nerves above the basal pair 5 or 6 on each side of the midrib, the midrib and nerves on both surfaces very sparingly appressed-hirsute. Panicles axillary, lax, peduncled, 9 to 16 cm long, the branches slender, irregularly arranged, the lower ones up to 7 cm long. Pistillate and staminate flowers pale-yellow, in the same inflorescences or sometimes in separate inflorescences on the same plant. Staminate flowers about 9 mm in diameter, their pedicels slender, 5 to 10 mm long. Sepals 5, elliptic to elliptic-ovate, 1.5 to 2 mm long, glabrous or with very few ciliate-hirsute hairs, glandular-punctate, the apex obtuse or notched and with a large conspicuous gland. Petals membranaceous, glabrous, obovate, about 4.5 mm long, 3 mm wide, the apex somewhat obliquely truncate-rounded. Disk 1 mm in diameter, entire. Androphore about 2 mm long, anthers 3, ellipsoid, entire, 0.4 mm long, the filaments 0.5 mm long. Pistillate flowers similar to the staminate ones, differing in their larger, prominently hirsute-ciliate sepals which are oblong and about 3 mm long. Ovary ovoid, glabrous; styles 3, entire, 0.5 mm long. Capsules subglobose, about 1 cm long. Seeds about 6 mm in diameter.

PANAY, Antique Province, Culasi, *Bur. Sci. 32424 McGregor* (type), June 3, 1918, in forests, altitude about 300 meters. The same species is represented by *Bur. Sci. 26228 McGregor* from the vicinity of Paete, Laguna Province, Luzon, June, 1915.

This species is not closely allied to any other known Philippine form and differs from the other species of this section in its axillary inflorescences. It is easily recognized by its lax inflorescences and its distinctly 3-nerved leaves, the basal nerves usually extending to near the middle of the leaf.

TRIGONOSTEMON LAXIFLORUS sp. nov.

Frutex, partibus junioribus et subtus foliis plus minusve pubescentibus; foliis oblongis ad oblongo-lanceolatis, circiter 25 cm longis, perspicue acuminatis, basi acutis, nervis utrinque circiter 18; inflorescentiis ♀ tenuibus, laxis, axillaribus, usque ad 30 cm longis; floribus paucis, longissime pedicellatis; bracteis foliaceis, lanceolatis, 1 ad 1.5 cm longis; sepalis oblongis ad oblongo-ovatis, acuminatis, ut videtur accrescentibus, 7 ad 11 mm longis; ovario ovoideo, pubescente; stylis 3, brevibus, partitis.

A shrub, more or less pubescent. Branches terete, glabrous, about 4 mm in diameter, the younger parts somewhat pubescent. Leaves oblong to oblong-lanceolate, about 25 cm long and 7 cm wide, narrowed below to the acute base and above to the conspicuously acuminate apex, the margins obscurely and distantly undulate-crenate, the upper surface glabrous, dark-olivaceous when dry, the lower surface paler, rather softly pubescent on the midrib, nerves, and reticulations, and with similar but more scattered hairs on the epidermis; lateral nerves about 18 on each side of the midrib, prominent; petioles 3 to 4.5 cm long, pubescent when young, soon becoming glabrous. Pistillate inflorescences slender, lax, rather few-flowered, long-peduncled, pubescent, up to 30 cm long, the branches few, rather short, each bearing from 1 to 3 very long-peduncled flowers, the branches subtended by lanceolate, 1 to 1.5 cm long, leaflike bracts. Pedicels 2 to 5 cm long, thickened upward, usually with a small linear-oblong bracteole. Sepals 5, oblong to oblong-ovate, acuminate, sparingly pubescent, apparently somewhat accrescent and persistent, 7 to 11 mm long, 2.5 to 5 mm wide. Disk glabrous, with 5, rounded, orbicular-ovate lobes. Ovary ovoid, rather densely cinereous-pubescent; styles 3, about 1.5 mm long, cleft nearly to the base. Capsules apparently globose, about 1 cm in diameter.

PANAY, Capiz Province, Jamindan, *Bur. Sci. 31097 Ramos & Edaño,* May 16, 1918, in damp forests.

This species is well characterized by its very slender, few-flowered, elongated, bracteate inflorescences and by its apparently accrescent, persistent, rather large sepals. It is closely allied to *Trigonostemon acuminatus* Merr., from which it is easily distinguished by its smaller bracts, and by its leaves being softly pubescent beneath.

TRIGONOSTEMON LUZONIENSE sp. nov.

Frutex erectus, perspicue hirsutus vel villosus, ramulis circiter 5 mm diametro, cicatricibus magnis instructis; foliis subcoriaceis, oblongo-obovatis ad oblanceolatis, 15 ad 23 cm longis, acutis vel obtusis, deorsum angustatis, integris, nervis utrinque circiter 10, perspicuis; infructescentiis longe pedunculatis, hirsutis, axillaribus, racemosis vel depauperato-paniculatis, foliis subaequantibus; capsulis circiter 1 cm diametro, dense hirsutis.

A shrub about 1 m high, the branchlets, petioles, inflorescences, and leaves on the lower surface more or less hirsute or villous. Ultimate branches about 5 mm in diameter, more or less pubescent, and with large petiolar scars. Leaves chartaceous or subcoriaceous, narrowly oblong-obovate to oblanceolate, 15 to 23 cm long, 6 to 8 cm wide, rather pale when dry, the apex acute to obtuse, narrowed below to the acute or very abruptly obtuse base, the margins entire, the upper surface glabrous, the lower conspicuously pubescent on the midrib, nerves, and reticulations; lateral nerves about 10 on each side of the midrib, curved-ascending, distinct, the reticulations lax; petioles 1.5 to 2 cm long, densely hirsute. Infructescences axillary, equaling or somewhat longer than the leaves, very long-peduncled, hirsute, racemose or depauperate-paniculate, flower-bearing in the upper 10 cm, the branchlets or pedicels subtended by bracts or very greatly reduced leaves which may reach a length of 1.5 cm, the fruiting pedicels up to 3 cm long, thickened upward. Capsules depressed-globose, densely hirsute, about 1 cm in diameter, composed of 3 dehiscent cocci.

LUZON, Camarines Province, Paracale, *Bur. Sci. 33539 Ramos & Edaño,* November 28, 1918, in forests along small streams at low altitudes.

This species differs from *Trigonostemon hirsutus* C. B. Rob. in its smaller, fewer-nerved leaves, and from *T. merrillii* Elm.

in its leaves being entirely glabrous on the upper surface; it seems to be more closely allied to the latter.

TRIGONOSTEMON ANOMALUS sp. nov.

Frutex circiter 8 m altus, inflorescentiis parcissime hirsutis exceptis glaber; foliis submembranaceis, oblongo-ovatis, usque ad 18 cm longis, longe acuminatis, integris, nervis utrinque circiter 7; inflorescentiis axillaribus, paucifloris, 1 ad 2 cm longis, racemosis vel corymbosis; floribus ♂ magis numerosis, sepalis 5, ellipticis, circiter 3 mm longis, integris, petalis bifidis, quam sepalis brevioribus latioribusque, glabris; floribus ♀ paucis, longe pedicellatis, sepalis 5 mm longis, petalis nullis.

A shrub about 8 m high, entirely glabrous except for the very slightly hirsute inflorescence. Branches slender, terete, reddish brown. Leaves alternate, oblong-ovate, membranaceous, 7 to 18 cm long, 3.5 to 6.5 cm wide, pale or somewhat olivaceous when dry, somewhat shining, entire, base acute, apex long and slenderly acuminate; lateral nerves about 7 on each side of the midrib, slender, distant, curved, the reticulations lax, subobsolete; petioles 2 to 7 mm long. Inflorescence axillary, 1 to 2 cm long, few-flowered, racemose or cymose. Female flowers apparently 1, few, or perhaps none in some inflorescences, their pedicels about 1.5 cm long, thickened upward. Sepals 5, imbricate, glabrous, oblong-elliptic, obtuse, 5 mm long, 3 mm wide. Petals none (or fallen). Ovary ovoid, glabrous, about 2 mm in diameter, 3-celled, cells 1-ovuled; styles 3, about 1 mm long, recurved. Male flowers more numerous than the females, their pedicels 5 to 6 mm long, the buds globose. Sepals of nearly mature buds 5, eglandular, imbricate, elliptic, rounded, concave, about 3 mm long, 2.2 mm wide, glabrous or externally with very few, scattered hairs. Petals 5, imbricate, 2 to 2.5 mm long, 3 to 3.5 mm wide, cleft to about the middle by a broad sinus, the lobes rounded. Stamens 3; anthers sessile, entire, 2-celled, about 1 mm long, longitudinally dehiscent.

MINDANAO, Zamboanga District, Naganaga, *For. Bur. 22018 Villamil*, June 2, 1914, on ridges, altitude about 75 meters, the flowers red.

The species is placed in *Trigonostemon* although it is anomalous in that its pistillate flowers apparently have no petals; as I had for examination but a single pistillate flower, however, it is possible that the petals had already fallen. Otherwise the species is distinguished by its short, racemose or corymbose inflorescences. It may belong in the section *Tylosepalum*.

CODIAEUM Jussieu

CODIAEUM TRICHOCALYX sp. nov.

Frutex erectus, dioicus, partibus junioribus inflorescentiisque exceptis glaber; foliis plus minusve confertis, chartaceis, olivaceis, oblongo-obovatis ad late oblanceolatis, usque ad 20 cm longis, obtusis vel breviter latissime obtuse acuminatis, basi cuneatis, integris, nervis utrinque circiter 15, patulis; petiolo 1.5 ad 2.5 cm longo; racemis ♂ elongatis, adpresse pubescentibus; floribus fasciculatis, pedicellis sepalisque dense longe ciliato-hirsutis; petalis minutis, glabris, oblongo-spatulatis, 1.5 mm longis; staminibus circiter 100.

An erect, apparently unbranched, dioecious shrub, glabrous except the younger parts and the inflorescences. Branches terete, smooth, the ultimate ones 3 to 4 mm in diameter. Leaves crowded at the apices of the branches, chartaceous, oblong-obovate to broadly oblanceolate, 13 to 20 cm long, 4.5 to 7 cm wide, apex obtuse to broadly and obtusely acuminate, gradually narrowed in the lower two-thirds to the cuneate base; lateral nerves about 15 on each side of the midrib, slender, spreading, very obscurely anastomosing; petioles 1.5 to 2.5 cm long. Staminate inflorescences elongated, 20 to 40 cm in length, appressed-pubescent with short hairs. Flowers white, in distant fascicles, up to 5 at a node, but 1 or 2 opening at one time, their pedicels and the sepals densely covered with long, rather stiff, spreading, white or pale hairs, the pedicels up to 1 cm in length. Sepals obovate, rounded, about 4 mm long. Petals minute, oblong-spatulate, 1.5 mm long, glabrous, entire. Disk-glands about 10, thick, angled, about 0.8 mm long, truncate. Stamens 100 or more, the filaments glabrous, 3 to 4 mm long.

LUZON, Zambales Province, Mount Aglao, *Bur. Sci. 26797 Edaño,* December 5, 1916, in forests at low altitudes.

A species manifestly allied to *Codiaeum luzonicum* Merr., and *C. cuneifolium* Pax & K. Hoffm., from both of which it is at once distinguished by the dense indumentum on the pedicels and calyces, which consists of long, stiff, spreading, white or pale hairs that are 0.8 to 1 mm in length.

CODIAEUM MEGALANTHUM sp. nov.

Frutex 1 m altus, haud ramosus, floribus ♀ exceptis glaber; foliis longe petiolatis, chartaceis, oblongo-oblanceolatis, 12 ad 27 cm longis, apice rotundatis vel latissime et brevissime acuminatis; inflorescentiis ♂ racemosis, usque ad 35 cm longis, floribus 1.2 ad 1.5 cm diametro, tenuiter longe pedicellatis, plerumque solitariis, sepalis glabris, staminibus circiter 100, glandulis circiter 15, quadratis, denticulatis; floribus ♀ pubescentibus, stylis 3, recurvatis, integris.

An erect, normally unbranched shrub, about 1 m high, entirely glabrous except the pistillate flowers. Leaves chartaceous, oblong-oblanceolate, 12 to 27 cm long, 3 to 7 cm wide, entire, olivaceous when dry, the apex rounded, or sometimes very broadly and shortly acuminate, gradually narrowed below to the cuneate or acute base; lateral nerves spreading, slender, distinct, up to 20 on each side of the midrib, anastomosing, the reticulations very lax, indistinct; petioles 3.5 to 7 cm long. Pistillate and staminate inflorescences either on the same plant or on separate plants, elongated, 17 to 35 cm long, rachis glabrous. Staminate flowers up to 1.5 cm in diameter, white, their pedicels slender, 2 to 2.5 cm long, solitary or somewhat fascicled. Sepals glabrous, orbicular, about 6 mm in diameter. Stamens 100 or more, their filaments about 6 mm long. Disk glands about 15, stout, 4-angled, about 1.2 mm long, the more or less quadrate apex minutely toothed. Petals none. Pistillate flowers racemose, solitary, their pedicels 1.2 mm long or less. Sepals somewhat pubescent, broadly ovate, acuminate, 1.5 mm long. Ovary ovoid, cinereous-pubescent; styles 3, entire, recurved, 6 mm long.

LUZON, Ilocos Norte Province, Burgos, *Bur. Sci. 27353 Ramos* (type), March 12, 1917, in forests at low altitudes; between Bangui and Claveria, *Bur. Sci. 33014 Ramos*, August 1, 1918: Cagayan Province, near Mount Narig, *For. Bur. 19640 Curran*, January 25, 1912.

The type was originally identified as *Codiaeum cuneifolium* Pax & K. Hoffmann, the latter species being identical with *C. luzonicum* Merr. It is distinguished from *C. luzonicum* and from *C. palawanense* Elm. by its larger staminate flowers; in being entirely glabrous except for its pistillate flowers; and more especially in its undivided style arms. In both *Codiaeum luzonicum* (including *C. cuneifolium*) and *C. palawanense* the styles are divided to the base, forming six equal arms. In the present species as in others of this group the staminate flowers are apetalous.

CODIAEUM CILIATUM sp. nov.

Frutex monoicus, 1 ad 2 m altus, perspicue ciliato-hirsutus; foliis oblongo-ovatis ad late oblongo-oblanceolatis, membranaceis ad chartaceis, utrinque plus minusve longe albido-ciliatis, usque ad 35 cm longis, acutis ad acuminatis, basi cuneatis, nervis utrinque 10 ad 20; inflorescentiis 30 ad 60 cm longis, multifloris; floribus ♂ extus glabris vel subglabris, 5-meris, plerumque fasciculatis, staminibus circiter 45; floribus ♀ pubescentibus, ovario pubescente atque ciliato-hirsuto; stylis 3, bipartitis.

An erect, unbranched, monoecious shrub, 1 to 2 m high, ciliate-hirsute with scattered, spreading, stiff, white hairs, especially on the inflorescences and lower surface of the leaves. Leaves oblong-obovate to broadly oblong-oblanceolate, membranaceous to chartaceous, 25 to 35 cm long, 9 to 15 cm wide, olivaceous when dry, the lower surface somewhat paler than the upper, the apex acute to somewhat acuminate, narrowed in the lower two-thirds to the usually cuneate base; lateral nerves 10 to 20 on each side of the midrib, prominent, spreading, anastomosing, the reticulations lax; petioles 4 to 8 cm long. Pistillate and staminate inflorescences on the same plant, racemose, stout, 30 to 60 cm long, the rachis cinereous-pubescent with short, appressed hairs and ciliate-hirsute with long, stiff, spreading ones. Staminate flowers usually numerous, fascicled, from 2 or 3 to as many as 100 in a fascicle, their pedicels up to 1 cm in length. Sepals orbicular to reniform, glabrous, the inner three about 4 mm in diameter, the outer two usually smaller. Petals not seen, if present then very minute. Stamens about 45. Pistillate flowers solitary, racemosely arranged, their pedicels 1 to 3 mm long, calyx pubescent and ciliate-hirsute; styles 3, each cleft nearly to the base into two 6-mm long arms. Capsules about 1 cm in diameter, brownish, shining, with few, scattered, short hairs, their pedicels 5 to 10 mm long.

PANAY, Capiz Province, Jamindan, *Bur. Sci. 31233* (type), *31230, 31231, 31232 Ramos & Edaño*, April 6, 1918, in forests along small streams, with the Visayan names *calangcang* and *panagang*.

This species belongs in the same group as *Codiaeum luzonicum* Merr., from which I do not consider *C. cuneifolium* Pax & Hoffm. to be specifically distinct. *Codiaeum ciliatum* is closely allied to *C. hirsutum* Merr., from which it is distinguished by its much broader leaves, its shorter inflorescences, and the glabrous or nearly glabrous sepals of the staminate flowers.

Pax and Hoffmann separated *Codiaeum cuneifolium* from *C. luzonicum* on the basis that the former has monoecious flowers and pubescent capsules, and that the latter is dioecious with glabrous capsules. As a matter of fact the capsules are appressed-pubescent in both species; the plants are more often monoecious but are frequently dioecious. There are no floral or vegetative characters by which they may be distinguished. In this connection it is well to call attention to the fact that the drawing of the pistillate flower given by Pax and Hoffmann [6] is erroneous in that the styles are shown as very short, obovate, and 3-toothed. In this species, as in *C. luzonicum* and all of the other indigenous ones of the genus found in the Philippines, the three styles are elongated and cleft nearly to the base into two long arms. In this character all of our indigenous species of the genus differ from typical *Codiaeum*, and a more natural arrangement would be their segregation as a subgenus or perhaps even their separation generically from *Codiaeum*.

CODIAEUM MACGREGORII sp. nov.

Frutex vel arbor parva, ramulis inflorescentiisque exceptis glabra; foliis lineari-oblongis, usque ad 30 cm longis, 3 ad 3.5 cm latis; inflorescentiis ♀ usque ad 45 cm longis, cinereo-pubescentibus; floribus 5-meris, sepalis dense pubescentibus; ovario dense hirsuto; stylis 3, bifidis, elongatis; capsulis dense hirsutis, obovoideis.

A shrub or small tree, the young branchlets and inflorescences densely cinereous-pubescent with short subappressed hairs. Leaves glabrous, chartaceous, linear-oblong, 30 to 40 cm long, 3 to 3.5 cm wide, their margins parallel, the base rather abruptly acute or cuneate, the apex acuminate; lateral nerves 20 to 30 on each side of the midrib, spreading, anastomosing, distinct; petioles 5 to 8 cm long. Pistillate inflorescences up to 45 cm in length, solitary, subtended by an oblong, sessile leaf about 10 cm long and 3 cm wide. Flowers rather numerous, racemosely arranged, their pedicels 2 to 5 mm long. Sepals densely pubescent, oblong-ovate, acute, about 2 mm long. Ovary very densely hirsute; styles 3, glabrous, each cleft nearly to the base into two 5-mm long arms. Young capsules obovate, about 7 mm long, rather densely hirsute with pale, stiff, spreading hairs.

PANAY, Antique Province, Culasi, *Bur. Sci. 32419 McGregor*, May 24, 1918, on forested slopes, altitude about 900 meters.

This species is well characterized by its elongated, narrow, glabrous leaves and its rather densely pubescent inflorescences and hirsute capsules; the indumentum is entirely different from that of *C. ciliatum*.

