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ANNALS

OF THE

ROYAL BOTANIC GARDENS,

PERADENIYA.

EDITED BY

J. C. WILLIS, M.A., F.L.S.,

DIRECTOR.

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The Royal Botanic Gardens of Ceylon, and their History.

BY

J. C. WILLIS.

THE commencement of a new century, and with it of the present Journal, affords a good opportunity for a brief sketch of the present position and past history of the well-known scientific establishment over which the writer has the honour to preside. In recent years, especially, a considerable expansion of the scope of the Department, and of the work carried on by it, has taken place. In many ways the history of the gradual enlargement of the establishment reflects the general history of the nineteenth century in Botany and its allied sciences and arts. In the early years of the past century, when Botany consisted only of the study of the external characters of plants, their classification, and the investigation and cataloguing of the floras of the different regions of the world, the Royal Botanic Gardens of Ceylon were occupied principally with the collection and description of the wild plants of the Island. Towards the middle of the century began the rise of Economic Botany, and the then Director did splendid service in the introduction and acclimatization of numerous useful and valuable plants from other parts of the world, whilst not neglecting the study of the still very incompletely known vegetation of Ceylon itself. Later still, and with the rise of Vegetable Pathology, the fact began to be recognized, partly no doubt as the

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result of the collapse of the great coffee industry by the attack of the leaf disease, that science can afford services of as much value in aiding established industries to combat disease as in introducing new industries, and this has gradually led to the appointment of two officers upon the staff of the gardens whose primary duty is the investigation of the insects and fungi of the Island, especially those likely to be injurious, and the discovery, if possible, of means of combating their attacks. For the work of these officers, and for other scientific work carried on here, a new laboratory has been opened. Whilst the collection of the local flora and the introduction and acclimatization of plants from abroad is still vigorously carried on, these are no longer the sole duties undertaken by the Department. The condition of the various local industries is investigated by the scientific staff, and experiments are carried on in order to determine in what ways the methods or operations of these industries may be profitably improved ; other experiments are devoted to the discovery, if possible, of new industries based on the cultivation of native or introduced plants.

It will thus be seen that there is scarcely any branch of modern botanical or agricultural science which is entirely unrepresented in the present organization of the Department. The general basis of the work is rigidly scientific, but the production of results of immediate practical value to local industries is steadily kept in view. Every facility for the carrying out of researches in pure or applied Botany is so far as possible afforded, both to workers on the regular staff of the gardens and to workers from Europe and abroad, for whom space is reserved in the laboratory.

It will be convenient to deal with the subject by the historical method. The present headquarters of the Royal Botanic Gardens, a Department of the Public Service of Ceylon, are at Peradeniya, but this was by no means always the case. The Dutch had a garden in Slave Island, Colombo, but after the English conquest this was neglected and sold by the Government. The first English Governor, the Hon. F. North (afterwards Lord Guilford) had a small private garden at Peliyagoda near Colombo, under the superintendence of Joseph Jonville or Joinville, whom he brought out as "Clerk for Natural History and Agriculture." In 1800 Jonville accompanied General MacDowall's Embassy to Kandy, and made a collection of plants which is now in the British Museum. He also drew some of the plates in Cordiner's "Description of Ceylon." Several exchanges were made between the garden in his charge and the gardens of the East India Company at Calcutta.

In 1810 Sir Joseph Banks, then President of the Royal Society, was instrumental in causing the opening of the first English Botanic Garden in Ceylon, under the superintendence of W. Kerr, who was transferred from Canton, arriving in 1812. Seven acres of land were opened in Slave Island, where the site is still indicated by Kew road, and Kerr was placed in charge of this and of the garden at King's House as "Resident Superintendent and Chief Gardener." Kerr brought with him several plants from China; his name is commemorated in the well-known shrub *Kerria japonica*, introduced by him to Europe.