[6] Engl. Pflanzenreich 47 (1911) 29, *f. 7 D.*

OMPHALEA Linnaeus

OMPHALEA GRANDIFOLIA sp. nov.

Frutex erectus, haud ramosus, circiter 3 m altus, inflorescentiis parce pubescentibus exceptis glaber; foliis coriaceis, longissime petiolatis, oblongis, 50 ad 60 cm longis, apice breviter acuminatis; nervis utrinque 14 ad 18, perspicuis; inflorescentiis lateralibus, diffusis, multiramosis, usque ad 80 cm longis, ramis irregulariter dispositis, elongatis; floribus ♀ fasciculatis, pedicellatis, circiter 2 mm longis; fructibus junioribus subglobosis, circiter 3 cm diametro.

An erect unbranched shrub, about 3 m high, the trunk 4 to 8 cm in diameter, glabrous except the somewhat puberulent inflorescences. Leaves coriaceous, shining, oblong, 50 to 60 cm long, 15 to 20 cm wide, the apex shortly acuminate, base acute or obtuse and with two conspicuous glands on the upper surface at the junction with the petiole: lateral nerves 14 to 18 on each side of the midrib, prominent as are the reticulations; petioles 14 to 28 cm long. Inflorescences lateral, much branched, diffuse, rather rigid, up to 80 cm in length. The primary branches irregularly arranged. Pistillate flowers numerous, fascicled, each fascicle usually subtended by a conspicuous gland. Pedicels about 8 mm long. Sepals 5, obtuse, oblong-elliptic to elliptic-ovate, about 2 mm long, membranaceous, slenderly nerved, their margins slightly ciliate. Ovary ovoid, glabrous, 3-celled. Immature fruit subglobose, about 3 cm in diameter, 3-celled, each cell with a single large seed.

PANAY, Capiz Province, Mount Macosolon and Jamindan, *Bur. Sci. 30813* (type), *30825 Ramos & Edaño,* April 23, and May 25, 1918, in damp forests along small streams.

This species is strongly characterized by its very large, long-petioled leaves as well as by its habit, it being described by the collectors as strictly erect and unbranched; the pistillate inflorescences are unusually large.

OMPHALEA SARGENTII sp. nov.

Frutex scandens, glaber; foliis oblongis, subcoriaceis, in siccitate pallidis, nitidis, utrinque concoloribus, circiter 20 cm longis, basi rotundatis ad obtusis, utrinque glandulis solitariis perspicuis instructis, apice obtusis ad brevissime acuminatis vel acutis, nervis utrinque circiter 8, perspicuis; fructibus globosis, circiter 5 cm diametro.

A scandent glabrous shrub reaching a length of 20 cm and a diameter of 4 cm, the branches terete, longitudinally striate when dry, pale; leaves subcoriaceous, pale and shining when dry, oblong, about 20 cm long, 8 to 9 cm wide, base rounded to obtuse, with a prominent gland on each side at the juncture of the lamina with the petiole, the apex obtuse or very shortly acute or acuminate; lateral nerves about 8 on each side of the midrib, prominent on the lower surface, distant, anastomosing, the reticulations lax; petioles stout, about 3.5 cm long; infructescences up to 40 cm in length, the branches few, short, spreading. Fruits globose, about 5 cm in diameter, smooth, glabrous, dark-brown when dry, shining, the seeds about 3 cm long and wide.

BANCALAN, between Palawan and Balabac, *C. M. Weber*, September 2, 1916, in forests, altitude about 3 meters.

A species well characterized by its few-nerved leaves and large fruits, by which it is readily distinguished from *Omphalea philippinensis* Merr. and *O. malayana* Merr.; the fourth species for the Philippine-Malayan region. It is dedicated to Dr. C. S. Sargent, director of the Arnold Arboretum, under whose auspices Weber's collection was made.

EXCOECARIA Linnaeus

EXCOECARIA PACHYPHYLLA sp. nov. § *Commia*.

Frutex circiter 2 m altus, glaber, ramis ramulisque teretibus; foliis oppositis, coriaceis, oblongis ad oblongo-ovatis, integris, usque ad 10 cm longis, apice breviter et late obtuse acuminatis, basi acutis, nervis utrinque circiter 9, patulis, vix perspicuis; racemis ♂ terminalibus, circiter 2 cm longis, bracteolis unifloris, floribus distincte pedicellatis, sepalis ovatis, margine glanduloso-denticulatis.

A glabrous shrub about 2 m high, the branches and branchlets terete, usually reddish-brown. Leaves opposite, thickly coriaceous, oblong to oblong-obovate, 7 to 10 cm long, 2.5 to 3.5 cm wide, smooth, shining, the upper surface pale-olivaceous, the lower paler when dry, entire, base acute, apex with a short, very broad, blunt acumen; lateral nerves about 9 on each side of the midrib, not prominent, spreading, rather obscurely anastomosing, usually more distinct on the upper than on the lower surface; petioles 1 to 1.5 cm long. Staminate racemes terminal, simple, solitary, about 2 cm long, the bracteoles ovate, rounded, about 1 mm long, the margins obscurely glandular-denticulate, 1-flowered, the glands prominent, about 1 mm in diameter. Pedicels stout, about 1 mm long. Sepals suborbicular, about 0.8

mm in diameter, margins obscurely glandular-denticulate. Filaments nearly 1 mm long. Pistillate flowers and fruits not seen.

LUZON, Tayabas Province, Mount Cadig, *Bur. Sci. 25404 Yates*, December 12, 1916, in the mossy forest, altitude at least 800 meters.

A characteristic species, readily distinguished by its thick, entire, opposite leaves, and its short, simple, terminal or subterminal racemose, not spicate, staminate inflorescences. Under Pax and Hoffmann's arrangement of the species of *Excoecaria*, it comes nearest to *Excoecaria crenulata* Wight and *E. bantamensis* Muell.-Arg.

EXCOECARIA MIRANDAE sp. nov. § *Commia*.

Frutex monoicus, circiter 2 m altus, glaber; foliis oppositis, chartaceis, oblongis, usque ad 13 cm longis, olivaceis, integris, acuminatis, basi acutis ad subobtusis, nervis utrinque circiter 9, curvatis, anastomosantibus, reticulis subobsoletis; inflorescentiis junioribus terminalibus, circiter 4 cm longis, basi floribus ♀ solitariis instructis; bracteolis unifloris; floribus ♂ sepalis lanceolatis, 1.5 mm longis, acuminatis, ♀ ovatis, 2.2 mm longis, longe et tenuiter acuminatis.

A monoecious glabrous shrub about 2 m high, the branches and branchlets slender, terete, reddish-brown. Leaves opposite, chartaceous, olivaceous when dry, the lower surface paler than the upper, 10 to 13 cm long, 3.5 to 4 cm wide, entire, base acute, apex distinctly acuminate, the acumen rather blunt; lateral nerves about 9 on each side of the midrib, curved, rather distinct, anastomosing, the reticulations obsolete or subobsolete; petioles 5 to 8 mm long. Inflorescences terminal, when young about 4 cm long, with a single pistillate flower at the base, the bracteoles 1-flowered. Pistillate flowers: Sepals ovate, 2.2 mm long, long and slenderly acuminate, the shoulders minutely denticulate. Ovary ovoid, glabrous, the style-arms rather stout, about 2 mm long. Staminate flowers: Sepals lanceolate, long-acuminate, about 1.3 mm long, the bracts ovate, acuminate. Fruits apparently about 1.5 cm in diameter, the pericarp crustaceous.

BASILAN, Bocboc Barrio, near Matangal Point, *For. Bur. 20062 Miranda*, October 4, 1912, altitude about 25 meters.

The alliance of this species is manifestly with *Excoecaria bicolor* Hassk., from which it is distinguished by being monoecious, although Hasskarl states that *E. bicolor* is sometimes monoecious; by its longer inflorescences; and by its prominently long-acuminate pistillate sepals.

EXCOECARIA MACROPHYLLA (Hassk.) J. J. Sm. in Meded. Dept. Landbouw 10 (1910) 611.

LUZON, Nueva Ecija Province, Muñoz, *For. Bur. 6029 Zschokke*, November, 1906; Pangasinan Province, Umingan, *For. Bur. 26299 Ablaza*, September, 1916, in both localities known as *sausao* or *sausau*.

This species has previously been reported only from Java and from Borneo, but I can detect no characters by which the Luzon form can be distinguished from the Javan one, of which three specimens collected by Koorders are before me. The Philippine form has intensely irritating milky juice, Ablaza merely stating that it burns the skin, while Zschokke states: "The sap is milky and the natives dread it very much. It makes painful burns, destroying the skin as an acid does."

SAPIUM Jacquin

SAPIUM LUZONICUM (Vidal) comb. nov.

Myrica luzonica Vidal Sinopsis Atlas (1883) 40, *t. 90, f. B;* Rolfe in Journ. Linn. Soc. Bot. 21 (1884) 316.

Sapium merrillianum Pax & Hoffm. in Engl. Pflanzenreich 52 (1912) 213.

Sapium lateriflorum Merr. in Philip. Journ. Sci. 1 (1906) Suppl. 83; Elm. Leafl. Philip. Bot. 4 (1911) 1303, non Hemsl. (1901).

Urandra elliptica Merr. in Philip. Journ. Sci. 5 (1910) Bot. 195.

The type of *Myrica luzonicum* Vidal was from Montalban, Rizal Province, Luzon, a specimen with staminate flowers; and, while the original description is short, both it and its accompanying figure definitely place the species as identical with the one I later described as *Sapium lateriflorum*, this being later renamed by Pax and Hoffmann *Sapium merrillianum*. The type of *Sapium lateriflorum* Merr. was from Bataan Province, Luzon. The form later described by me as *Urandra elliptica*, the type being a fruiting specimen, was also from Bataan Province; it is clearly synonymous with *Sapium luzonicum*, representing a plant with relatively broader leaves than the common form. The species is now represented by the following specimens:

LUZON, Ilocos Sur Province, Tambor, *For. Bur. 13027 Paraiso;* Danglao, *For. Bur. 23109 Cruz:* Bulacan Province, Angat, *Merrill Phil. Pl. 1407:* Bataan Province, Mount Mariveles, Lamao, *Williams 643, For. Bur. 338 Barnes, For. Bur. 2565 Borden* (type of *Sapium lateriflorum* Merr. and of *S. merrillianum* Pax), *For. Bur. 17601, 19153 Curran;* Duale, *For. Bur. 20003 Topacio* (type of *Urandra elliptica* Merr.): Rizal Province, San Isidro, *For.*

Bur. 1991 Ahern's collector, Merrill Phil. Pl. 2013: Laguna Province, Mount Maquiling, Los Baños, *For. Bur. 11676, 19808 Whitford, For. Bur. 11919 Tamesis, For. Bur. 22955 Calycosa, For. Bur. 13232 Curran.* MINDORO, *For. Bur. 9913 Merritt.* PALAWAN, Brooks Point, *Elmer 12630.* TICAO, *For. Bur. 1080 Clark.* BUCAS GRANDE, *Bur. Sci. 35078 Ramos & Pascasio.* MINDANAO, Davao Province, *For. Bur. 27587 De Mesa.*

In forested ravines and on forested slopes at low altitudes. Endemic.

EUPHORBIA Linnaeus

EUPHORBIA LUZONIENSIS sp. nov. § *Chamaesycae.*

Herba perennis, tenuibus, prostratis, e radicis lignosis, ramulis parce pubescentibus; foliis orbicularis ad orbiculari-ovatis, subcoriaceis, integris vel obscure crenulatis, apice late rotundatis, basi inaequilateralibus, usque ad 8 mm longis; involucris numerosis 1.5 mm longis cymosis, cymis 1 ad 1.5 cm longis, foliis depauperatis 1 ad 3 mm longis instructis, glandulis reniformibus, integris; capsulis ovoideis, 1.5 mm longis, 3-angulatis, leviter pubescentibus.

A slender, prostrate, dichotomously branched, perennial herb from thick woody roots, the branchlets very slightly pubescent, the woody roots up to 8 mm in diameter. Branches 1 mm in diameter or less, the internodes up to 1.5 cm in length. Leaves orbicular to orbicular-ovate, 5 to 8 mm long, subcoriaceous, entire or very obscurely crenulate, apex broadly rounded, base distinctly inequilateral, more or less oblique on one side, sometimes shallowly laterally cordate, olivaceous when dry, the upper surface glabrous, the lower when young often slightly pubescent, soon becoming glabrous; lateral nerves 3 or 4 on each side of the midrib, faint, obscure, the reticulations close; petioles 1 to 2 mm long; stipules broadly ovate, thin, denticulate, sometimes cleft, 0.5 to 1 mm long. Involucres rather numerous, forming terminal leafy cymes 1 to 1.5 cm long and about as wide, the leaves associated with the involucres in the inflorescence similar to the normal ones but very much smaller, 1 to 3 mm long. Individual involucres cup-shaped, very slightly pubescent, about 1.5 mm long, their pedicels 1 to 1.5 mm long; bracteoles thin, short, somewhat ciliate; glands reniform, about 0.6 mm wide, the appendages entire. Ovary slightly pubescent; styles cleft about one-third to the base, the arms short, somewhat thickened. Capsule ovoid, about 1.5 mm long, very slightly pubescent, 3-angled. Seeds slightly rugose, about 1 mm long.

LUZON, Ilocos Norte Province, between Burgos and Bangui, *Bur. Sci. 27309* bis (type), *27517 Ramos,* March, 1917, on open dry slopes at low altitudes.

This species is distinguished among its congeners such as *Euphorbia humifusa* Willd., *E. makinoi* Hayata, and allied forms by its orbicular leaves and its cymose inflorescences.

EUPHORBIA MAKINOI Hayata in Journ. Coll. Sci. Tokyo 30^1 (1911) 262.

Euphorbia microphylla Hayata op. cit. 20^3 (1904) 79, *t. 5, f. H,* non Heyne.

LUZON, Ilocos Norte Province, Burgos, *Bur. Sci. 27309, 32746 Ramos,* February, 1917, and July, 1918, in open dry places at low altitudes.

This species has previously been known only from Formosa, the specimens cited above agreeing perfectly with Hayata's description and figure. It is very closely allied to *Euphorbia neocaledonica* Boiss., as represented by *Cribs 753* and *758* from New Caledonia, the former number having minutely serrulate leaves, as described by Boissier, the latter having entire leaves.

DETERMINATION OF GLUCOSE AND STARCH BY THE ALKALINE POTASSIUM PERMANGANATE METHOD [1]

By Francisco A. Quisumbing

Of the Laboratory of Agricultural Chemistry, College of Agriculture, University of the Philippines

SIX TEXT FIGURES

No one analytical method has been so useful in the analysis of saccharine products as has Fehling's in its numerous modifications, though many attempts had been made to substitute others, entirely different in principle, for the copper-reducing method. Results have shown that the substitutes have not been as satisfactory, and the copper-reducing method has therefore remained in its classical use. In its more recent modifications, it is one of the most accurate and convenient methods we have. At first sight, it might appear a superfluous task to attempt to find a substitute for such a reliable method, but I thought it would be worth while to work out an entirely different, simpler, and more rapid one to save time and material in the numerous analyses of starchy products that the department of chemistry has to perform in connection with the investigation of the feeding values of grains and root crops.

Among the many other possible methods, the alkaline potassium permanganate appeared to me to be the most promising. Previous preliminary experiments have shown that, when glucose was oxidized by alkaline potassium permanganate solution of a definite concentration, the amount oxidized decreased with increase in concentration of the former, if the length of time of heating was the same. The same thing has been observed also by Witzemann and others. I have studied the conditions of the reaction, by using different concentrations of alkali and of potassium permanganate, and by standardizing the time of heating, as was done with the copper-reducing method. From the results obtained a procedure was worked out for the deter-

[1] This investigation was undertaken at the suggestion of Assistant Professor Manuel L. Roxas and carried out under his personal supervision. The author desires to express his thanks and appreciation to Professor Roxas for his advice and suggestion.

mination of starch in starchy products, and a glucose-starch table, similar to the tables of Munson and Walker and of Allihn, was constructed. These results are given in the following pages.

DISSOCIATION OF THE GLUCOSE MOLECULE

According to Mathews,(8) sugars behave as weak acids; that is, the hydrogen of one of the hydroxyl groups dissociates into ion. Cohen (2) has found the dissociation constant of glucose to be 5.9×10^{-13}. It is believed that the dissociating hydrogen is that of the hydroxyl group next to the aldehyde group. Nef,(10) however, believes that the dissociating hydrogen is not always the same. It may be the hydrogen of any of the hydroxyl groups of the glucose molecule.

In the presence of an alkali a glucose salt is formed, and this dissociates into a positive and the negative glucose ion. The latter, being unstable, undergoes a rearrangement resulting in the disturbance of electrical equilibrium and the subsequent formation of easily oxidizable compounds.

ACTION OF THE ALKALI

Mathews's (8) experiments show that, under the action of an alkali, the glucose molecule is broken up into a number of reducing particles. He concludes that, in the rearrangement of the glucose molecule, intramolecular oxidation and reduction take place. These conclusions were derived from his experiments on the rate of formation of acids from sugars by alkalies. According to these experiments, acids are formed secondarily. The first effect of the alkali is to produce easily oxidizable bodies, which in turn become acids—a result perhaps obtained "by intramolecular oxidation or by the reduction of some of the reaction products."

According to Witzemann's(14) views, the alkali serves as a catalyst in facilitating the oxidation of glucose and its decomposition products. These views seem to be confirmed by the works of Nef(10) and his pupils, and by those of Mathews.(8)

THE EFFECT OF ALKALI CONCENTRATION UPON OXIDATION

Glucose and other sugars are easily oxidized in alkaline solutions. It has been found by Mathews and McGuingan(9) that the velocity of oxidation of sugars is much greater in an alkaline than in an acid solution, and the difference in the rate of oxidation of the different sugars studied, observed in the latter solution, disappears in the former. The velocity of oxidation in alkaline solutions of all the common sugars undergoes steady acceleration from the beginning of the reaction and for some time thereafter. When air is the source of oxygen, the optimum concentration of alkali for oxidation is between *N* and 2 *N*, the velocity falling off in either direction.

According to investigations made on the oxidation of sugars with alkaline potassium permanganate solution, smaller concentrations of alkali are more effective than those used in the oxidation with air. Witzemann(14) found that the optimum concentration of alkali lies close to 0.1 to 0.2 *N*, or between these two figures. He also observed that oxidation is markedly induced even by very small concentrations of alkali, 0.014 *N* alkali giving strong effect.

EARLY INVESTIGATIONS OF THE METHOD OF ANALYSIS

One of the earliest investigations on the oxidation of organic substances by potassium permanganate was performed by Berthelot.(1) He worked principally on the oxidation of fats and found that oxidation is greater in an alkaline than in an acid medium. Donath and Ditz(3) found that, when boiled at a high temperature and with relatively high concentration of potassium permanganate, organic bodies give carbon dioxide and water as oxidation products. Smolka,(13) experimenting on simple sugars, found that, when glucose is completely oxidized, the products of oxidation are carbon dioxide and water; and that, when oxidation is carried on in the cold, small amounts of oxalic acid are detected. Karez(6) performed a series of experiments on the oxidation of carbohydrates, using sugar solutions. The sugars were oxidized by heating the solution for fifteen minutes, with potassium permanganate containing 20 per cent of sulphuric acid, and determining the amount of oxalic acid produced by titration with standard potassium permanganate solution. Hetper(5) found that there is a difference both in the products and in the degree of oxidation, when this is carried on in acid or alkaline media. Donath and Ditz,(3) working on the same subject, came to the conclusion that oxalic acid is a product obtained when sugars are oxidized by potassium permanganate in an alkaline solution, while carbon dioxide and water are obtained in an acid medium. This conclusion agrees with that from Witzemann's results.