In 1813 the garden was moved to Kalutara, on the south-west coast, the Colombo site having been found too subject to flooding. The Government had resumed possession of an unsuccessful sugar estate of 600 acres at Ugalboda, on the left bank of the river, and upon this the garden was reopened. In the following year Kerr died, and was succeeded by Alexander Moon, who arrived in Ceylon in 1817. Under him the gardens were much improved, and in 1821, six years after the conquest of the Kandyan kingdom, were transferred to their present site at Peradeniya, four miles from the centre of Kandy, on the Colombo road. The site chosen was in most ways excellent, suffering chiefly in the lack of a sufficient water supply, the river which almost encircles it being at too low a level to be available for watering the garden. The site is almost horseshoe-shaped, occupying a peninsula round which flows the broad and rapid stream of the Mahaweli-ganga, the principal river of Ceylon. It is about one mile in length from north to south, and has an area of 143 acres, prettily undulated. The southern end is rocky, but with fairly good soil in many parts ; the northern end consists largely of old river deposits of sand and gravel. On the farther side of the river rise the hills of Gangaroowa estate, one of which, to the north-east, is about 700 feet higher than the garden and acts as an efficient barrier against the force of the north-east monsoon. The general level of the garden is about 1,550 feet above the sea, and the climate is warm and damp, but very much pleasanter than the climate of the wet zone of the low-country, as exemplified in Colombo. The air has a bracing freshness that is lacking in the plains, and the nights are always cool. The climate is sufficiently warm to render possible the cultivation of all but a very few tropical plants, for which the nights are too cold in February and March and the days too dry, and sufficiently cool to allow of the cultivation of many sub-tropical plants suitable to medium elevations in the mountain zone, but not capable of cultivation in the low-country. It is also sufficiently cold to allow of energetic office or laboratory work with as little discomfort as in Europe. The successful working of the Botanical Department is in no small degree due to the choice by Moon of so excellent a site as regards climate and position.

Before returning to the history, it may be well to say a little about the climate of Peradeniya. The weather of the year depends upon the two monsoons, in each of which there is usually a very rainy commencing period, and a drier termination ; the dry season of the north-east monsoon is the more pronounced, and is generally known here as the "dry" or "hot" season. The following table gives the rainfalls, number of rainy days, approximate mean temperatures, and approximate ranges of temperature for each month of the year :—

Month.	Rain-fall. Inches.	Days.	Mean Temp. F.	Mean Max. F.	Mean Min. F.	Wind from
January ...	2·83	6	74	83	65	N.E.
February ...	1·57	4	76	87	65	N.E.
March ...	4·67	8	77	88	66	N.E.
April ...	9·66	14	78	88	68	N.E–S.W.
May ...	7·16	12	78	86	70	S.W.
June ...	10·17	20	75	80	70	S.W.
July ...	6·84	17	75	80	70	S.W.
August ...	5·96	16	76	83	69	S.W.
September ...	6·40	15	76	85	67	S.W.
October ...	13·18	19	75	84	66	S.W–N.E.
November ...	9·74	16	74	84	64	N.E.
December ...	8·07	13	74	84	64	N.E.
Year ...	86·25	160	76	84	68	—

The figures for the temperatures are merely rough approximations, as no regular records have been kept at Peradeniya. The highest recorded temperatures in the year rarely reach 90°, the lowest 60°. The highest rainfall in twenty-four hours seldom exceeds three inches, though almost treble this amount has been recorded.

The rainfall of the year is well distributed, but there is a somewhat severe drought in the first three months of the year, sufficient to make the lawns look rather brown, and to prevent that loading of the trees with epiphytes which is seen in the wetter parts of the Island, and in such a garden as Buitenzorg, where there is more than twice the rainfall.

Moon transferred to Peradeniya all the plants which could be moved from Kalutara, and laid out the south-eastern part of the ground, planting especially coffee and cinnamon. He spent much time in the investigation of the flora of the Colony, and collected largely in the Western Province, as well as near Kandy and in Uva. In 1824 he published at Colombo, in English and Sinhalese, his " Catalogue of the