A series of oxidation experiments with carbohydrates was conducted by Greifenhagen, König and Scholl,(4) whose method of procedure is as follows: A definite number of cubic centimeters of sugar solution is placed in an Erlenmeyer flask and definite volumes of 0.2 *N* potassium permanganate and of 10 per cent potassium hydroxide solutions are added, and the whole mixture is boiled for ten minutes. After this lapse of time the mixture is cooled to 70° and 20 per cent sulphuric acid and 0.2 *N* oxalic acid solutions are added. The excess oxalic acid is titrated by standard potassium permanganate solution until the pink color can be detected. Their work was principally on the oxidation of lactose, sucrose, glucose, raffinose, mannite, maltose, and hydrolyzed starch. They determined the number of grams of carbon dioxide produced in each case. In the determination of starch, a sample of the air-dry material is dried at 40° C. and the ash, water, protein, pentosans, and fat are determined in this dried matter. The hydrolyzed starch solution obtained by inversion is oxidized as described above. The percentage of starch is calculated on the basis of potassium permanganate used in oxidation. Their results with tapioca and rice give percentages of starch higher by 1 per cent than when determined by difference; that is, by subtracting the sum of the percentages of the other constituents (ash, water, protein, fat, pentosans, etc.) from 100.

EXPERIMENTAL

The experimental part of this paper is discussed under the following heads:

A. Determination of the proper concentration of alkali and potassium permanganate solutions in which to carry on oxidation of glucose.
B. Determination of the optimum temperature and time of heating.
C. Application of the method to glucose determination.
D. Application of the method to starch analysis.
E. Comparison of the Munson and Walker method with the one proposed.

A. DETERMINATION OF THE PROPER CONCENTRATION OF ALKALI AND POTASSIUM PERMANGANATE SOLUTIONS IN WHICH TO CARRY ON OXIDATION OF GLUCOSE

To find the effect of oxidizing known amounts of pure glucose in different concentrations of alkali by 0.2 *N*, 0.1 *N*, and 0.05 *N* potassium permanganate solutions, respectively, experiments were conducted following a procedure similar to that described under C, and using a final volume of 60 cubic centimeters for the mixture.

DISCUSSION OF RESULTS

Table 1 is self-explanatory. The results can be visualized and discussed clearly with the aid of the curves in figs. 1, 2, and 3.

TABLE 1.—*Oxidation of different concentrations of glucose in different concentrations of alkali by 0.2 N, 0.1 N, 0.05 N potassium permanganate solutions, respectively.*

[Figures show amounts in cubic centimeters of potassium permanganate reduced by glucose.]

Glucose.	Concentration of alkali.				
	0.8 *N*.	0.6 *N*.	0.4 *N*.	0.2 *N*.	0.04 *N*.
OXIDATION OF GLUCOSE BY 0.2 *N* POTASSIUM PERMANGANATE.					
mg.					
50	26.26	27.24	26.52	30.79	26.57
40	24.03	24.61	24.82	27.56	23.64
30	17.46	19.16	18.42	22.54	17.23
20	13.44	13.47	12.81	16.96	12.44
10	6.27	7.59	6.41	10.81	6.09
OXIDATION OF GLUCOSE BY 0.1 *N* POTASSIUM PERMANGANATE.					
50	21.36	22.13	22.02	22.70	21.80
40	19.89	21.86	20.55	21.61	21.60
30	17.98	21.16	18.58	21.05	20.17
20	16.72	18.59	17.00	17.41	17.26
10	10.32	11.83	11.61	11.60	10.97
OXIDATION OF GLUCOSE BY 0.05 *N* POTASSIUM PERMANGANATE.					
25	25.01	24.22	25.30	25.57	24.95
20	23.00	22.34	24.24	24.95	23.59
15	21.15	21.15	22.92	22.85	22.41
10	20.12	19.46	21.56	21.17	20.15
5	12.37	8.13	10.90	11.04	12.67
2.5	7.12	6.38	8.04	7.71	7.41

These curves bring out the relation between the volume of potassium permanganate solution and the alkali concentration used with varying concentrations of glucose for 0.2 *N*, 0.1 *N*, and 0.05 *N* potassium permanganate, respectively. The curves in figs. 4 and 5 bring out the relation between the amount of glucose used and the value of potassium permanganate reduced in terms of 0.05 *N*. It is apparent that for 0.2 *N* potassium permanganate, 0.2 *N* alkali furnishes the most favorable concentration for the oxidation of glucose. This is shown by curve 4 A, fig. 4, in which all the points are above the others. It is to be noted that the concentration of alkali in all of these experiments is the actual concentration in the mixture, while the normality of the potassium permanganate is that of the standard stock solution used and not that of the mixture. When the concentration of potassium permanganate is 0.1 *N*, 0.6 *N* alkali (curve 2B, fig. 5) seems to furnish the concentration most favorable for the oxidation of glucose, when the amount of the latter in the reaction mixture does not exceed 40 milligrams. In the latter case 0.2 N is again the most favorable concentration of alkali. When the concentration of alkali is 0.04 N (curve 5B, fig. 5) there seems to be a more uniformly rising curve when the amount of glucose is increased from 10 to 40

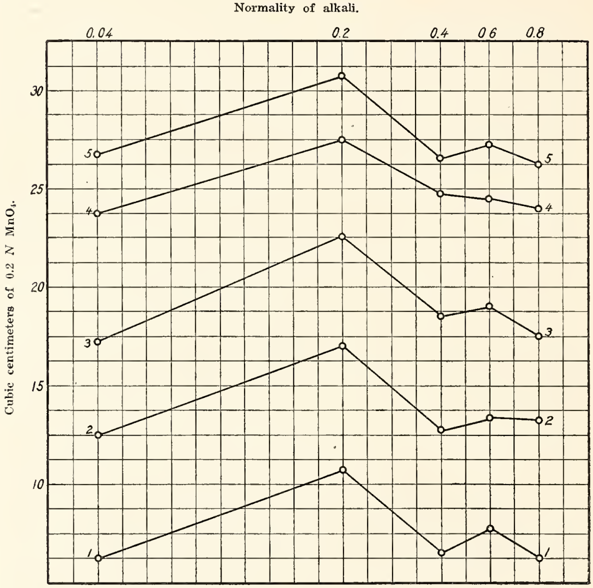

FIG. 1. Effect of normality of alkali on the amount of potassium permanganate in cubic centimeters of 0.2 N solution reduced to glucose. Curves 1, 2, 3, 4, and 5 are for 10, 20, 30, 40, and 50 milligrams, respectively.

milligrams. When the concentration of potassium permanganate is 0.05 N (curves C, fig. 5) the differences between the effects of the several concentrations of alkali tend to disappear.

In choosing the concentrations of alkali and of potassium permanganate to be used in devising a method for the quantitative determination of glucose and starch in agricultural products, I considered the following points:

1. The selection of a concentration which would be least likely to oxidize soluble substances. 0.1 *N* potassium permanganate was chosen, in preference to either the 0.2 *N* or the 0.05 *N*, because it was thought that this concentration would have less chance than would the 0.2 *N* to oxidize soluble substances other than glucose that might be present in the commercial product, and at the same time would give more accurate results; while, on the other hand, it would give a greater range of glucose concentration than the 0.05 *N*.

2. The selection of a concentration of alkali which would give a wider range of concentration of glucose consistent with uni-

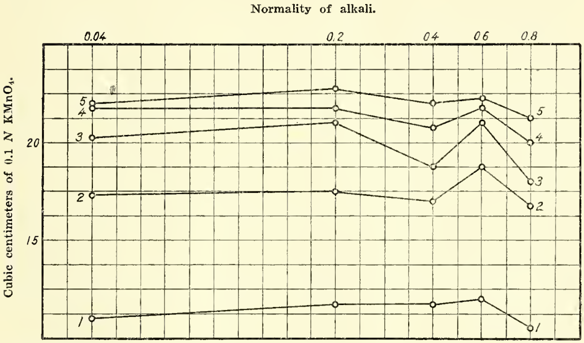

FIG. 2. Effect of normality of alkali on the amount of potassium permanganate in cubic centimeters of 0.1 *N* solution reduced to glucose. Curves 1, 2, 3, 4, and 5 are for 10, 20, 30, 40, and 50 milligrams, respectively.

formity of results; 0.04 *N*, as shown by the uniform slope of its curve, fulfills this condition.

B. DETERMINATION OF THE OPTIMUM TEMPERATURE AND TIME OF HEATING

STANDARDIZATION OF HEATING POWER

Mechanical arrangement.—The solution is heated in a 400 cubic centimeter Erlenmeyer flask, closed with a two-hole rubber stopper; one hole holds the thermometer, the other an exit tube for the steam. The flask is placed on an asbestos wire gauze over a tripod, and the flame so regulated that it will heat 60 or 100 cubic centimeters of water from 29° to 95° C. in approximately two or four minutes, as the case may be. Draught and consequent changes of temperature are prevented by partially protecting the apparatus with a cylindrical hood of asbestos board. This arrangement of the apparatus is of great advantage because little or no fluctuation of the mercury thread occurs, and air is excluded by the steam arising from the liquid. It is important that the apparatus and its accessories be at room temperature (29° C.) before starting the test.

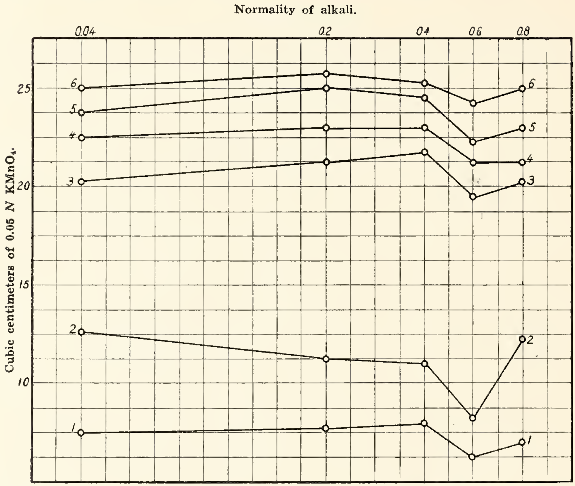

FIG. 3. Effect of normality of alkali on amount of potassium permanganate in cubic centimeters of a 0.05 N solution reduced by glucose. Curves 1, 2, 3, 4, 5, and 6 are for 2.5, 5, 10, 15, 20, and 25 milligrams, respectively.

PROCESS OF STANDARDIZATION

In the oxidation process the time of boiling is reckoned from the point when the temperature within the heated liquid is 95° C., rather than from the time when the liquid just begins to boil. Numerous trials show that it is practically impossible to determine exactly by visual observation when the mixture begins to boil. There is an easily measurable interval during which an observer cannot decide from what point he shall reckon the time of boiling. The appearance of bubbles does not usually indicate the beginning of boiling because bubbles of gas escape at irregular intervals before real boiling takes place. Slight

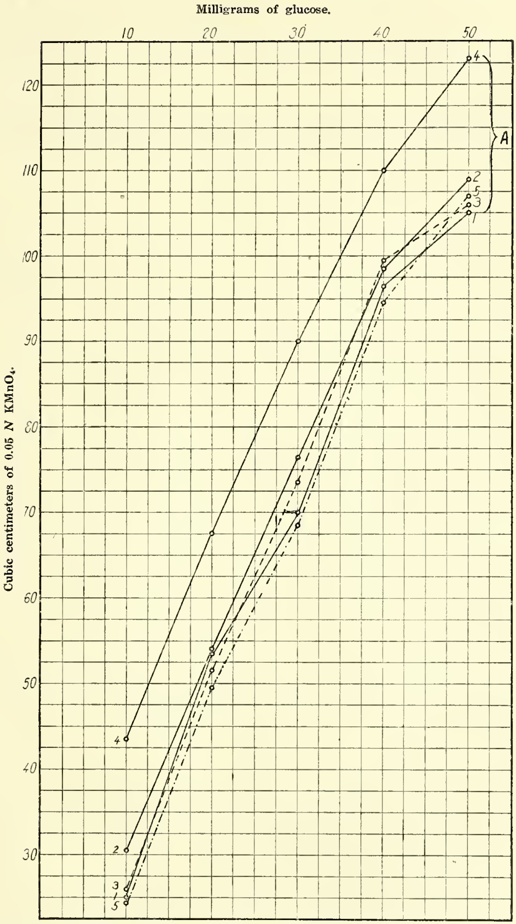

FIG. 4. Relation between milligrams of glucose and cubic centimeters of 0.05 N potassium permanganate solution reduced. Curves A are for 0.2 N potassium permanganate; curve 1 is for 0.8 N alkali solution; curve 2, for 0.6 N solution; curve 3, for 0.4 N solution; curve 4, for 0.2 N solution; curve 5, for 0.04 N solution.

deviations from this standard are negligible if only small quantities of glucose are involved in the analysis; but they become of great importance when relatively large amounts are present in the solution.

Experiments show that the mercury thread begins to fluctuate approximately thirty seconds after the thermometer reaches 95°. The temperature at the end of the thirty seconds, and just when

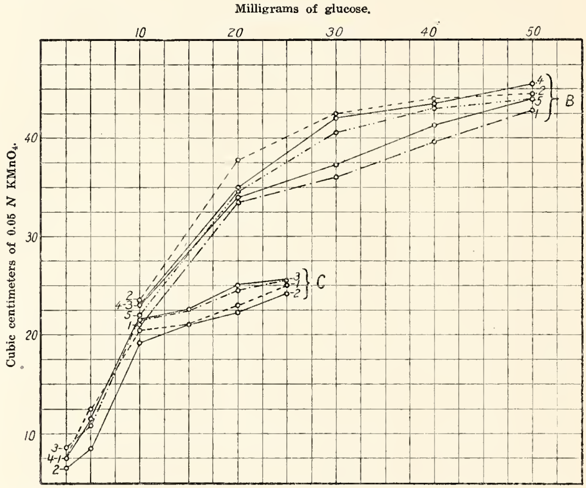

FIG. 5. Relation between milligrams of glucose and cubic centimeters of 0.05 *N* potassium permanganate solution reduced. Curves B are for 0.1 *N* and curves C, for 0.05 *N* potassium permanganate. Curve 1 is for 0.8 *N* alkali solution; curve 2, for 0.6 *N* solution; curve 3, for 0.4 *N* solution; curve 4, for 0.2 *N* solution; curve 5, for 0.04 *N* solution.

fluctuation begins, has been observed to be about 104° to 105° C. when the dilution is 100 cubic centimeters, and 110° C. when the dilution is 60 cubic centimeters. Boiling of the solution starts within 5° before fluctuation begins. At this point, the rise of temperature is in most cases so rapid that it is impossible to time it accurately.

THE INFLUENCE OF TIME AND TEMPERATURE UPON THE OXIDATION

A series of experiments was performed to determine the influence of temperature and time of heating upon the degree of oxidation of glucose, using 0.1 *N* alkaline potassium permanganate solution. The total number of cubic centimeters of 0.1 *N* potassium permanganate used for oxidation was obtained by heating the alkaline potassium permanganate mixtures of the same composition to different temperatures, and for different lengths of time after 95° C. had been reached. The results are given in Tables 2, 3, and 4.

TABLE 2.—*Glucose oxidation by potassium permanganate at various temperatures rising from 29° to 95° C. in four minutes.*

[For final volume of mixture of 60 cubic centimeters.]

Observation.	Temperature.	Time of heating.		0.1 *N* potassium permanganate.	Oxidation.
	°*C.*	*Min.*	*sec.*	*cc.*	*Per cent.*
1	60	1	36	6.53	49.69
2	70	2	02	7.50	56.82
3	80	2	48	9.05	68.56
4	90	4	32	10.57	80.07
5	95	4	41	10.59	80.02
6			[a] 30	10.80	81.81
7			[a] 60	11.12	84.50
8			[a] 90	11.18	84.70
9			[a] 120	11.47	86.96
10			[a] 150	11.45	86.96
11			[a] 180	11.50	87.01

[a] Length of time after 95° C. had been reached.

TABLE 3.—*Glucose oxidation by potassium permanganate at various temperatures rising from 29° to 95° C. in two minutes.*

[For final volume of mixture of 60 cubic centimeters.]

Observation.	Temperature.	Time of heating.		0.1 *N* potassium permanganate.	Oxidation.
	°*C.*	*Min.*	*sec.*	*cc.*	*Per cent.*
1	60	0	45	5.60	42.42
2	70	1	00	6.15	46.50
3	80	1	15	6.70	50.76
4	90	1	45	8.30	62.87
5	95	2	00	9.10	68.94
6		0	[a] 30	10.25	77.65
7		0	[a] 60	10.77	81.60
8		0	[a] 90	11.10	84.10
9		0	[a] 120	11.23	85.10
10		0	[a] 150	11.45	86.72
11		0	[a] 180	11.52	87.04

[a] Length of time after 95° C. had been reached.

TABLE 4.—*Glucose oxidation by potassium permanganate at various temperatures rising from 29° to 95° C. in two minutes.*

[For final volume of mixture of 100 cubic centimeters.]

Observation.	Temperature.	Time of heating.	0.1 *N* potassium permanganate.	Oxidation.
	°C	*Min. sec.*	*cc.*	*Per cent.*
1	60	0 55	8.55	64.77
2	70	1 15	8.55	64.77
3	80	1 30	9.68	73.33
4	90	1 50	10.18	77.12
5	95	2 00	10.93	82.80
6		[a] 30	11.50	87.12
7		[a] 60	11.80	89.39
8		[a] 90	12.04	91.21
9		[a] 120	12.08	91.51
10		[a] 180	12.53	94.92

[a] Length of time after 95° C. had been reached.

Table 2 shows the volumes of 0.1 *N* potassium permanganate used to oxidize 10 milligrams of dextrose at different intervals of temperature for a total volume of 60 cubic centimeters and with heating power so regulated that it raises the temperature of the mixture from 29° to 95° C. in exactly four minutes. In all determinations ten or eleven quadruplicate observations were made. Column four shows the actual number of cubic centimeters of potassium permanganate used for oxidation, and column five gives these same values in percentage of the volume of 0.1 *N* potassium permanganate solution required for the complete oxidation to carbon dioxide and water of 10 milligrams of glucose. For each determination blanks were run, and the values in column four are actual values minus the corrections for the average blanks.

Tables 3 and 4 are similar to Table 2, but the heating power here is that required to raise the temperature of the mixture, 60 cubic centimeters and 100 cubic centimeters, respectively, from 29° to 95° C. in exactly two minutes.

Tables 2 and 3 were prepared by oxidizing the glucose with 25 cubic centimeters of 0.1 *N* potassium permanganate solution diluted to a final volume of 60 cubic centimeters, while Table 4 was obtained by using 50 cubic centimeters of 0.1 *N* potassium permanganate diluted to a final volume of 100 cubic centimeters. The procedure followed was that described under C, with corresponding modifications.

The data in these tables are visualized in fig. 6 in which the abscissas represent the temperatures and time intervals, and the ordinates the values given in column four. The curves in fig. 6 show in a general way that the percentage of glucose oxidized increases with increase in temperature and in time of heating. Curve 1 indicates, however, that the reaction does not proceed as regularly with the longer time of heating as with the shorter. The percentages of glucose oxidized are higher in Table 4 than in Tables 2 and 3, because the concentration of potassium permangate is larger in the mixture for Table 4 than for the other two.