Indigenous and Exotic Plants growing in Ceylon." Of the 1,127 plants native to the Colony there enumerated, 164 are new species described for the first time. He made a considerable herbarium, now mostly at Kew, and commenced the library of the Department. In 1818 Harmanis de Alwis Seneviratne was appointed writer under him, and displayed such talent for drawing that Moon had him taught at his own cost and appointed as draughtsman in 1823. This was the beginning of the splendid series of coloured drawings of the Ceylon flora and of other plants cultivated in the gardens, which has been steadily continued to the present time by H. de Alwis and his two sons, one of whom, William de Alwis Seneviratne, Muhandiram, is at present the draughtsman of the Department. In May, 1825, Moon died of fever, and for some time the gardens were in charge of Andrew Walker as Acting Superintendent. He was succeeded in 1827 by James Macrae, who collected many plants, especially orchids From this time till 1844 the Department languished, being chiefly used as a Government market garden, the produce of which was sold in Kandy. Macrae died in 1830, and after another interregnum under G. Bird, James George Watson was appointed Superintendent in 1832. He collected plants at Jaffna and Puttalam and died in July, 1838. The rubber avenue at the entrance to the gardens was laid out by him in 1833. Another period of interregnum under J. G. Lear,* who came to Ceylon in 1837 or earlier as collector for Messrs. Knight of Chelsea, followed, lasting till the appointment in 1840 of H. T. Normansell, "a clever young surgeon." Lear collected and described a number of orchids, and was one of the earliest tea planters; he planted tea at Nuwara Eliya in 1837. He laid out the beautiful group of palms at the entrance of the gardens.

In January, 1843, Normansell died, and W. C. Ondaatje acted as Superintendent till the arrival in May, 1844, of

* Many letters of his on garden matters are reprinted in "Literary Register," 1890.

George Gardner, F.L.S., the well-known Brazilian traveller, who was appointed on the recommendation of Sir William Hooker. With his arrival the Department started on a new career. Only one quarter of the land was then in use ; the remainder was largely cleared and planted, new roads opened, and many new plants introduced from other countries. A new bungalow for the Superintendent was built in the centre of the garden, and the entrance lodge erected. Gardner travelled almost all over the Colony, and made large collections of native plants, many of which were new to science. Unfortunately for the Department and for science, he died of apoplexy at Nuwara Eliya, at the early age of 37, in March, 1849. A cenotaph, containing a brass to his memory, was erected in the gardens in 1855. His herbarium was purchased by the British Museum, and thus unfortunately lost to the Colony.

From March to December, 1849, Mr. G. Fraser was Acting Superintendent of the Gardens pending the arrival of the newly-appointed Superintendent, George Henry Kendrick Thwaites, who was for 31 years to control the destinies of the Department, and to do so much for scientific botany and for the planting industries of Ceylon. Born in Bristol in 1812, Thwaites was 37 years old when he arrived in Ceylon, and had already won a distinguished reputation in Botany. Until about 1857 his duties were largely of a purely scientific kind, but afterwards his time was increasingly taken up with economic work.

In 1854 a vigorous attempt was made in Council to abolish the gardens. They were defended by Mr. W. Ferguson in the "*Observer*" and by Dr. Lindley in the "*Gardeners' Chronicle*." Thwaites maintained the gardens in a very high state of efficiency and opened out further portions of the jungle for cultivation. The title of the post was changed from Superintendent to Director in 1857, and in 1860 a new European post was created, that of Conductor (now Curator), to which Mr. Cameron of Kew was appointed. This appointment relieved the Director of most of the routine garden work, leaving him free to devote more time to the work on the Ceylon Flora and to the introduction of new and useful plants. In 1857 Thwaites obtained the assistance of Dr. (now Sir) J. D. Hooker in the production of his proposed Flora of the Island, and in the following year the first part of it appeared, under the title of "Enumeratio Plantarum Zeylaniæ." The work was completed in 1864, and contains the descriptions of many new species, as well as notes on habitat, uses, native names, &c. Thwaites at the same time issued large sets of dried specimens of Ceylon plants ("C. P." sets), and with the proceeds of the sale of some of these added many important works to the garden library.

In 1860 the site of the Hakgala Garden was selected by Thwaites for the reception of the cinchona plants brought from Peru by Sir Clements Markham, and was placed in charge of Mr. MacNicoll. The garden lies on the side of Hakgala mountain at an elevation of about 5,600 feet, in a cool, temperate climate, with a mean annual temperature of 61°, and rainfall of 91 inches, distributed over the year in a similar way to that at Peradeniya. An area of about 550 acres of land was reserved for the garden; most of this is still covered with jungle or grass (patana). Here the cinchonas were soon established, and in a few years large numbers of plants were ready for distribution. At first planters were disinclined to try the new industry, but a few years later, as coffee ceased to do well, cinchona was very largely taken up, finally becoming for some years the staple industry of the Colony, and bridging over the period between coffee and tea. The gardens began to distribute seed of the latter about 1864, but for many years previously Thwaites had called attention to it in vain. In 1868 the new building of the herbarium was opened, and the library and herbarium moved into it from the Director's house (the present Museum).