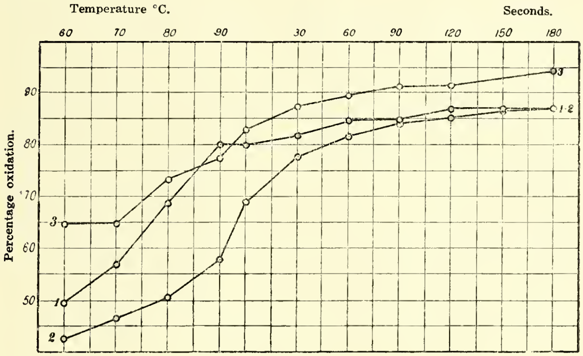

FIG. 6. Effect of temperature and length of heating on the percentage of glucose oxidation by 0.1 *N* potassium permanganate solution. Curve 1 is for heating power of four minutes and volume of mixture of 60 cubic centimeters. Curves 2 and 3 are for heating power of two minutes and for 60 and 100 cubic centimeters, respectively.

In view of these results the conditions in Table 4 have been adopted as standard for the proposed method:

a. 100 cubic centimeters for the final volume of the mixture.

b. A heating power so regulated that it will raise the temperature of 100 cubic centimeters of the mixture from 29° to 95° C. in exactly two minutes.

c. A total time of heating of four minutes: two minutes to raise the temperature from 29° to 95° C. and two minutes more thereafter.

C. APPLICATION OF THE METHOD TO GLUCOSE DETERMINATION

METHOD OF PROCEDURE

Place 50 cubic centimeters of 0.1 *N* potassium permanganate, 25 cubic centimeters of a solution of sodium carbonate containing 8.48 grams of anhydrous sodium carbonate per liter, and

25 cubic centimeters of the glucose or hydrolyzed starch solution in an Erlenmeyer flask, or 10 cubic centimeters of the solution to be analyzed and 15 cubic centimeters of distilled water, to make the volume exactly 100 cubic centimeters. Place the flask on the heating device described on page 587 with the heating power so regulated that its temperature is raised from 29° to 95° C. in two minutes, and heat it for exactly two minutes after the temperature has reached 95°C. Remove the flask and add gradually 25 cubic centimeters of 28 per cent sulphuric acid and 25 cubic centimeters of 0.1 *N* oxalic acid solutions. Titrate the excess of oxalic acid against standard potassium permanganate solution, adding the latter until the liquid assumes a pink color which it retains for a few seconds. The sum of the number of cubic centimeters of 0.1 *N* potassium permanganate used in oxidation and in titration minus the number of cubic centimeters of 0.1 *N* oxalic acid solution used gives the total number of cubic centimeters of 0.1 *N* potassium permanganate actually used in oxidation.

Table 5 was prepared with pure glucose. The glucose was obtained by repeated crystallization of Kahlbaum's Traubenzucker from methyl alcohol. It was dissolved in the least pos-

TABLE 5.—*For calculating the weight of glucose and starch from the volume of 0.1 N potassium permanganate.*

0.1 *N* potassium permanganate.	Glucose.	Starch.	0.1 *N* potassium permanganate.	Glucose.	Starch.
cc.	*mg.*	*mg.*	*cc.*	*mg.*	*mg.*
5.40	4	3.72	27.88	23	21.39
6.54	5	4.65	28.48	24	22.32
7.68	6	5.58	29.47	25	23.25
8.76	7	6.51	30.46	26	24.18
9.84	8	7.44	31.67	27	25.11
11.08	9	8.39	32.88	28	26.04
12.32	10	9.30	33.81	29	26.97
13.45	11	10.23	34.75	30	27.90
14.58	12	11.16	35.80	31	28.83
15.75	13	12.09	36.86	32	29.76
16.93	14	13.02	37.58	33	30.69
17.85	15	13.92	38.24	34	31.62
18.77	16	14.88	39.38	35	32.55
20.13	17	15.81	40.52	36	33.48
21.49	18	16.74	41.05	37	34.41
22.74	19	17.67	41.58	38	35.34
23.99	20	18.60	42.22	39	36.17
25.13	21	19.53	42.86	40	37.20
26.28	22	20.46	43.35	41	38.13

sible amount of methyl alcohol and the solution thus obtained was treated with a few cubic centimeters of ether until crystals began to appear. The vessel was then placed in a desiccator over concentrated sulphuric acid and the alcohol allowed to evaporate slowly. The crystals were separated from the mother liquor by suction and washed with small amounts of methyl alcohol and ether, and then dried at 40° C. under vacuum in an apparatus similar to that described in Browne's Handbook of Sugar Analysis, page 23.

D. APPLICATION OF THE METHOD TO STARCH ANALYSIS

DIRECT ACID HYDROLYSIS (MODIFIED TO SUIT CONDITIONS FOR OXIDATION WITH POTASSIUM PERMANGANATE), APPLICABLE TO GLUCOSE AND COMMERCIAL STARCH

Stir a 2- to 3-gram sample of the dry material in a beaker with 50 cubic centimeters of cold water for an hour. Transfer to a filter and wash with 250 cubic centimeters of cold water. Heat the insoluble residue for from three to four hours with 200 cubic centimeters of water and 15 cubic centimeters of sulphuric acid (specific gravity, 1.84) in a flask provided with a reflux condenser. Cool and neutralize exactly with sodium hydroxide solution. Complete the volume to 500 cubic centimeters, filter, and determine the dextrose in an aliquot of the filtrate as directed under the described method of procedure. The number of milligrams of dextrose, or its equivalent in starch in solution, corresponding to the number of cubic centimeters of 0.1 *N* potassium permanganate used by the samples, will be given by the corresponding values in Table 5, by interpolation if necessary.

The factor 0.9 is the theoretical ratio between starch and glucose but, according to Noyes(11) and other investigators, the factor 0.93 more nearly approaches the actual value. The factor 0.93 is used in this work.

THE SALIVA METHOD,(7) APPLICABLE TO ALL PRODUCTS CONTAINING STARCH

The direct acid hydrolysis method just described cannot be applied to the analysis of flour or other plant products containing substances other than starch, as will be seen in Table 6. If, however, the diastase or saliva method is used, results that are comparable with those by the Munson and Walker method are obtained.

Saliva contains the ferment ptyalin, which possesses the power of bringing starch into solution by converting it into dextrin and finally into maltose.

Procedure.—Collect saliva by chewing a piece of paraffin. Filter and neutralize exactly with dilute hydrochloric acid. Heat the gelatinized starch to 40° C., add 25 cubic centimeters of saliva, and allow the solution to remain at 40° C. until a drop of the liquid gives no test for starch with iodine solution. Filter the solution, make the volume to 200 cubic centimeters hydrolyze by the acid hydrolysis method and determine starch in the hydrolysate by the alkaline potassium permanganate method.

Blank determination.—Take an amount of saliva equal to that used in the determination of starch, dilute to 200 cubic centimeters, and proceed as in the determination of starch as given above.

E. COMPARISON OF THE MUNSON AND WALKER METHOD WITH THE ONE PROPOSED

To test the accuracy of the proposed method parallel determinations were run with it and with the Munson and Walker method, using pure glucose, commercial starch, and air-dry flour prepared from some tubers. The analyses of pure glucose are shown below with details given in full. The results with starch and flour are given in Table 6.

ANALYSIS OF PURE GLUCOSE, BY THE MUNSON AND WALKER METHOD

The Munson and Walker method(12) was followed.

Sample 1.—0.4900 gram of glucose was dissolved in 110 cubic centimeters of distilled water and 10 cubic centimeter portions were taken for analysis.

Weight of cuprous oxide.

	Samples. Grams.	Blanks.[a] Grams.
	0.2110	....
	0.2110	0.1083
	0.2116	0.1096
	0.2132	0.1070
	0.2076	....
Average,	0.2109	0.1083

[a] The Rochelle salt solution used in these determinations happened to be an old one, and this is the reason why blanks are very high.

Total weight of cuprous oxide from 10 cubic centimeters of glucose solution, 102.6 milligrams.

102.6 milligrams cuprous oxide, 44.5 milligrams glucose.

Glucose found by analysis, 99.89 per cent.

Sample 2.—0.500 gram of glucose was dissolved in 100 cubic centimeters of distilled water, and 10 cubic centimeter portions were taken for analysis.

Weight of cuprous oxide.

	Samples. Grams.	Blanks. Grams.
	0.1125	0.0015
	0.1141	0.0017
	0.1136	0.0016
	0.1134	....
	0.4536	0.0048
Average,	0.1135	0.0016

Total weight of cuprous oxide from 10 cubic centimeters of glucose solution, 111.9 milligrams.

111.9 milligrams cuprous oxide, 48.6 milligrams glucose.

Glucose found by analysis, 99.20 per cent.

ANALYSIS OF PURE GLUCOSE, BY THE ALKALINE POTASSIUM PERMANGANATE METHOD

Sample 1.—0.100 gram of glucose was dissolved in 100 cubic centimeters of distilled water, and 10 cubic centimeter portions were taken for analysis.

Ten milligrams of glucose required 12.34 cubic centimeters of 0.1 *N* potassium permanganate solution.

12.34 cubic centimeters of 0.1 *N* potassium permanganate according to values in Table 5 are equivalent to 10.02 milligrams of glucose.

Glucose found by analysis, 100.2 per cent.

Sample 2.—0.500 gram of glucose was dissolved in 100 cubic centimeters of distilled water, and 5 cubic centimeter portions were taken for analysis.

25 milligrams of glucose required 29.24 cubic centimeters 0.1 *N* potassium permanganate solution.

29.24 cubic centimeters 0.1 *N* potassium permanganate according to values in Table 5 are equivalent to 24.76 milligrams dextrose.

Glucose found by analysis, 99.04 per cent.

Table 6 shows that the alkaline potassium permanganate used with the direct acid hydrolysis method for the determination of starch in flour gives results that are about 10 per cent higher than those obtained with the Munson and Walker method. This is undoubtedly due to oxidation of soluble substances present in the flour. With commercial starch preparation, the results by the two methods differ by 0.65 per cent, although at times the difference may reach 1 per cent. The determination of flour by hydrolosis with saliva gives results by the two methods which agree very closely.

SUMMARY

The extent to which glucose is oxidized by constant concentration of potassium permanganate varies for the same concentration of glucose with change in the concentration of alkali. In the case of a mixture of 25 cubic centimeters of 0.2 *N* potassium

TABLE 6.—*Analysis of starch and flour by the Munson and Walker and the alkaline potassium permanganate methods.*

Sample No.	Name of sample.	Munson and Walker method.		Alkaline potassium permanganate method.	
		Direct acid hydrolysis method.	Saliva method.	Direct acid hydrolysis method.	Saliva method.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	Corn starch	79.79		80.35	
2	Do	79.98		80.89	
3	Do	83.71		82.96	
4	Do	78.89		79.18	
5	Cassava starch	79.52		78.76	
6	Do	79.43		80.43	
7	Do	78.70		78.01	
8	Do	78.20		77.72	
9	Do	78.70		77.88	
10	Do	78.90		78.03	
11	Arrowroot flour	77.79		84.00	
12	Do	78.90	68.83	84.04	70.39
13	Rice flour	70.94		76.58	
14	Banana flour	56.88		66.75	
15	*Dioscorea doemona* flour	56.88	45.21	68.28	45.32
16	*Dioscorea alata* flour	66.49	60.13	72.86	59.89

permanganate in a volume of 100 cubic centimeters, 0.2 N alkali is found to be the concentration most favorable for the oxidation of glucose, the extent to which this sugar is oxidized declining when the concentration of alkali is changed from this point. In the case of 0.1 N potassium permanganate, there are two concentrations of alkali most favorable for the oxidation of glucose; these are 0.6 N and 0.2 N. The results obtained in these experiments on the concentration of alkali most favorable for the oxidation of glucose by potassium permanganate agree with those of the previous work on the subject. The amount of potassium permanganate used increases uniformly with increasing amount of glucose from 1 to 40 milligrams only when the concentration of alkali is 0.04 N. This is the main reason for choosing this concentration of alkali, for with it more accurate and consistent results and a wider range of concentration of glucose can be obtained. One-tenth N potassium permanganate was chosen in preference to 0.2 N because it was thought that the former concentration would have less power to oxidize organic substances other than glucose when the method is applied to agricultural products, and it will surely give more accurate results.

A new method for the analysis of starch and glucose has been developed and applied to the determination of starch in commercial starch and flour. The method would give results as accurate as the Munson and Walker method with commercial starch. However, it cannot be used with flour with the acid hydrolysis method. For the determination of the latter, the saliva or the diastase method should be used. In either case, the alkaline potassium permanganate is practically as reliable as the Munson and Walker method.

CONCLUSIONS

1. A method for the determination of glucose and starch has been developed.
2. A description of the method is given.
3. The method is applicable to commercial starch, whether hydrolyzed by acid or by diastase.
4. When the flour is analyzed, it should be hydrolyzed by the saliva or the diastase method. If it is hydrolyzed by acid, the results obtained by the new method are about 10 per cent higher than those obtained by the Munson and Walker.
5. Some of the results obtained in these experiments on the concentration of alkali most favorable to the oxidation of glucose by alkaline potassium permanganate agree with those of the previous work on the subject.

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ILLUSTRATIONS

TEXT FIGURES

THE GROWTH OF RICE AS RELATED TO PROPORTIONS OF FERTILIZER SALTS ADDED TO SOIL CULTURES

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FIVE TEXT FIGURES

INTRODUCTION

The essential mineral elements that must enter through the plant roots are nitrogen, potassium, phosphorus, magnesium, calcium, iron, and sulphur. Soils that support plant growth contain all of these elements in suitable compounds. Three of them—magnesium, sulphur, and iron—are usually present in the soil in amounts beyond what the plants need. The elements that are likely to be present in insufficient quantities, or that usually produce marked improvement in plant growth when added to the soil, are phosphorus, nitrogen, potassium, and calcium.(12) Calcium is most frequently added in fertilizer practice as limestone ($CaCO_3$) or as gypsum ($CaSO_4$); and it is the indirect effects of these calcium salts upon the soil that are commonly beneficial, rather than the added supply of calcium as such.

The present study deals with the growth of rice plants in soil cultures to which the three very important elements, phosphorus, nitrogen, and potassium, were added in various proportions. The addition of these elements was made by means of the three salts, primary calcium phosphate [$Ca(H_2PO_4)_2$], ammonium sulphate [$(NH_4)_2SO_4$], and potassium sulphate (K_2SO_4). These three salts are largely used in commercial fertilizers. Primary calcium phosphate is commonly used to supply phosphorus, ammonium sulphate to supply nitrogen, and potassium sulphate to supply potassium. Besides the three elements just mentioned, sulphur and calcium also are added when these fertilizer salts are used. These three fertilizer salts actually contain all of the essential elements for plants except iron and magnesium, and in agricultural work a mixture of the three compounds would be called a complete fertilizer.

In the experiments here reported the three salts were added to the soil in thirty-six different sets of proportions, including all possible sets of proportions with each salt varying in amount, from set to set, by increments of 0.1 of the total salt content of the mixture, which was osmotically the same in all the sets. For these tests rice was employed, growing in a water-saturated soil, in culture vessels having a capacity of approximately 19 liters each. The present experiments are of a preliminary nature; but no previously reported work has dealt with the range of possible sets of proportions in the way here followed, and the results may be valuable to other workers. The study was carried out at the College of Agriculture, at Los Baños, during the period from June to October, 1918, which comprises the most favorable season for the growth of rice in this part of the Philippine Islands. It is a pleasure to acknowledge indebtedness to Prof. B. E. Livingston, of Johns Hopkins University, for aid in the preparation of this paper; and to P. David and F. de Peralta for assistance in the experimentation.

The rice plants were grown to maturity. The total osmotic value of the salts added to the soil was always calculated to be the same, the unit of variation being 0.1 of this calculated value. This method is similar to that already employed in solution cultures and in sand cultures by various workers.[1] In the present experiments with water-saturated soil the salts were supplied in addition to those already present in the soil. To each culture a sufficient quantity of salts was added to give in 19 liters of water a total osmotic concentration of approximately 0.5 atmosphere at 25° C.[2]

It is of course realized that, after addition to the soil, the salts were immediately altered to a greater or less degree by chemical changes and absorption. But so little is known concerning such alterations that they cannot be quantitatively discussed as yet.

The thirty-six different salt combinations may be represented by means of a triangular diagram like that described by Shive in the papers already cited. Such a diagram is shown in fig. 1. In this triangular diagram each of the intersections of lines represents one of the salt combinations used. The lowest row

[1] See the articles by Tottingham, (15) by Shive, (13, 14) and McCall (10) that are cited at the end of this paper.

[2] The culture medium was composed of approximately 19 liters of water-saturated soil. It contained approximately 16,000 grams of moisture-free soil and 12,000 cubic centimeters of solution. The quantity of salt added to each culture was calculated to give approximately 0.5 atmosphere osmotic concentration in 19 liters of solution; this would give approximately 0.79 atmosphere in 12,000 cubic centimeters.

of intersections (R1) represents combinations in which 0.1 of the total osmotic concentration is due to primary calcium phosphate; the second row (R2) represents those having 0.2 due to primary calcium phosphate, etc.; while the apex of the triangle (R8) has 0.8 due to primary calcium phosphate. Similarly, the line forming the left-hand margin of the triangle represents combinations in which 0.1 of the osmotic value is due to ammonium sulphate, while the angle at the extreme right represents a combination having 0.8 due to this salt. Likewise, the line

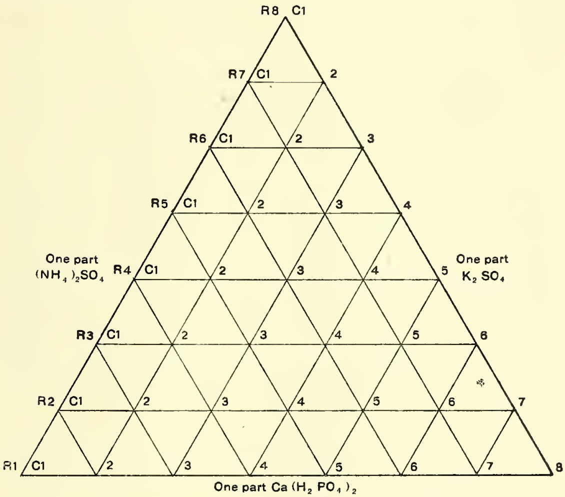

FIG. 1. Culture numbers and osmotic proportions of the three salts.

at the right-hand margin denotes combinations in which 0.1 of the total osmotic value is due to potassium sulphate, while the angle at the extreme left denotes a combination in which 0.8 are due to this salt. Following the method employed by Shive, each culture is designated by the row number and the number of the culture within the row—for example, R1C5. The salt mixture for this culture has 0.1 of its total osmotic value due to primary calcium phosphate, 0.5 due to ammonium sulphate, and 0.4 due to potassium sulphate.

TABLE 1.—*Number of gram molecules of each salt required in 1 liter of water, to produce from 0.1 to 0.8 of a total osmotic concentration of approximately 0.5 atmosphere.*

Tenths of 0.5 atmosphere.	$Ca(H_2PO_4)_2$.	$(NH_4)_2SO_4$.	K_2SO_4.
1	0.00081	0.00081	0.00081
2	0.00161	0.00161	0.00161
3	0.00242	0.00242	0.00242
4	0.00323	0.00323	0.00323
5	0.00404	0.00404	0.00404
6	0.00485	0.00485	0.00485
7	0.00566	0.00566	0.00566
8	0.00647	0.00647	0.00647

The amount of each salt needed to produce the required partial concentrations has been approximately calculated by means of the van't Hoff equation for osmotic pressure. The general method used in such calculations is presented in detail in the paper by Tottingham previously mentioned. Table 1 gives the calculated number of gram molecules of each salt required to produce from 0.1 to 0.8 of the total osmotic concentration of approximately 0.5 atmosphere in 1 liter of water. The culture medium used was composed of saturated soil with water standing to a depth of about 3 centimeters on the surface, and occupied a volume of approximately 19 liters. Accordingly, the values given in Table 1 were multiplied by 19 to obtain the amount of each salt required for each of the thirty-six cultures of these tests. The values thus calculated are shown in Table 2, where they are expressed both in terms of gram molecules and in terms of grams, for each of the salts.

TABLE 2.—*Amount of each salt, expressed in grams and in gram molecules, that was added to the 19 liters of water-saturated soil of each culture.*

Tenths of 0.5 atmosphere.	$Ca(H_2PO_4)_2$.		$(NH_4)_2SO_4$.		K_2SO_4.	
	gm. mol.	*gm.*[a]	*gm. mol.*	*gm.*	*gm. mol.*	*gm.*
1	0.0154	3.60	0.0154	2.03	0.0154	2.68
2	0.0307	7.19	0.0307	4.05	0.0307	5.35
3	0.0461	10.78	0.0461	6.08	0.0461	8.02
4	0.0614	14.37	0.0614	8.11	0.0614	10.70
5	0.0768	17.97	0.0768	10.14	0.0768	13.38
6	0.0922	21.57	0.0922	12.16	0.0922	16.05
7	0.1075	25.15	0.1075	14.19	0.1075	18.73
8	0.1228	28.75	0.1228	16.22	0.1228	21.40

[a] Grams of the anhydrous salt.

TABLE 3.—*Culture numbers and composition of each of the salt combinations. Also, average height of the plants at time of flowering; relative air-dry yield of tops; relative air-dry yield of grain; relative number of fruiting panicles—for two plants.*

Culture No.	Amount of salts.			Growth and yield data for two plants.			
	Ca $(H_2PO_4)_2$.	$(NH_4)_2SO_4$.	K_2SO_4.	Relative average height of plants, Sept. 17.	Relative dry yield of tops.	Relative yield of grain.	Fruiting panicles.
	gm. mol.	*gm. mol.*	*gm. mol.*	*cm.*	*gm.*	*gm.*	
R1C1	0.0154	0.0154	0.1228	59 L	21 L	20 L	26 L
R1C2	0.0154	0.0307	0.1075	76	39	42	33 L
R1C3	0.0154	0.0461	0.0922	83	53	50	39
R1C4	0.0154	0.0614	0.0768	90	72	67	37
R1C5	0.0154	0.0768	0.0614	91H	79H	52	52
R1C6	0.0154	0.0922	0.0461	91H	84H	96H	52
R1C7	0.0154	0.1075	0.0307	93H	88H	91H	67H
R1C8	**0.0154**	**0.1228**	**0.0154**	**96H**	**100H**	**100H**	**100H**
					[b](206)	[b](140)	(54)
R2C1	0.0307	0.0154	0.1075	72 L	23 L	20 L	26 L
R2C2	0.0307	0.0307	0.0922	74 L	35 L	41	37
R2C3	0.0307	0.0461	0.0768	78	50	46	39
R2C4	0.0307	0.0614	0.0614	88	68	56	50
R2C5	0.0307	0.0768	0.0461	97H	85H	63	72H
R2C6	0.0307	0.0922	0.0307	98H	93H	94H	70H
R2C7	0.0307	0.1075	0.0154	88	67	76H	48
R3C1	0.0461	0.0154	0.0922	68 L	21 L	20 L	24 L
R3C2	0.0461	0.0307	0.0768	74 L	40	22 L	37
R3C3	0.0461	0.0461	0.0614	80	57	56	46
R3C4	**0.0461**	**0.0614**	**0.0461**	**100H**	65	70	56H
				[a](138)			
R3C5	0.0461	0.0768	0.0307	94H	78	79H	65H
R3C6	0.0461	0.0922	0.0154	91H	96H	93H	70H
R4C1	0.0614	0.0154	0.0768	69 L	23 L	23 L	24 L
R4C2	0.0614	0.0307	0.0614	86	48	41	39
R4C3	0.0614	0.0461	0.0461	94H	54	59	46
R4C4	0.0614	0.0614	0.0307	94H	62	74H	43
R4C5	0.0614	0.0768	0.0154	89	87H	86H	69H
R5C1	0.0768	0.0154	0.0614	78	34 L	32	32 L
R5C2	0.0768	0.0307	0.0461	77	37	41	33 L
R5C3	0.0768	0.0461	0.0307	90	46	53	39
R5C4	0.0768	0.0614	0.0154	88	81H	74H	56H
R6C1	0.0922	0.0154	0.0461	85	32 L	25 L	28 L
R6C2	0.0922	0.0307	0.0307	74 L	41	39	35
R6C3	0.0922	0.0461	0.0154	62 L	21 L	23 L	28 L
R7C1	0.1075	0.0154	0.0307	71 L	30 L	29 L	33 L
R7C2	0.1075	0.0307	0.0154	85	64	51	52
R8C1	0.0128	0.0154	0.0154	70 L	35 L	23 L	41
Control 1				56 L	16 L	17 L	22 L
Control 2				57 L	20 L	15 L	22 L
Control 3				58 L	22 L	22 L	32 L
Average control				57 L	19 L	18 L	25 L

[a] Actual height in centimeters. [b] Actual yield in grams.

The culture numbers and sets of salt proportions in each of the cultures actually used in this work are shown in Table 3. The culture numbers are shown in the first column, and the numbers of gram molecules of each of the three salts are shown in the three following columns. Besides the cultures supplied with fertilizers, three control cultures, which had no addition of salts, were included in the series.

The soil used in these tests was a clay loam collected from the college mulberry plantation, near the seed laboratory. Into each culture vessel (an ordinary 5-gallon, tin petroleum can) were placed approximately 20 kilograms of thoroughly mixed soil. The fertilizer salts were added to the cultures on July 4, 1918. This was done by first preparing stock solutions of each of the salts with rain water. The necessary amount of each stock solution was then added to three liters of water, and the solution thus obtained was thoroughly mixed with the soil of the culture.

The rice employed in the present study was of the variety known as *sanglay puti,* a variety sometimes grown as a lowland rice with continuous irrigation, but more frequently grown as an upland rice, without irrigation and depending on the precipitation of the rainy season. The seeds used had been harvested on October 13, 1917, from a crop grown on the college farm. They were soaked in water for twenty-four hours and were planted on June 8, 1918, in shallow seed boxes. The seeds germinated on June 10, and made uniform and healthy growth. On July 6, when three leaves had developed, eight apparently similar seedlings were transplanted to each of the culture vessels, the soil having been previously prepared and the salts added as above described. After transplanting the seedlings the soil in each culture was saturated with water. The cultures were allowed to remain in the shade until July 16, when they were transferred to full sunlight in a location where they were all exposed to nearly uniform conditions of light and wind. They were watered every day in order to maintain an approximately constant water level—about 3 centimeters above the soil surface—in all of the cans. On July 26, four plants were removed from each culture, leaving the four largest plants. On July 31, two more plants were removed, leaving the two largest plants in each culture. Harvest occurred on October 16, 1918, the grain and tops being collected separately, and the number of fruiting panicles in each culture being recorded. The grain and tops were allowed to become air-dry, after which the final weighings were made.

EXPERIMENTAL RESULTS

APPEARANCE OF THE PLANTS

The plants in all of the cultures made vigorous growth. Within a week after transplanting many of the cultures were observed to be growing more rapidly than the control cultures, and these differences became more marked as the experiment continued. Although the plants that had received fertilizer grew more rapidly than those of the control cultures, even the latter made rather good growth and appeared nearly as vigorous as plants growing in the field. Besides these differences in rate of growth, differences in color were noted, these becoming conspicuous about three weeks after transplanting. At this time the cultures having 0.1 and 0.2 of their total osmotic concentration due to ammonium sulphate were small and were light green in color; those having 0.3, 0.4, and 0.5 due to ammonium sulphate were a medium shade of green; and the cultures having 0.6, 0.7, and 0.8 of their total concentration due to this salt were a very dark shade of green. The plants that were medium and those that were dark in color were apparently the most vigorous and made the most rapid vegetative growth; they also produced the largest numbers of stools and the broadest leaves. It is thus suggested that the greenness and breadth of the leaves and the number of stools were roughly proportional to the ammonium sulphate content of the fertilizer mixture. These differences in color remained noticeable until several weeks after the time of flowering, when all of the cultures became yellower in color and the differences became less marked.

Flowering began in the first week in September. There was no very great difference between the various cultures in the time of flowering. Within a week after the first flowers appeared most of the plants had developed flowers, and within two weeks all of the plants were in bloom.

MEASUREMENT OF PLANT GROWTH

In order to obtain an approximate measurement of the rates of growth, the height of the tallest leaf in each plant was measured at weekly intervals. These measurements need not all be presented here, but those made on September 17, when most of the plants had reached approximately their maximum size and had begun to produce flowers, may be considered. The measurements are given in the fifth column of Table 3; each one represents the average of the two measurements made for each culture on this date. To facilitate comparison the values are expressed as relative numbers, on the basis of the largest average considered as 100; but the actual value of the largest average is given in the table, in parentheses. It may be supposed that the values give an approximate idea of the vegetative growth that had been made by the plants at the time of flowering, although of course they do not show the number of stools. This method gives only a somewhat rough approximation of the size of the plants; a more accurate method for comparing vegetative growth in such cultures might show the average stem height and the total leaf area for each culture. The relative height values have been classified in Table 3 into three groups, characterized as high, medium, and low, following a method similar to that used by Shive. The highest nine values are designated as high, indicated in the table by the letter H following the value; since two other values were the same as the lowest of the nine, these also are designated as high. Similarly, the lowest nine values are designated by the letter L. Medium values are without special designation in the table. The highest relative value is shown in bold-faced type. The relative values obtained with each of the three control cultures, and also their average, are given at the bottom of the column.

This division of the yield values into three large groups allows ready comparison to be made between these values and the salt proportions tested, and eliminates complexity that may result from small variations, due to unknown or uncontrolled conditions, such as hereditary variability of the plants. Only general conclusions, based upon large differences in plant measurements, may be drawn from the rather limited series of data here available.

The air-dry weights of tops are shown in the sixth column of Table 3, where they are presented as relative average values derived from two plants, classified as high, medium, and low, as in the case of the height values. The actual yield, in grams, of the culture giving the highest yield of tops is shown below the relative value (100) for that culture; actual yields for any of the other cultures can of course readily be calculated from these data. In order to bring out relations between the top yields and the proportions of the fertilizer salts employed, these data have been plotted on the triangular diagram of fig. 2, which is similar in arrangement to fig. 1. In fig. 2 the culture numbers have been omitted, and the yields of tops have been placed near the intersections designating the several salt proportions. The area representing high yields is here distinguished by small crosses, the culture giving the very highest value being indicated by a large cross; areas of low top yields are designated by small circles, the lowest value (obtained with three cultures) being indicated by large circles; and areas of medium yields are without special designation.

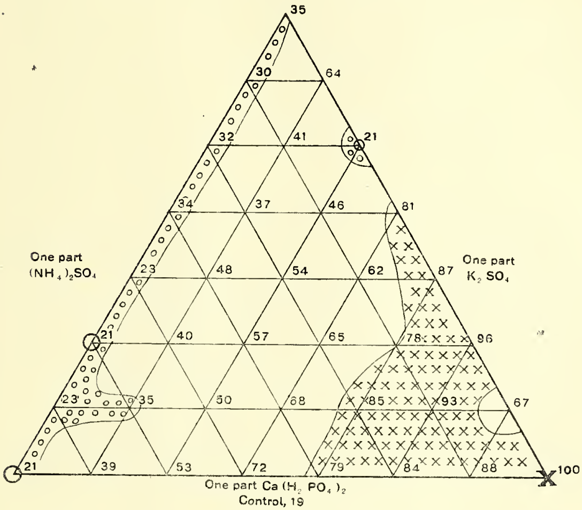

FIG. 2. Relative yields of rice tops. Area of low yields indicated by small circles; area of high yields, by small crosses. Highest yield indicated by a large cross; lowest, by large circles.

Relative yields of grain are shown in the seventh column of Table 3, where the arrangement and method of presentation correspond to those used for the other yield data; and the grain yields have been plotted on the triangular diagram of fig. 3, which is similar in arrangement to fig. 2.

The data showing the relative number of fruiting panicles in each culture are presented in the eighth column of Table 3.

DISCUSSION OF RESULTS

Relative dry yields of tops.—The triangular diagram showing the relative dry yields of tops (fig. 2) brings out some interesting relations between the proportions of the salts supplied to the soil and the resulting plant growth as indicated by the production of dry tops. In this diagram the area of high yields (denoted by small crosses) occupies the right-hand corner of the triangle, areas of medium yields occupy the central region, and the area of low yields (denoted by circles) embraces the whole of the left-hand margin of the triangle.

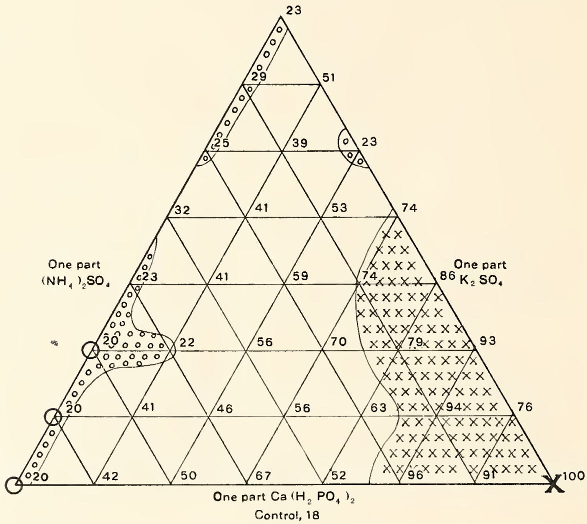

FIG. 3. Relative yields of rice grain. Area of low yields indicated by small circles; area of high yields, by small crosses. Highest yield indicated by a large cross; lowest, by large circles.

The area of high yields includes the cultures characterized by the highest proportions of ammonium sulphate, and it will be seen that no high yields were obtained when this salt made up less than 0.4 of the total osmotic value of the salt mixture. Culture R2C7 is apparently exceptional, since it gave only a medium yield, although it lies in a region where a high yield might be expected. With this exception, all the cultures having high proportions of ammonium sulphate gave high yields of tops. An examination of this diagram with reference to the proportions of the other two salts shows that high yields of tops were not obtained when potassium sulphate made up more than 0.4 of the total osmotic value of the mixture, but that many cultures having low proportions of this salt gave only medium or low yields. Furthermore, it is seen that high yields were not obtained when primary calcium phosphate comprised more than 0.5 of the total osmotic value, but that low or medium yields were obtained in many cultures in which this salt made up only a small proportion of the complete salt mixture. It is evident that high yields were definitely correlated with high proportions of ammonium sulphate (supplying the element nitrogen to the plants), and that high yields were not obtained with the highest proportions of potassium sulphate and primary calcium phosphate, but could not be related definitely to low proportions of these two salts.

It will be noted that the highest yield of tops was obtained with culture R1C8, having the following fertilizer mixture: 0.0154 gram molecule of primary calcium phosphate, 0.1228 gram molecule of amonium sulphate, and 0.0154 gram molecule of potassium sulphate. This salt mixture contains the highest proportion of ammonium sulphate tested, and the lowest proportions of primary calcium phosphate and potassium sulphate. The great increase in growth resulting from the addition of the fertilizer is shown by the fact that the yield of tops with the control culture, which was without fertilizer, was only 19 per cent of that obtained with culture R1C8.

Turning now to areas of low yields, it will be observed that these include a single row of cultures at the extreme left-hand margin of the triangle, together with two other cultures: R2C2, close to the left-hand margin; and R6C3, in the upper part of the right-hand margin. The latter culture, R6C3, is apparently abnormally low, occupying a region generally characterized by medium yields. Aside from this apparently exceptional culture, low yields are confined to cultures having very small amounts of ammonium sulphate; all of the cultures giving low top yields except R2C2 and R6C3, had only 0.1 of the total osmotic value of their salt mixtures due to ammonium sulphate. Inspection of the diagram with reference to the proportions of the other two salts—potassium sulphate and primary calcium phosphate—shows that low yields were obtained with all the proportions of these salts tested. There is thus no relation, in the present tests, between low yields of tops and the proportion of either the potassium or the phosphate salt.

The lowest yield obtained with any of the cultures, exclusive of the control, had a relative value of 21. This lowest yield, indicated on the diagram by large circles, was obtained with three cultures—R1C1, R3C1, and R6C3. The first two of these cultures giving lowest yields were characterized by the lowest proportion of ammonium sulphate and relatively low proportions of primary calcium phosphate. The third culture, R6C3, had a much higher proportion of primary calcium phosphate (0.6 of the osmotic value of its salt mixture) and a somewhat higher proportion of ammonium sulphate (0.3 of the total value of its salt mixture). The slight improvement in growth resulting from the addition to the soil of these poorest salt proportions is shown by the fact that the average yield of tops from the control cultures (lacking fertilizer altogether) had a relative value of 19, as compared with the lowest value of 21 from the cultures supplied with the poorest fertilizer mixtures. This difference is probably not significant, and the most poorly fertilized cultures may be considered as about equal to the controls.

Relative dry yields of grain.—The relative yields of grain are shown on the triangular diagram of fig. 3. Since it is the grain that is the commercial product of rice, the grain yield may be considered the most valuable growth criterion for this plant. As in the preceding diagram (fig. 2), the area of high yields is denoted by small crosses, areas of low yields by small circles, and the highest and the lowest yields are indicated by a large cross and by large circles, respectively. In its general characteristics this diagram for grain yields is very similar to the one for top yields. The regions of high, medium, and low yields on the diagram, fig. 3, correspond rather closely with those of fig. 2, thus showing that the several sets of salt proportions affected grain and top yields in a very similar manner. The area of high grain yields is confined to the right-hand corner of the diagram, corresponding to the highest proportions of ammonium sulphate. High yields of grain were definitely correlated, in these tests, with salt mixtures that contained high proportions of ammonium sulphate, and were never obtained when this salt made up less than 0.4 of the total osmotic value of the salt mixtures employed. As in the case of top yields, there was no clear relation, however, between grain yields and the proportions of either of the other two salts. Although high grain yields were not obtained when potassium sulphate made up more than 0.3 of the total salt value, nor when primary calcium phosphate comprised more than 0.5 of the total osmotic value of the salts supplied, nevertheless, high yields do not appear to have been determined by the proportion of either one of these two salts.

The highest grain yield was obtained with culture R1C8, and the same culture gave highest top yields. This culture, it will be remembered, is characterized by having the highest proportion of ammonium sulphate tested in the series, and by having the lowest proportions of potassium sulphate and primary calcium phosphate tested. The remarkable improvement in grain yield resulting from proper application of fertilizer salts is shown by the fact that the control cultures, which received no addition of mineral nutrients, gave a yield of grain only 18 per cent as high as that obtained with this best fertilized culture, R1C8.