In the report for 1871 appears the first mention of the coffee leaf disease, *Hemileia vastatrix*, and in all succeeding reports Thwaites deals with this, consistently rejecting the popular idea of the possible discovery of a cure. At this period he devoted a good deal of attention to the fungi of Ceylon, of which no less than 1,200 species, sent by him, were described by Berkeley and Broome in the Journal of the Linnean Society for 1871.

In the report for 1873 the spread of tea cultivation is noticed, and the cultivation of cacao and cardamoms, both now important industries in Ceylon, is for the first time pressed upon public attention.

The "Enumeratio" was purely a scientific botanist's Flora, and with a view of getting more freedom from routine work to enable him to compile a popular Flora of Ceylon, Thwaites obtained in 1874 the appointment of an Assistant Director (the Conductorship had been abolished in 1863). The first holder of this post was Mr. M. M. Hartog, now of Queen's College, Cork; the second, Dr. D. Morris, now Imperial Commissioner of Agriculture in the West Indies. In spite of this help, however, the duties of the Directorship proved too heavy for Thwaites to carry out the proposed work, and it was left in a very fragmentary condition at his retirement.

In 1876, the Indian Government having obtained seeds and plants of *Hevea brasiliensis*, the Para indiarubber, from South America, it was found that the climate of India was unsuitable for them, and they were sent to Ceylon, where the branch garden at Henaratgoda, 17 miles from Colombo, on the Kandy railway, was opened for their reception, and as an experimental garden for strictly low-country products. In this garden, with its hot steamy climate (mean temperature about 82°, elevation about 15 feet above sea level) and well-distributed rainfall of 100 inches, many plants of the hot equatorial regions flourish much better than at Peradeniya, and the garden, besides its use as a nursery for rubber plants, has proved a very useful adjunct to the principal garden. It contains among other features of interest a small piece of untouched jungle. The cultivated area is now about 30 acres.

Thwaites retired in the beginning of 1880, after a long service of 31 years, spent without once quitting the Colony. Dr. Morris, the Assistant Director, had left for an appointment in Jamaica a short time before, and the vacancy in the Directorship was filled by the appointment of Henry Trimen, M.B., F.L.S., Assistant in the Botanical Department of the British Museum. Thwaites retired to Kandy, where he purchased Fairieland bungalow. During his tenure of office he had received the distinctions of F.R.S. (1864), Honorary Degree of PH.D., and C.M.G. (1878). He died in 1882 at the age of 70. A memorial building, containing a brass, was erected in the gardens soon afterwards.

The new Director arrived at a time of trial for the Colony, for the coffee industry was rapidly sinking under the attacks of its fungus enemy. At this period Mr. (now Professor) H. Marshall Ward came out for two years, 1880–82, to carry out a series of researches into the life-history of the *Hemileia* with the view of endeavouring to discover preventive measures. The mission, though successful in the former object, was unsuccessful in the latter, as Thwaites and Mr. Ward himself had predicted would likely be the case. No Assistant Director was appointed at this time, but the appointment of Conductor was revived, and Mr. P. D. G. Clark was appointed to it as Head Gardener. The garden at Peradeniya was largely cleared of the redundant vegetation it contained, and the South Garden, the last remaining uncultivated piece, laid out systematically. With the appointment of Mr. W. Nock in 1882 to the post of Superintendent of Hakgala, that garden was also taken in hand, and gradually transformed from a cinchona nursery into the beautiful and useful Botanic Garden that it now is. In 1883 the small branch garden at Anuradhapura, the capital of the North-Central Province, was opened ; this gave the opportunity, hitherto wanting, of growing many plants which are intolerant of the wet climate of the three already existing gardens. The climate of Anuradhapura, 300 feet above sea level, is that of Peninsular India ; the mean annual temperature is over 80°, and the rainfall is chiefly in the last three months of the year. Out of a total mean rainfall of 54 inches, 29 fall in these months. In 1886 another branch garden of 11 acres was opened at Badulla, the capital of the Province of Uva, at an elevation of 2,220 feet. Here, on the eastern side of the main mountain mass of the Island, the climate has a different periodicity, and is also somewhat drier, than on the western side. The mean rainfall is 79 inches, chiefly falling in the north-east monsoon, and the "dry" season is from July to September, instead of from January to March. The flowering and fruiting seasons of many of the plants differ correspondingly. The mean temperature of the locality is 73°.