Low grain yields were secured with practically the same sets of salt proportions as those that gave low top yields. As seen in fig. 3, low yields of grain were produced in the cultures denoted by the left-hand margin of the triangular diagram. Culture R6C3, as in the case of top yields, is apparently exceptional, since it gave low grain yields, although it occupies a position of the triangle where medium yields are indicated. It is apparent that low grain yields are correlated with low proportions of ammonium sulphate, which supplies the element nitrogen. With the exception of culture R5C1, low grain yields were obtained with all cultures in which ammonium sulphate formed only 0.1 of the osmotic value of the salt mixture. Culture R3C2, having 0.2 due to ammonium sulphate, and culture R6C3, having 0.3 due to this salt, also gave low grain yields. The proportions of the other two salts, potassium sulphate and primary calcium phosphate, do not appear to be related to the low yield of grain, since low yields were obtained with salt mixtures throughout the entire range of proportions of these two salts.

Lowest yields of grain were obtained with three cultures—R1C1, R2C1, and R3C1. As already mentioned, the first and third of these cultures also produced lowest top yields. The salt mixtures added to all three of these cultures contained the lowest proportion of ammonium sulphate tested, and low proportions of primary calcium phosphate, but contained high proportions of potassium sulphate. A very slight, but probably not significant, improvement resulted from the addition of these

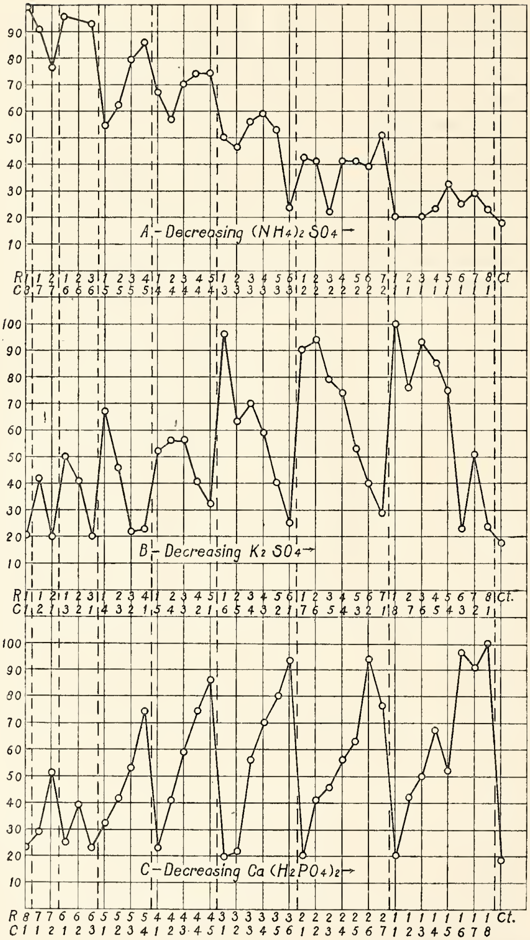

FIG. 4. Relative yields of rice grain as related to proportions of individual fertilizer salts. (Data are from Table 3.)

poorest salt mixtures to the soil, since the grain yield (20) obtained with these mixtures was slightly higher than the average yield (18) from the control cultures.

Grain yields and individual salts.—In fig. 4 the data of the relative yields of grain, given in the seventh column of Table 3 and plotted on the triangular diagram of fig. 3, have been replotted in such a way as to bring out relations that may hold between yield values and the proportions of the individual salts. In all three graphs of fig. 4 the relative yields of grain are plotted as ordinates. In the uppermost graph, A, the abscissas represent the cultures arranged as a series in the order of the magnitude of the ammonium sulphate content of their fertilizer mixtures, beginning with the culture receiving the highest amount of this salt and ending with the control culture having no fertilizer at all. In the middle graph, B, the abscissas represent the cultures arranged in the order of the magnitude of the potassium sulphate content of the fertilizer mixture, while in the lowest graph, C, the cultures are similarly arranged in the order of the magnitude of the primary calcium phosphate content of the salt mixture. The most striking general features of these graphs are that the uppermost, although showing minor fluctuations, indicates a strong general downward slope to the right, while the two lower graphs fluctuate widely, with some indication of a general upward slope toward the right. Each of the three graphs will now be considered in greater detail.

The uppermost graph was plotted in order to bring out any general relation that might exist between the proportion of ammonium sulphate (supplying the important element nitrogen) and the yield of grain. As just mentioned, the abscissas, from left to right, give the cultures arranged in order of the magnitude of the ammonium sulphate content of their fertilizer mixtures, and the ordinates represent the corresponding relative grain yields. The vertical dotted lines in this figure divide the cultures into nine groups; all of the cultures of each group received the same amount of ammonium sulphate, but they differed with respect to the proportions of the other two salts in the fertilizer mixture. A single culture (to the left of the first vertical dotted line) had 0.8 of its total salt addition due to ammonium sulphate; the second group of two cultures had 0.7 due to this salt, etc.; and the group of eight cultures, at the extreme right, had 0.1 due to this salt. Finally, the control culture, having no fertilizer at all, is plotted for the sake of comparison. This graph shows a strong tendency to fall rather uniformly in passing from left to right.

A generalized graph representing the downward slope of this graph might be shown by a straight line drawn from the value of 100, for the culture having 0.8 of its fertilizer addition due to ammonium sulphate, to a value of about 24, for the group of cultures at the right having 0.1 due to ammonium sulphate. It will be noted that the control culture, having no fertilizer, has a still lower value (18). Thus, with decreasing proportions of ammonium sulphate in the fertilizer mixture there was a general tendency for the yield of grain to decrease, which strongly suggests that the yield of grain, under the conditions of this experiment, was approximately proportional to the ammonium (nitrogen) content of the fertilizer mixture applied to the soil. This graph exhibits irregularities or fluctuations, which are in part due, no doubt, to unknown or uncontrolled conditions (such as initial internal differences in the plants used), and also in part due to the fact that the suggested proportionality between yield and ammonium sulphate content of the mixture does not hold rigidly—the proportions of the other salts also influencing the yield. It must be added that still higher yields may be expected when tests are made with salt mixtures containing still greater amounts of ammonium sulphate than any used in the present series. The results of a test with a salt mixture having approximately the proportions of culture R1C8 have indicated that increase in yield accompanies an increase in the concentration of total salt added, until the latter has an osmotic value slightly higher than 2 atmospheres. Thus, increase in yield may be expected to follow an increase in the ammonium (nitrogen) content of the salt mixture up to more than four times the amount used in the present tests.

The general proportionality between yields and the ammonium (nitrogen) content of the fertilizer is of course not surprising, since it has long been known that the amount of plant growth may usually be greatly increased by means of proper nitrogenous fertilizers. Russell,(12) page 32, in discussing the effects of nitrogen on cereal crops, states that the increasing effects produced, up to a certain point, by successive increments of suitable nitrogenous compounds may be due to the circumstance that the additional nitrogen not only increases the concentration of nitrogenous compounds in the soil, but also increases the amount of root (the absorbing surface) and of leaf (the photosynthesizing surface). The process thus resembles autocatalysis, where one of the products of the reaction acts as a catalyzer and hastens the reaction; but the increase does not go on indefinitely, because some other condition checks it. He further states that the first addition of nitrate causes a marked rise in the weight of the grain and the proportion of grain to the total product, but that successive additions show no further rise, and that an excess of nitrogenous fertilizer causes the proportion of grain to decrease, cereal crops producing a very high proportion of straw if the nitrogen supply is excessive. As will become evident from a discussion of the comparative plant measurements, in the next following section of this paper, that feature was not observed with the concentrations of ammonium sulphate employed in the study upon rice here reported.

The middle graph, B, of fig. 4 should indicate whether or not a correlation exists between the proportion of potassium sulphate and the yield of grain. The arrangement of this graph is similar to that of graph A, except that the cultures in the middle graph are arranged as abscissas in the order of the magnitude of their potassium sulphate content. This graph is irregular and fluctuates most widely in its latter half, where the yield values with each amount of potassium sulphate vary from the highest to approximately the lowest value of grain yield. The character of this graph indicates that, with the soil, the plants, and the general conditions of the present experiment, there was little or no general relation between the potassium sulphate content of the fertilizer mixture and the yield of grain. The only suggestion of a general trend in this graph is an upward slope in passing from left to right. This might suggest an inverse relationship between the potassium sulphate content of the fertilizer and the yield. But, if the conclusion reached regarding the rough proportionality between yield and ammonium (nitrogen) supply be true, then this indicated upward slope, in passing from left to right, may be explained by the distribution of the salt proportions tested. It will be observed that, with 0.8 of the salt mixture due to potassium sulphate, only 0.1 was due to ammonium sulphate; while with lower proportions of potassium sulphate much higher proportions of the ammonium (nitrogen) salt were used. Thus, the average content of the ammonium salt increases in passing to the right from one group of cultures to the next. If the yield is roughly proportional to the ammonium (nitrogen) content of the mix-

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ture and practically uninfluenced by the potassium content, then this moderately increased average yield with cultures having lower proportions of potassium sulphate is to be expected.

From the evidence of fig. 3, and of graph B of fig. 4, it thus appears that the increased proportions of potassium added to the soil in the present tests were practically without influence upon the yield of grain, or possibly even reduced the yield. This experiment, therefore, indicates that a marked increase in yield of rice grain is not to be expected when a potassium fertilizer, or a fertilizer containing very high proportions of a potassium salt, is added to the soil, under conditions similar to those of the present experiment.

An examination of graph C of fig. 4 furnishes conclusions regarding primary calcium phosphate that are similar to those given regarding potassium sulphate. This graph fluctuates very widely and exhibits a general tendency to rise somewhat with decreasing amounts of primary calcium phosphate. In a given group of cultures having the same content of primary calcium phosphate the yields vary from low to high values. This is apparently explained by the fact that the corresponding proportions of ammonium sulphate also increase in the same manner. The tendency of the average value of each group to increase somewhat as the proportion of phosphate decreases is interpreted to be due principally to the fact that the average proportion of ammonium (nitrogen) increases in a similar way. Primary calcium phosphate appeared in the present tests to be practically without influence upon the yield of grain, or to exert a slight retarding action upon this yield. Consequently, the evidence presented by the graphs of fig. 4 indicates that slight benefit is to be expected from phosphate fertilizers, under the present experimental conditions, when compared with the very great benefit resulting from the ammonium (nitrogen) fertilizer.

Logical thoroughness in the interpretation of these results requires that at least mention be made of a point that cannot be discussed adequately at the present time. The chemical elements—nitrogen, phosphorus, potassium, sulphur, etc.—may or may not be the units that are important to the plant. It is more probable that the ions—NH_4^+, P^+, K^+, $SO_4^=$, etc.—are the units that should be considered. The present tests make it logical to conclude that ammonium sulphate [$(NH_4)_2SO_4$] made the plants grow better, and that the other salts had little or no influence beyond determining the partial concentration of the ammonium sulphate. If, however, it is stated that the nitrogen (N) content of the fertilizer mixture is apparently effective in determining certain differences in growth, the conclusions are carried somewhat further than the experimental results justify. It must first be shown that the sulphate ion ($SO_4^{=}$) did not account for the improved growth. Indirect evidence that the sulphate ion did not determine the growth is furnished by the fact that increased yields were not obtained with increased proportions of potassium sulphate. Following this rather indirect line of reasoning, it is apparently safe to conclude that the ammonium ion (NH_4^{+}) in the fertilizer mixture was responsible for the increased growth. Since the element hydrogen of the ammonium radicle could hardly be supposed to bring about marked improvement in plant growth, it might then be concluded that the element nitrogen (N) was the important material in the fertilizer mixture. But the element nitrogen is not always beneficial in promoting plant growth. Indeed, several studies have shown that nitrogen in the nitrate (NO_3^{-}) form is of but little use for rice plants.[3] Thus, the importance of the element nitrogen should not be given especial emphasis without, at least, qualifying statements regarding the chemical combination in which the nitrogen exists; and, in general, it seems advisable to avoid the older assumption that the element nitrogen is important to plants. To illustrate this point an extreme example may be cited: Potassium cyanide (HCN) would never be regarded as efficacious in promoting plant growth. In view of these considerations, it seems best to state the main result of this study in specific terms, as follows: Ammonium sulphate, in the present experiments, brought about a marked improvement in the growth of rice plants in soil cultures, while primary calcium phosphate and potassium sulphate had little or no influence upon the plants.

Comparison of plant data.—It seemed of interest to summarize the different kinds of quantitative plant data in a way that would allow a ready comparison between the relative values obtained with each culture. This has been done by means of the graphs of fig. 5, which is somewhat similar in arrangement to fig. 4. For each of the graphs the ordinates represent relative growth data, while the abscissas give the cultures arranged in the order of the magnitude of their grain yields, from highest to lowest. The uppermost graph, representing the relative yields of grain, has a rather uniform downward slope, from left to right, from 100, the highest value, to 18, the lowest. The

[3] See Kellner,(6) Kelley,(5) and Espino.(3)

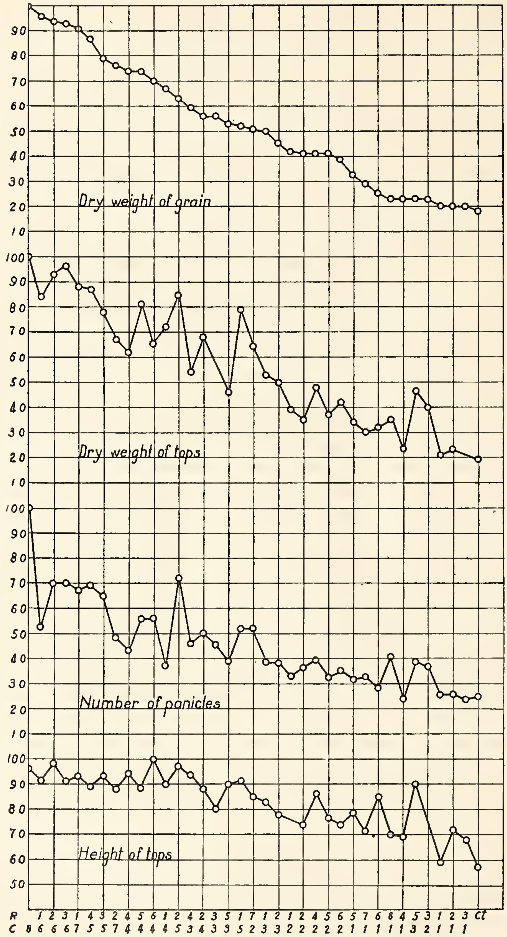

FIG. 5. Comparison between different kinds of plant measurements. (Data are from Table 3.)

lower graphs in this figure show the corresponding data of relative weight of tops, relative number of panicles, and relative height of tops, respectively, plotted with the same abscissas. The general slope and degree of fluctuation of the lower graphs give an idea of the degree of correspondence of the other kinds of data with those of the grain yield. By comparing the two upper graphs, it will be observed that in a general way they correspond in slope. The uppermost graph, showing grain yields, falls in approximately a linear manner from the value of 100 to 18, since the order of arrangement is that of grain yield. The graph below this, for top yields, is somewhat irregular, but has the same general downward slope as the graph for grain yields; in fact, the uppermost graph represents very well the smoothed graph that would be drawn from the graph of top yields. It may be concluded, therefore, that in a general way yields of grain and of tops were proportional to one another; both were affected in a similar way, and to about the same degree, by the same alteration in the various additions of fertilizer salts.

When the next graph, showing the relative number of panicles, is compared with the graph for grain yield, a smaller degree of correspondence is seen; still, the two graphs correspond in general form at least. Though the variations are numerous and in some cases great, the number of panicles is in a very general way proportional to the yield of grain.

The graph at the bottom of the page, representing the height of tops, fluctuates considerably, but differs from the graph for grain yield mainly in the fact that its slope is much less steep. The graph for height of tops shows a general downward slope from left to right; but the total range in relative values lies between 100 and 57, whereas in the case of the other graphs here considered the range is from 100 to approximately 20. Evidently, the various salt mixtures had a much less-pronounced influence upon the height of the plants than upon the number of panicles, the weight of the tops, or the yield of grain. This suggests that increased size in rice plants might be more definitely shown by an increase in the number and size of the stools than by an increase in the stem or leaf height.

General considerations.—The plant and the soil in which it grows form an exceedingly complex physico-chemical system, in which the processes are determined by many variable conditions. The development of scientific agriculture requires careful investigation of the general principles determining the rates of the processes that take place in this system, and proper fertilizer practice must depend upon a knowledge of these principles. Although investigators have been working for a century on the general problem of the salt nutrition of plants, nevertheless, scarcely more than pioneer work has thus far been done in this field. For the proper interpretation of the mineral requirements of even a single plant species, an enormous amount of research would be required. The present study suggests a number of problems that need to be subjected to careful investigation, some of which are mentioned below.

In the study reported in this paper only one total concentration of the fertilizer salts was tested. Similar experiments should be conducted with a range of total concentrations, from very low values to values that are well above the optimum.[4] In this way it will be possible to determine approximately the optimum proportions of the fertilizer salts at the optimum total concentration.[5] Such studies should enable us to determine the very best total concentration and the best proportions of these fertilizer salts for the growth of rice plants under the general conditions of these experiments. Studies should be made extending the sets of proportions to include single salts and mixtures of two of the salts used in the present study; since, under certain conditions, just as satisfactory growth may be obtained when only one or two of these salts are used as when all three are employed. Furthermore, such studies must be made to include many types of soils that are different from the one used in the present work. This is requisite because the amount and character of growth made by a given plant species is strongly influenced by the physical and chemical characteristics of the soil, and these characteristics influence the effect produced by fertilizer additions. Soil temperature, soil water content, and soil air content are likewise important. The studies must also include an investigation of the effects of different methods of cultivation, and must be extended to field tests. This phase of the problem will necessitate a study of the physical, chemical, and biological changes that take place in the soil as the result

[4] It must of course be borne in mind that optimum conditions for one plant process are likely to be different from those that represent optimum conditions for other plant processes, and also that the optimum total concentration for one set of salt proportions may be different from that for another set.

[5] See McCall,(10) p. 214; also Breazeale,(1) Livingston,(7) Livingston and Hawkins,(8) Pulling and Livingston,(11) and Trelease.(16)

of the addition of fertilizer salts, and may involve a determination of the changes that the salts undergo after they are added to the soil. Such changes may be due to chemical reactions, to absorption phenomena, or to both.

In the present tests, the total quantity of fertilizer was supplied in a single addition to the soil, made before the plants were placed in the latter. Obviously, an adequate investigation of this problem will require, also, investigations of the effects produced by adding the fertilizer salts at intervals during the growth of the plants.

Since the saprophytic organisms that inhabit the soil play a very important part in the chemical changes that take place in the soil, a further study must be made of the relation of soil bacteria and fungi to the plant reactions resulting from alterations in the supply of mineral salts.

The study here reported deals with the effects of additions of various proportions of salts containing elements that are essential to the growth of plants. Substances that supply only non-essential elements are known to produce marked alterations in the growth of some plants; and the reactions of plants to various stimulating or poisonous substances appear to vary with differences in the proportions and concentrations of the nutrient salts.[6] Therefore, studies of the kind here discussed must involve the elements that are likely to produce toxic or stimulating effects in the plant. Also, investigations should be made into the relation of soil aëration to changes induced by alterations in the mineral salts, with specific reference to the rice plant. Moreover, since the effects produced by altering the salt supply are very likely to depend upon the acid or alkaline reaction of the soil, this phase of the problem must be further investigated.

In the present work, three very common fertilizer salts have been employed; one supplying nitrogen in the ammonium form, another supplying potassium, and the third the phosphate radicle. These same nutrients may, obviously, be supplied to the plant in available forms by means of many other chemical substances besides those used in the present tests, and the plant responses may be expected to depend upon the nature of these substances.(9) Consequently, studies must be made of the effects produced upon the rice plant by supplying these necessary mineral nutrients through the agency of many other substances,

[6] See Brenchley,(2) and Free and Trelease.(4)

including the so-called natural fertilizers, such as manures, soybean cake, etc.

It is a well-established principle of plant physiology that the amount and character of growth made by a given plant species is greatly influenced by climatic conditions.(12) With other aërial conditions, the comparative results recorded in the present paper might have been very different. Consequently, adequate studies of the salt requirements of the rice plant must involve a consideration of climatic variations. Such studies will necessitate tests during the different seasons of the year, and will require a correlation of changes induced by alterations in the salt supply with fluctuations in the conditions of air temperature, sunshine intensity, and evaporating power of the air.

The preceding discussion has dealt exclusively with the conditions of the environment; first, the conditions that are effective around the roots and, second, those that are effective around the aërial parts of the plant. Besides these external conditions, it is well known that the internal conditions influence the amount and quality of plant growth; and, before general interpretations may be obtained regarding the salt nutrition of the rice plant, it will be necessary to employ many varieties of rice and to investigate the salt requirements during the various developmental stages of each of these varieties. The best salt proportions for vegetative growth of rice may be expected to be different from the best proportions for the period of flowering and fruiting.

It will be seen that the conditions in this system, composed of the plant and its environment, are exceedingly complex, and that the investigations here briefly outlined will require an enormous amount of work and time. The conditions surrounding the roots may be considerably simplified and more easily controlled by employing solution cultures or sand cultures instead of soil cultures; and it is probable that many of the lines of investigation here mentioned can be best approached by means of solution cultures and sand cultures, under carefully controlled laboratory conditions.

As yet we must depend largely upon the method of trial for determining what fertilizer salts and proportions must be used upon a given type of soil for a certain kind of plant growth. Thus far, general principles that may be applied to this problem have not been obtained; but a gradual advance in our knowledge of salt requirements may be expected to result from such trials.

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ILLUSTRATIONS

TEXT FIGURES

SUPPLEMENTARY NOTES ON THE SOCIAL BEES OF THE PHILIPPINE ISLANDS

By T. D. A. COCKERELL
Of the University of Colorado

The discovery of a new species of *Bombus* on Negros Island is an event of considerable interest; and it is very satisfactory to obtain a new variety from Luzon, with the hitherto unknown male of *B. irisanensis.*

Bombus irisanensis Cockerell var. **baguionensis** var. nov.

The workers differ from the original description in having the fifth segment of abdomen in middle or right across, and the sixth, with long pale fulvous hair instead of black. The male has the hair of apical part of the abdomen black, as in the type. The clypeus of the male is covered with ocherous hair, and the third antennal joint is a trifle shorter than the fourth, the two together being scarcely longer than the fifth. The anterior wing of the male is about 16.5 millimeters long; the expanse, about 41. The first two abdominal segments in the workers have the hair pale fulvous or ochraceous; in the male it is darker, on the second segment almost a seal brown. In the male the hair of the legs is black, but in the workers the tibiæ have long fulvous hair, sometimes partly dark. It seems best, on account of the numerous differences, to distinguish this form as variety *baguionensis,* but it remains to be seen whether the Irisan type is racially distinct, or was described from a peculiarly colored individual. The type of the variety is a worker with fifth abdominal all pale haired, and the hind tibiæ and tarsi red. (*Baker 11841.*) The third antennal joint is distinctly longer than the fifth.

LUZON, Benguet, Baguio (*Baker 11840, 11841, 11842*), 1 male and 3 workers.

Bombus bakeri sp. nov.

Female.—Length, about 22 millimeters; anterior wing, 13.5; black, robust, very hairy; anterior and middle tibiæ and tarsi dark reddish, hind tibiæ and tarsi clear ferruginous; malar space about as broad as long; labrum bigibbous, fringed with red hair; third antennal joint a little longer than fifth, fifth longer than fourth; clypeus convex, smooth and shining in middle, punctured at sides; sides of clypeus depressed, separated from disk by a low ridge; clypeus overlapped by long fulvous to dark reddish hairs; hair of head otherwise, and of thorax entirely, rusty black, very dark; tegulæ black, obscure reddish posteriorly; wings pale reddish, orange-tinted, the broad outer margin more dusky; femora with black or dark hair, tibiæ and tarsi with light fulvous hair, ferruginous on inner side of tarsi; abdomen with rusty-black hair on first four segments, becoming red on apical part of fourth, and beyond this clear reddish fulvous.

NEGROS, Cuernos Mountains (*Baker 11839*), 2 specimens. In coloration this resembles *B. eximius* Smith var. *tonkinensis* Friese, but the malar space is much longer than in *eximius*. Structurally, the species is related to *B. irisanensis*.

Apis florea var. **rufiventris** Friese.

Apis florea var. *rufiventris* Friese, BUTTEL-REEPEN, Mitt. Zool. Mus. Berlin (1906) 170, 197; ENDERLEIN, Stett. Ent. Zeit. (1906) 338, 344.

PALAWAN. This has segments 1 to 6 of the abdomen almost uniformly red brown. The reddest form received from Sandakan, Borneo (*Baker*), has only the first two abdominal segments reddened, as described for typical *florea*. The form *andreniformis* (Smith), with black abdomen, also occurs at Sandakan.

Apis binghami Cockerell.

Apparently common at Manila, where Mr. R. C. McGregor collected a number of specimens November 7 and 9, 1918. They visit the flowers of *Antigonon leptopus* Hook. & Arn., according to a note supplied by Mr. McGregor.

Apis dorsata Fabricius.

SINGAPORE (*Baker 9220*). BORNEO, Sandakan (*Baker*). I have no specimens from the Philippines.

PROTOZOÖLOGIC AND CLINICAL STUDIES ON THE TREATMENT OF PROTOZOAL DYSENTERY WITH BENZYL BENZOATE

II. TREATMENT OF A CASE OF ACUTE BALANTIDIOSIS; RECOVERY; DEATH FROM OTHER CAUSES; FAILURE TO FIND THE PARASITES IN THE BOWEL LUMEN AND GUT WALL AT AUTOPSY [1]

By FRANK G. HAUGHWOUT

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and

ELIAS DOMINGO

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WITH A PRELIMINARY NOTE ON THE ANATOMICAL FINDINGS AT AUTOPSY

By WALFRIDO DE LEON

Instructor in Pathology, University of the Philippines

In the first paper of this series the senior author, in collaboration with Doctors Lantin and Asuzano,(1) reported on the treatment of eight cases of acute entamœbiasis with benzyl benzoate. The results obtained in that series were so encouraging that it was determined to extend the experiments to affections produced by other intestinal protozoa. Subsequent experiments on cases of entamœbiasis have confirmed our earlier observations, but the treatment of flagellate infections has been, as was our expectation, much less encouraging. The case about to be reported is the first infection with *Balantidium coli* that has fallen under our control since the experiments were started; and, although we report a single case with some hesitation, still, the circumstances under which the case was studied were, in some respects, so favorable, and the results we obtained so good, that we feel justified in making the report in order that other investigators may take up the work as opportunity comes to them. Moreover, it must be recalled that the clinical treatment of balantidiosis has always been more or less unsatisfactory.

[1] Contribution from the laboratory of protozoölogy and parasitology, Bureau of Science.

When we first undertook the study of the material obtained at the necropsy of our case, the findings seemed relatively simple. But, as we continue the study of our sections and toto mounts, interesting problems present themselves and emphasize the necessity of a more thorough study of the material. Therefore, we have decided to report the autopsy findings very briefly in this paper and reserve the details for a paper to be published later, by which time we shall have, in addition to the material from this case, more material from other sources for comparison.

The salient features presented by the case now under consideration are as follows:

The patient developed dysentery late in December of last year. The stools were dysenteric in character and contained swarms of *Balantidium coli.* Bacteriological cultures were negative for *Bacillus dysenteriæ.* Local treatment was given by proctoclysis; but on January 10, when the case was first referred to the senior author, the patient had lost greatly in strength and appeared to be approaching death. On January 13, when treatment with benzyl benzoate was started, the patient was practically in extremis. The bowels were in almost constant motion, and he was apparently in great pain and distress. It seemed unlikely that any treatment would be successful.

However, four days after the treatment was started, all other forms of treatment having in the meantime been discontinued, the pain and tenesmus had entirely disappeared and the patient was passing formed, feculent stools; his appetite had shown distinct improvement, and he was able to sleep quietly. The treatment was continued for twenty-four days, the balantidia showing a general tendency to disappear and finally appearing in the stool for the last time on January 29, nineteen days before the death of the patient from causes unrelated to the dysentery.

During the course of the benzyl benzoate treatment the patient showed a slow but constant improvement as regarded his general condition. The dysenteric symptoms never recurred, and his stools, though occasionally soft, were always feculent. About February 12, however, he became sick again with symptoms indicating trouble in the respiratory tract. He rapidly grew worse, and died on February 17. His stool was examined for the last time the previous day. It was hard and feculent and contained no balantidia. The patient had received no benzyl benzoate since February 6.

Autopsy was performed one hour after death, the body still being warm. Scrapings were taken from points along the intestinal tract and search made in them for *Balantidium*. None was found. The site of the dysenteric process was found in the region of the splenic flexure. The ulcerative process had healed. This area was cut out with some of the neighboring gut, divided between the two operators (W. de L. and F. G. H.), and immediately placed in fixing solution. Subsequently it was all cut into many small blocks and embedded in paraffine. Several sections were cut from each block and stained. Study of these gave ample evidence of the former presence of the parasites, but we utterly failed to find the parasites themselves. This is in such marked contradistinction to the findings in the intestines of persons who have died of balantidial dysentery, that we are inclined to suspect that our patient had lost his balantidial infection some time before death.

The patient was a male Spaniard, 54 years old, and was admitted to the psychiatric ward of San Lazaro Hospital, Manila, on January 18, 1917, by the attending physician, Dr. Samuel Tietze. Doctor Tietze informs us that the man showed no symptoms of balantidiosis prior to the onset of the acute attack on December 21, 1919. The patient, previous to his admission to San Lazaro Hospital, had been confined in the Hospicio San José in Cavite. No earlier history was forthcoming from that institution. He was fairly well nourished and fairly neat in his habits. Mentally, he was depressed, idle and seclusive, mumbling in speech, and his answers to questions were senseless and irrelevant. Nothing in his history or habits gave us any clue as to the manner in which he became parasitized with *Balantidium*. A diagnosis was made of terminal dementia of the senile, arteriosclerotic type.

The dysenteric symptoms developed abruptly on December 21, on which day he was found lying on his bed, too weak to move about. He was having frequent watery stools, that were greenish in color and apparently was suffering much pain. Throughout the course of the disease we frequently were compelled to draw conclusions regarding the presence or absence of pain and tenesmus from a study of the patient's countenance, for his answers, when he answered at all, were misleading. We likewise found it difficult to determine the exact number of stools passed by the patient during the twenty-four hours. He usually failed to call the nurse when his bowels moved, and we had reason to suspect, in many instances, that the results ultimately found by the nurse represented the product of two or more stools. This naturally makes our clinical report more or less incomplete.

The patient refused all food and grew steadily weaker. He was given appropriate stimulation, but showed no improvement. *Balantidium coli* was first found in his fæces by Doctor Torbillo, of the hospital laboratory, on December 23. The stool was negative for *Bacillus dysenteriæ*. In the absence of any treatment of proved efficacy, santonin was given in the hope of benefiting the patient. It apparently had no effect.

The condition of the patient grew steadily worse. From time to time he vomited his food and finally refused to take any. As a consequence of this he became very weak. He was given proctoclysis with normal salt solution, which was usually poorly retained. On January 10, as the patient refused to take anything by mouth, an attempt was made to administer nutritive enemata. As he was, at that time, having almost continuous bowel movements accompanied by much pain and tenesmus, this attempt, as might be expected, was not successful. Better results were secured later.

On January 10 the stool was examined for the first time by the senior author. It was totally devoid of fæcal matter and consisted mainly of balantidia, pieces of desquamated epithelium, and leucocytes, all suspended in mucus. Small numbers of erythrocytes were scattered through the mass, but the stool was scarcely "bloody." The balantidia, which were present in immense numbers, showed considerable variation in size, as if division were proceeding somewhere at an exceedingly rapid rate. A few dividing forms were seen in the stained preparations that were made at the time. All were in approximately the same stage of division—an early telophase—as if something had occurred to arrest the process.

There was little change in the condition of the patient for the next few days, aside from continued loss of strength. On the morning of January 13, however, the administration of benzyl benzoate was started in doses of ten drops of the 20 per cent alcoholic solution given in water three times a day. In the afternoon, the patient seemed to have experienced some relief, and he took food without resistance. The following day he was distinctly better and gave no sign of the presence of either pain or tenesmus. His bowels moved eight times. Five of these movements were reported by the nurse as being watery, one "resembled condensed milk," and two were soft and feculent. It is to be regretted that none of these was saved for examination.

The dose of benzyl benzoate was increased to fifteen drops, three times a day, on January 15. On January 17 the patient's bowels moved twice. The first stool, passed at 7 o'clock in the morning, was yellow, watery, and feculent. No blood or cellular débris was found. It contained numerous active balantidia. The second stool was passed at 9.30 a. m. It was yellow and semiformed and, like the earlier specimen, contained no tissue elements. A few sluggish balantidia were found; also numerous ova of hookworm and *Trichuris*. The latter continued to appear regularly up to the time of the patient's death. Both helminthal infections were very heavy.

The patient passed only one stool the following day, and it was not saved for examination. His general condition was much improved in every way. As he seemed to tolerate the drug well, the dose of benzyl benzoate was raised to twenty drops three times a day on January 19. His bowels moved once, but the specimen sent to the laboratory was unfit for examination, so no stress can be laid on our failure to find parasites on that day. A few vigorous balantidia were found the next day, however, and on January 21, notwithstanding the patient was eating and sleeping well, his stool, which was soft and yellow, contained traces of mucus and swarms of healthy-looking, vigorous balantidia. The parasites appeared to be as numerous as they were at the height of the acute stage of the infection and their increase in numbers was abrupt and very marked. On January 22, the stool was diarrhœal, but contained no albuminous matter. No balantidia were found in either the fresh or the stained preparations. A few badly plasmolyzed balantidia and some that were dead were found in the stool the next day, however; but with them were several hookworm eggs in a late stage of segmentation, indicating that the condition of the balantidia was due to the age of the stool rather than the action of the drug.

The general soft and feculent character of the yellow stools was maintained until February 1, when the fæces became hard and constipated and so remained until the patient died. The balantidia appeared in the fæces for the last time on January 29, when four sluggish, badly deformed individuals were counted in the examination of twelve fresh preparations, by the aid of the mechanical stage. The administration of the benzyl benzoate was continued, however, until February 6, when the patient vomited and complained of severe abdominal pain. We are inclined to believe it possible that the vomiting might have been caused by the drug, because, in one or two instances, the senior author has encountered patients who complained of a slight degree of nausea after the drug had been administered to them over a period of several weeks. However, the great majority of the patients studied by him have never complained of even this. In no instance has the nausea attributed to benzyl benzoate been in any way comparable to that produced in the general run of cases by ipecacuanha or emetine-bismuthous-iodide.

The abdominal pain subsided under paregoric, but the patient began to complain of general bodily pain, and on February 11 it was seen that he was very ill. He was unable to swallow his food. Later, he became delirious and suffered distressingly in his efforts to breathe. His stools remained well formed—a state bordering on constipation—and careful search failed to reveal any balantidia. The last stool was examined just twenty-four hours before the death of the patient, which occurred at 3.20 p. m., on February 17. It was negative for *Balantidium*.

The abdominal and thoracic cavities were open one hour and ten minutes later. The intestinal tract was removed as quickly as possible. Inspection of the body before this had led to the discovery of a shallow but rather extensive infected ulcer about 5 centimeters in diameter over the prominence of the large trochanter on the right side.

The left pleural cavity contained about 150 cubic centimeters of sero-purulent material. The base of the left lung was slightly adherent to the pleura by fibrino-purulent adhesions. The right pleura was free and slightly moist.

The left lung was greatly congested at the inferior lobe, the base of which was hæmorrhagic. In two places the lung was greenish in color, necrosed and suppurating. Much purulent material was expressed from these necrotic areas. Purulent material was also expressed from the cut ends of the bronchi. The upper lobe of the right lung was pale, slightly pigmented, and slightly emphysematous. This lung was congested at the base. Thin, easily removable adhesions were found between the base of the left lung and the adjacent pleura.

Pathological changes were noted also in the heart, spleen, liver, and kidneys, which, so far as we can determine, seemed to bear no relation to the balantidial infection.

The alimentary tract was examined with particular care. Fæcal material was taken from points along the lumen of the intestinal tract, promptly fixed, and later examined for balantidia. None was found. The small intestine showed a slight thinning of the mucosa, and a marked thinning of the entire wall. The large intestine showed some œdema and slight induration of the wall which, at the points of flexure, was thickened. This thickening was slight in extent and was most marked in the sigmoid colon near the cæcum in the region of the splenic flexure. At this point the intestinal wall was thicker, rougher, and more congested than the rest of the gut and showed petechial hæmorrhages. It was firm in consistence.

Here the mucosa was slightly congested and dirty looking. There was evidence of an increase of the mucous secretion and of epithelial desquamation. No ulceration of any kind was noted macroscopically in any portion of the gut. The anatomical diagnosis was: Toxæmia, acute vegetative septicæmia, aortic endocarditis, abscess of the base of the left lung with fibrino-purulent pleurisy, acute bronchopneumonia of the base of the right lung, fatty degeneration of the viscera, chronic catarrhal colitis, and hæmorrhagic infarction of the spleen.

The area of the large intestine that had been the site of the healed colitis was excised and divided between the two operators. That taken by the pathologist was fixed in Zenker's fluid; that taken by the senior author was fixed in Bouin's picro-aceto-formol fluid. Pieces were similarly cut from the ileum near the ileo-cæcal valve and from the duodenum, divided and fixed similary. Blocks cut from the other viscera were fixed in Zenker's fluid.

After thorough washing out of the fixing fluid, the intestine was cut into many small pieces. These were embedded and sectioned. We fully expected to find balantidia in the intestinal tissues, notwithstanding we had failed to find them in the lumen of the bowel, and when sections from the first few blocks failed to yield any, we were at first mildly interested; but when we had cut and stained three to five sections from each block of the Bouin-fixed tissue, and had utterly failed to find any parasites, our interest was thoroughly aroused. More sections were cut from the same blocks and also from blocks that contained apparently undamaged tissue, but the search for balantidia was still fruitless. We also failed to find balantidia in blocks of the tissue that was fixed in Zenker's fluid. Needless to say, we found no parasites in the lung, liver, or other viscera.