In 1883 the Director's bungalow in the centre of the garden was transformed into a Museum, and gradually stocked with a good collection of vegetable products and specimens, chiefly economic. The Director's residence was transferred to the "Assistant Director's house," just vacated by Mr. Ward.

Coffee was now failing fast, and Trimen devoted much energy and enthusiasm to the introduction and spread of new industries, especially cinchona, now becoming the staple of the Colony, tea, cacao, and indiarubber, together with Liberian coffee, and many others. He also devoted himself to the preparation of a complete and thorough Flora of Ceylon, the publication of which was at length begun in 1893. Unfortunately he did not live to complete this work, but the last two volumes of the five have been finished by the veteran Sir J. D. Hooker, the concluding volume appearing in 1900.

Trimen also published, besides many purely scientific papers, a Catalogue of the Plants growing in the Gardens, and a Hand-Guide to Peradeniya Garden, of which four editions appeared before his retirement. A fifth, re-written, appeared in 1898.

About 1886 the garden began to attract visiting botanists in appreciable numbers, and in 1888 a small room in the Museum, next to the Director's office, was turned into a laboratory for their use, by aid of a grant made from the funds of the British Association for the Advancement of Science. Mr. M. C. Potter, now of the College of Science, Newcastle, was the first to work in it. He was followed, in 1891, by Mr. J. B. Farmer, now Professor at the Royal College of Science, London, and in 1893 by Mr. F. W. Keeble of Cambridge.

During the last few years of Dr. Trimen's Directorship he was mainly occupied with the preparation and publication of his "Flora of Ceylon," which forms a splendid monument of his work here. His health failed very much in later years, and on June 30, 1896, he retired on pension, remaining in the Colony to work at the Flora, which unfortunately he was prevented from completing by his death on October 16 of the same year, in the 53rd year of his age. He had received the distinction of F.R.S. in 1888, and a brass to his memory has been erected in the Museum by the Planters' Association of Ceylon.

The writer, then Assistant in the University of Glasgow, was appointed to succeed to the Directorship, and commenced work on September 14, 1896. Mr. Nock had taken charge as Acting Director since Dr. Trimen's retirement.

During the last four years, which have been years of great prosperity in Ceylon, owing to the growth and success of the tea industry, many changes have been made in the Department. Under the Curatorship of Mr. H. F. Macmillan, appointed in 1895, the Peradeniya Garden has been greatly improved, and a number of new experimental cultivations started. There is not, however, enough space for the efficient carrying out of real experimental cultivation of important plants, and the Government has now under consideration the opening of an Experimental Garden near to the Botanic Gardens at Peradeniya, in which such work can be properly carried on under a skilled Superintendent. With this garden will be combined the training of students, hitherto carried on at the Agricultural School in Colombo, which was closed in March of the present year.

The tea industry, as well as others, having been troubled with attacks of disease due to insects or fungi, the need of having scientific help in the prevention and cure of such troubles has been realized, and met by the appointment of an Entomologist in 1899, Mr. E. E. Green, and of a Mycologist in 1900, Mr. J. B. Carruthers. The latter officer also acts as Assistant Director, taking charge of the whole Department in the absence of the Director, and taking charge at all times of certain branches of the economic work. A small annual vote also provides for an Assistant (appointed for a period not exceeding three years) for special investigations. The first worker under this scheme was Mr. J. Parkin, who made a very thorough investigation into the treatment of latex for the preparation of indiarubber ; the present Assistant, Mr. H. Wright, is occupied among other things with various questions bearing on the Forestry of the island, such as the sources of the ebony and other Diospyros timbers, and the formation of rings of growth in tropical timbers. Another important appointment made in 1900 is that of Mr. M. K. Bamber as Agricultural Chemist to the Department. Mr. Bamber has so far been chiefly engaged in work on citronella oil, tobacco, and camphor, the first two with the view of aiding established industries, the last with that of aiding the establishment of a new one.