As stated in the beginning, it is not our intention at this time to describe in detail the pathological changes observed on study of our preparations. While we failed to find parasites in their customary habitat or, indeed, in other localities where we have found them in other cases, we certainly discovered in the intestine what we, at present, are inclined to interpret as unmistakable evidence of their former presence. But some of the points involved are too fine to warrant any positive statements on our part until we have gone over the material repeatedly and cut new sections and compared them with sections cut from other cases. Then we may be able to add something definite to what is already known concerning balantidiosis in man.

The general microscopic picture presented by our sections was cloudiness of the muscular coat and moderate injection of the blood vessels. There was some œdema of the submucous coat and of the interglandular tissues, with slight diffuse infiltration of the superficial mucosa with polymorphonuclear leucocytes and a moderate number of plasma-cells. The material showed a catarrhal colitis, with some very superficial ulcerations accompanied by slight secondary infection.

In any event, it cannot be said that our failure so far to discover balantidia in the tissues was due to their destruction by post-mortem changes, for our tissue was fixed, and well fixed, within one and a half hours following the death of the patient. Balantidia in a fair state of gross preservation have been found in tissues fixed twelve hours and more after the death of the patient. Our material, particularly that portion fixed in Bouin's fluid, was in excellent condition, and there was remarkably little shrinkage of the glandular elements.

Aside from the interest it holds to the student of the problems connected with protozoal dysentery, this case is of interest to the clinician, by reason of the fact that the treatment of balantidial dysentery in the past has been anything but satisfactory. The ipecacuanha compounds seem not to be as efficacious as they are in entamœbiasis, and other modes of treatment have been disappointing. If it is possible in subsequent cases to secure results similar to those we seem to have attained by the use of benzyl benzoate in this case, the outlook for the patient will appear more favorable.

Mason(4) has recently reported on the treatment of a case of balantidiosis, occurring in a Danish missionary in Yunnan Province, China, with oil of chenopodium and olive oil injected directly into the lower bowel. The acute symptoms cleared up very promptly. The patient had a slight relapse six days after the second treatment and was treated again. The case was under observation for three weeks, at the end of which time the stools were negative for the parasites and the patient seemed perfectly well. Mason takes a conservative view of his case and admits the possibility of a relapse, but reports his findings as we do ours, for what they may be worth to other investigators. We gather from his account of the case, however, that it was not nearly so severe as ours, for his patient seems to have been ambulant. Three weeks' observation is too small a limit to place in determining a cure, as Mason seems fully to realize.

SUMMARY AND DISCUSSION

By Frank G. Haughwout

A case of acute balantidiosis, complicated by infections with hookworm and *Trichuris,* was treated with benzyl benzoate.

At the time treatment was started, twenty-three days after the onset of the disease, the patient was exhausted and apparently near to death.

The abdominal pain and tenesmus, associated with the dysenteric process, disappeared within twenty-four hours after treatment was started and did not return again, even after treatment was stopped twenty-four days later.

The parasites showed a tendency to diminish in numbers in the fæces until the eighth day following the institution of treatment, when they suddenly appeared in the stool in immense numbers. On this day the stool was feculent, but contained mucus. No demonstrable tissue elements were found. I am inclined to regard this as the expression of a wholesale exodus of the ciliates from the tissues.

I believe that, had the patient not been under treatment, this "swarming" of the parasites would have been accompanied by pain, tenesmus, and the other symptoms constituting the dysenteric complex.

That the patient did not exhibit the symptoms that ordinarily accompany the departure of such large numbers of parasites from the tissues is, I believe, largely due to the selective action of benzyl benzoate. This drug, as Macht(2) has shown, acts in a manner similar to papaverin, in that it tends to inhibit peristalsis of smooth muscle organs, and lowers their tonicity and relaxes their spasm.

It is to be noted that Mason's patient suffered a relapse of a somewhat similar nature, six days after the second course of treatment was administered.

Observations I have made on this and other cases of balantidial infection, indicate the likelihood that *Balantidium coli* behaves in the tissues very much as we believe *Entamœba histolytica*[2] behaves. It seems likely that during clinically quiescent periods of the infection there is a more or less constant migration of the parasites, in relatively small numbers, back into the lumen of the intestine as a part of the normal life-cycle activities of the organism. The natural outcome to be expected as a result of this would seem to be the prompt encystment of the organism as soon as it reached the lumen, but apparently this does not usually occur in man. The ciliates thereupon find

[2] It will be noted that in this article the dysentery amœba is referred to as *Entamœba histolytica*, whereas, in the first paper of the series it is spoken of variously as *Entameba dysenterica*, *Entamœba dysenterica* and *Endamœba dysenterica*. Likewise, *Ancylostoma* is styled *Ankylostoma* in the table. Furthermore, there are allusions to "endamebiasis," "endamebic dysentery," "endamebas," and "amebas." This has led at least one entirely competent and discriminating reviewer, Trop. Dis. Bull. **15** (1920) 190, to employ the accusing "(*sic*)" after some of these incongruities. With the reviewers, I have no quarrel; indeed, I am deeply grateful to them for unconsciously directing attention to what seems to me a growing and intolerable tendency on the part of the editors of certain medical journals to alter accepted zoölogical terms to accord with their own notions and terminology. Not only do they commit an offense against rules that have been adopted after much thought and deliberation on the part of entirely capable zoölogists and which surely are as helpful to the physician as the zoölogist in that they aid him in the interpretation of the reports of the zoölogist, but they clog the literature with vague and incorrect terms.

It is perhaps needless for me to say that as sent to the publisher, the terminology used in the manuscript, was *Entamœba histolytica*, *Ancylostoma*, entamœbæ and amœbæ. The only alterations of consequence that were made in the copy in its preparation for the compositor were made in these zoölogical terms. The onus of the offense naturally falls upon the unoffending authors—particularly the senior author—and the offense is all the more heinous in that he has occupied the chair of protozoölogy in a large university in the tropics for several years. Had the paper been written by medical men who had never specialized in protozoölgoy, the offense could, in a measure, have been condoned as those things have been con-themselves unprotected in a most unfavorable environment for locomotion and the procuring of food suited to them. If the fæces are hard and lacking in moisture, the greater number of the organisms probably perish before reaching the anus. On the other hand, if the fæces are soft or fluid, the parasites live long enough to be seen by the microscopist, if he examines the stool with reasonable promptness. So far, there seems to me no good evidence that *Balantidium coli* derives any nourishment from the fæces—indeed, the indications are that nothing whatever is taken in through the cytostome after the balantidia leave the tissues. This, of course, lends support to the supposition that this species of *Balantidium* is an obligatory tissue parasite in man.

However, when something happens to bring about the expulsion, in large numbers, of the parasites from the submucous tissues, a tremendous stress is placed upon the tissues. The parasites appear to make their way down between the glands of Lieberkuhn and the supporting stroma. When they do this in small numbers, the separation of the tissue elements probably closes up rather promptly, and the relatively few bacteria en-

doned in the past. The editorial indecision that led to the designation of the generic name by three separate spellings can only be regretted. All this necessitated the attachment of errata slips to each reprint of the article that was sent out.

I know of no amœba bearing the specific name "*dysenterica*," and search of the literature has so far failed to reveal one to me. Therefore, I certainly do not care, in view of the present state of our knowledge of the parasitic amœbæ in man, to stand sponsor for any further additions to the already confusing synonomy of *Entamœba histolytica.* Doubtless the person who made this alteration in our manuscript had heard of the name *Endamœba dysenteriæ* as employed by Pestana after Councilman and Lafleur, and, with the object, perhaps, of making the name run more trippingly off the tongue of the busy practitioner, changed it to "*dysenterica*." Manifestly, economy of space was gained by changing entamœbæ to "endamebas" and amœba to "ameba," although the latter term may be colloquially used as a group name with more or less propriety.

I am one of those who are in entire accord with Prof. Clifford Dobell regarding the inconsistency and inadvisability of substituting the specific name *dysenteriæ* for Schaudinn's ill-chosen, but nevertheless time-honored, name *histolytica* as the specific name for the dysentery amœba. In view of this it is, to say the least, somewhat disconcerting unwittingly to be made to appear as contradicting the teaching and writing of years. I cannot regard it as a mitigating circumstance that the proof of this paper was read in the United States by a friend who, though a scientific man, is not a zoölogist, and who could not be expected to cross swords with the editor on a question of nomenclature.

tering at the point of exit are probably promptly disposed of by the leucocytes.

On the other hand, when large numbers of the parasites are passing out, this reparative process is hindered and the intestine responds to the developing irritation by increased peristalsis that quickly becomes excessive. It is not improbable, then, that the violent peristalsis assists in the desquamation of epithelial structures already separated from their supporting tissues and, as a result, groups of epithelial cells become detached and contribute their share to the microscopic picture. The gates are then open to secondary bacterial invasion and the battle is on.

It would seem as if benzyl benzoate, through its specific action on the smooth musculature of the intestine, might inhibit this suicidal tendency on the part of the organism. This may be the reason why our patient did not show the clinical picture of acute balantidiosis with his parasitic relapse of January 21. It also may explain how it happens that a patient may pass frequent stools consisting mainly of tissue débris, pus, and parasites on one day, and four days later pass practically normal, feculent stools in which no traces of cell débris can be detected. Such were our observations in this case.

The case, however, raises other questions regarding the action of benzyl benzoate on intestinal protozoal infections. So far as our study of the material has progressed, the autopsy seems to have furnished evidence that a cure, in an absolute sense, was brought about coincidentally with the employment of the drug and possibly as a direct result of its action on the parasites. Balantidia were absent from the fæces for nineteen days prior to the death of the patient, although this, in itself, is not by any means convincing. But at autopsy we failed to find any in the lumen of the intestine. Furthermore, a thorough search of the tissues has, so far, failed to yield any of them; they may be there, but we have not found them yet. Has the drug a specific protozoöcidal action? That is to be suspected, but remains to be proved. The work of Macht and Fisher,(3) on the toxic effects of benzyl benzoate on the free-living ciliate *Paramœcium putrinum,* is no more convincing on that point than are many other similar, painstakingly conducted experiments with free-living protozoa or with parasitic species in vitro. However, their suggestion that such specific action on parasitic organisms may follow the splitting off of the benzol radical in the metabolism of the drug should be carried well in mind.

I have noted, in connection with several cases of intestinal entamœbiasis treated with benzyl benzoate, that the patients apparently did not pass cysts as convalescence progressed. This has seemed worthy of note in passing, but I have seen the same thing occasionally when other drugs have been employed; and it not infrequently happens that persons infected with *Entamœba histolytica* fail to discharge cysts, in sufficient numbers to admit of their detection in the fæces by the methods usually employed, for periods of weeks or even months. Unfortunately, we have been unable to keep track of our discharged amœbic cases, so we cannot tell if they are still infected. However, only one of these has applied to us for treatment of a relapse, and he had previously left the hospital notwithstanding his fæces still contained motile *Entamœba histolytica* and we had warned him that he was far from cured.

To settle the question as to whether or not this patient was absolutely sterilized as regards his *Balantidium* infection it would, theoretically at least, seem necessary to make serial sections of the entire colon. However, this is obviously impractical, even had we fixed and embedded the entire organ. It has only been possible to minimize the chances of missing the organisms by dividing the tissue into many small blocks and taking sections from each block. This we have done and, so far, we have been unsuccessful in our search for the organisms. We offer the evidence that we have collected with the promise to continue our studies and report in greater detail in the near future.

The clinical phenomena observed in this case were, in general, similar to those we have seen in our entamœbic cases. While we have had opportunity so far to treat only two cases [3] of balantidiosis, I am inclined to believe that we shall find benzyl benzoate to be as efficacious in balantidial as it seems to be in entamœbic infections.

It is again seen that the drug exerts no influence on helminthal infections.

The death of the patient was clearly due to causes unrelated to the balantidial infection.

[3] As this paper is being written I am studying a case, somewhat similar to the foregoing, with Dr. Wenceslao Vitug, in the Philippine General Hospital.

ADDENDUM

As the final proof of this paper is being read, I am in receipt of a letter from Doctor Mason concerning the case of balantidiosis he treated with chenopodium in which he says:

> I saw my patient six months after treatment and he had had no return *then.* But I have since heard indirectly that he had a dysentery. This was a lay diagnosis. I sent him some chenopodium with instructions for its use. He wrote me later that he was well, but whether with or without treatment I do not know. I will write to him asking for a statement of his health since the first attack, and when I receive that I will send it to you.

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1. HAUGHWOUT, FRANK G.; LANTIN, PEDRO T.; and ASUZANO, M. A. Protozoölogic and clinical studies on the treatment of protozoal dysentery with benzyl benzoate. I. A preliminary report on eight cases of endamebic dysentery and one case of bacillary dysentery treated at the Philippine General Hospital. Arch. Int. Med. **24** (1919) 383.
2. MACHT, DAVID I. A pharmacological and therapeutic study of some benzyl esters. Journ. Pharm. & Exper. Therap. **11** (1918) 419.
3. MACHT, DAVID I., and FISHER, HOMER G. On the toxic action of opium alkaloids individually and in combination with each other on Paramecia. Journ. Pharm. & Exper. Therap. **10** (1917) 95.
4. MASON, C. W. A case of Balantidium coli dysentery. Journ. Parasitol. **5** (1919) 137.

REVIEWS

La Pratique | du | Pneumothorax | Therapeutique | par | F. Dumarest | Médecin en chef | & | C. Murard | Médecin adjoint | des sanatoriums d'Hauteville | Paris | Masson & Cie, Editeurs | Libraires de l'Académie de Médecine | 120, Boulevard Saint-Germain, VI | 1919. 261 pp., illustrated. Paper, 12 francs net.

The practice of artificial pneumothorax has been making considerable progress in recent years, and it is adapted to the varied exigencies of the clinic.

This book by Doctor Dumarest is a thorough study of artificial pneumothorax and gives complete information on the technic, apparatus, possible accidents, and also the medical rules by which the practitioner must be guided, in conducting treatment; in pleural complications; and in the study of remote results.

The work closes with physiological considerations of the mode of action of pneumothorax and touches upon the general indications and contra-indications encountered by this method of treatment.

Doctor Dumarest's practice, extending over many years, lends especial authority to his book. He has enriched it by various considerations, thereby making the use of this therapy possible to the beginner, especially when dealing with tuberculosis, which has wrought unprecedented ravages in France.

The main sections of the book cover: Apparatus, technic, accidents; conduction of treatment, constitution and evolution of pneumothorax, results, accidents, convalescence; pleural complications, frequency, clinical study, pathogeny and treatment of pleural complications; remote results, interruption of treatment; mode of action of pneumothorax; indications in pulmonary tuberculosis; counter indications, clinical technic.

Toxines | et | Antitoxines | par | M. Nicolle | E. Césari | C. Jouan | de l'Institut Pasteur | Masson et Cie, Editeurs | Libraires de l'Académie de Médecine | 120, Boulevard Saint-Germain, Paris | 1919. i–viii + 1–123 pp. Paper, 5 francs net.

This work is essentially a "personal" book; nevertheless, it may perhaps be considered a complete monograph and such an adjustment of the question of toxins as might be achieved by means of scientific experimentation.

Personal the work may seem at first glance because the authors are among those who have contributed most to an explicit understanding of the problems that arise from modern theories of immunity and the reactions of defense of the organism. Therefore, to study toxins and antitoxins from this point of view is largely to cite, and comment upon, their labors.

We repeat, it is a personal work, in the sense that no theory, however classic, is advanced by the authors, unless based upon laboratory verification, or unless the problem has been studied from the beginning, so as to eliminate incorrect interpretations. It presupposes many years of patient labor and the use of technical resources of a laboratory which it would be difficult to find elsewhere than in the Pasteur Institute. This book, which is a compilation of many studies, is confined to 123 pages. A mere glance will suffice to show the great care expended upon the arrangement of the divisions, the subjects treated, and the wide range of theories and facts it embodies.

Faithful to the classic method among masters of French science, and from which they rarely depart, the picture presented to us by M. Nicolle and his coworkers is devoid of all extraneous considerations; a large question is approached boldly and the authors go straight to the point without seeking support or theoretical assistance in affiliated considerations. This is what makes the monograph, though so brief, a systematic, complete, objective, and instructive exposition of the problem of toxins.

ERRATA

Pages 218 and 219, in the legends of Tables 2 and 3, for *Amphibia* read *Salientia.*

Page 228, line 2, *for* Total length 25 *read* Total length 250.

Page 228, before the center head RANIDÆ, insert:

Order SALIENTIA

Four limbs present; tail not present except in larval form; no intromittent organ; body short, more or less depressed. Two suborders are recognized, characterized as follows:

Key to the suborders of the Salientia.

a^1. Tongue present; separate inner ear openings.................... **Phaneroglossa.**
a^2. Tongue absent; a single opening to the Eustachian tubes........ **Aglossa.**

Suborder PHANEROGLOSSA

Only the suborder Phaneroglossa is represented in the Philippines. It is usually divided into two groups, each of which is represented by two families in the Philippines.

Key to the Philippine families of the Phaneroglossa.

a^1. Coracoids united by a simple epicoracoid cartilage; precoracoids resting with their distal extremity on the coracoid or connected with it by cartilage; precoracoid sometimes absent.......................... **Firmisternia.**
  b^1. Upper jaw toothed; diapophyses of the sacral vertebra not or only slightly dilated; precoracoids always present........................ **Ranidæ.**
  b^2. Upper jaw toothless; diapophyses of the sacral vertebra dilated; precoracoids present or absent.. **Engystomidæ.**
a^2. Coracoids and precoracoids connected by an arched epicoracoid cartilage, that of one side overlapping that of the other........................ **Arcifera.**
  c^1. Jaws toothless; diapophyses of sacral vertebra dilated.... **Bufonidæ.**
  c^2. Upper jaw toothed; diapophyses of sacral vertebra very strongly dilated .... **Pelobatidæ.**

Page 228, under RANIDÆ, line 1, *for* vertebræ *read* vertebra.

Page 232, line 8, *for* in habit, and are invariably found in water *read* in habit and are usually found in water.

Page 252, line 29, *for* of fifth toe smallest, prominent; inner etc. *read* of fifth toe smallest; prominent inner etc.

Page 269, line 8, *for* longer *read* larger.

Page 269, in table of measurements, last line, *for* 1.8 *read* 18.

Page 290, line 16, *for* Wiegman had a Manila specimen collected by Meyer for the *read* Wiegmann had a Manila specimen collected by Meyen for the.

Page 316, line 6, substitute a semicolon for the first comma.

Page 319, line 2, *for* vertebræ *read* vertebra.

Page 320, line 18, *for* vertebræ *read* vertebra.

Page 323, line 9, *for* slits on side *read* slits at side.

Page 328, line 29, *for* vertebræ *read* vertebra.

Page 332, line 2 of paragraph 2, *for* body *read* bony.

Page 333, line 6, *for* granular on *read* granular; no.

Page 334, last line under *Tadpoles*, *for* ticulation *read* tal characters.

Page 337, under BUFONIDÆ, line 1, *for* vertebræ *read* vertebra.

Page 337, in line 2 of the *Key*, *for* horinzontal *read* horizontal.

Page 339, in the table of measurements, *for* Tibia 65 *read* Tibia 6.5.

Page 345, last line, *for* Boie, from *read* Boie, a snake from.

Page 346, under PELOBATIDÆ, line 2, *for* vertebræ *read* vertebra.

INDEX

[New generic and specific names and new combinations are printed in clarendon; synonyms and names of species incidentally mentioned in the text are printed in *italic.*]

B

CONTENTS

The Philippine Journal of Science is issued twelve times a year. The sections were discontinued with the completion of Volume XIII (1918).

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