The appointment of so many scientific officers of course involved the construction of a proper laboratory, the more so as the stream of scientific visitors from abroad was now reaching considerable proportions. In 1896 and 1897 there was only one visitor, but in 1898 the number rose to five, and in 1899 to six. A new building, lying to the north of the herbarium, was commenced in 1899, and is now complete. It contains rooms for general morphological, physiological, chemical, economic, and photographic work, and has accommodation for eleven or twelve workers. Visitors from abroad are cordially welcomed, and every facility provided for their work. A resthouse is now being erected opposite the entrance of the gardens, and there is ample hotel accommodation in Kandy. In connection with the chief laboratory at Peradeniya a small working room has been opened in the garden at Henaratgoda, near which there is also a resthouse, and a similar room, with sleeping and living accommodation, is nearly completed at Hakgala. The Library of the Department has been much enlarged, and now amounts to about 2,500 books and papers; the chief periodicals are regularly received.

The economic history of Ceylon during the last few years is chiefly that of tea, which is by far the chief industry of the Colony, though it deserves special remark that tea is not, in proportion to other exports, nearly so great a staple as coffee was. It forms about 52 per cent. of the value of the exports, cocoanuts, cacao, and other products forming no small proportion of the total. Mindful of the fate of coffee, the Department makes every effort to encourage the development of the minor industries, to introduce or discover new ones, and to aid the planters in combating the first appearances of disease among their crops. At present there seems every prospect of indiarubber and camphor becoming valuable new minor industries in Ceylon, through the efforts of the Department, which in the case of rubber date from 1876.

The present organization and staff of the Department is as follows:—

Director: J. C. Willis, M.A., F.L.S.

Chief Clerk: R. H. Pereira.

Scientific Department.

Botanist: The Director.

Assistant Director and Mycologist: J. B. Carruthers, F.L.S.

Entomologist: E. E. Green, F.E.S.

Agricultural Chemist: M. K. Bamber, F.C.S.

Assistant: H. Wright, A.R.C.S.

Draughtsman: W. de Alwis, Muhandiram.

Herbarium and Laboratory Attendants, and two Plant Collectors.

Botanic Gardens Department.

Peradeniya.—Curator : H. F. Macmillan, and native staff.

Hakgala.—Superintendent : W. Nock, and native staff.

Henaratgoda.—Conductor : S. de Silva, and coolies.

Anuradhapura.—Conductor : D. F. de Silva, and coolies.

Badulla.—Conductor : D. D. Fernando, and coolies.

Proposed Experimental Gardens Department and Agricultural School.

(Not yet organized.)

Superintendent, foremen, and coolies.

Teaching Staff : The Officers of the Department.

NOTE.—In the preparation of the above Paper I have made considerable use of notes on the history of Ceylon Botany left by Dr. Trimen ; at some later date I may hope to publish extracts from these in more detail.

The Royal Botanic Gardens of Ceylon as a Centre for Botanical Study and Research.

BY

J. C. WILLIS.

IT would be difficult to exaggerate the value of travel in other countries to the working botanist, especially if his work lie in the departments of systematic botany, geographical distribution, ecology, morphology, or economic botany, whilst to the physiological or anatomical worker there are also innumerable problems which can only be solved by research in tropical countries. Even though only a short visit be paid to a country whose climate and flora are unfamiliar, and though no definite piece of research work be undertaken, the traveller gains in breadth of view and in understanding of the great problems of the science. As the present reaction from the exclusive study of plants in the laboratory to their study in the field as well gains in strength, the necessity and advantages of travel and of study and research in other countries will become more manifest.

The first flora and vegetation the traveller desires to see is usually that of the tropical zone, and there is no place where he can see it with greater ease than in Ceylon, nor any tropical land with so great a variety of climate and vegetation in so small a compass and so easily reached from whatever headquarters may be selected. In the south-western plains, between the mountains of the central part of the Island and the sea at Galle and Colombo, the climate and the vegetation

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are characteristically equatorial—a damp hot climate, very equable, with rain at all times of year, and with the rank luxuriance of vegetation that such conditions favour. Though a large part of this region is now cultivated, there still remain magnificent pieces of "high forest" into which botanical excursions can be made. The north and east, on the other hand, show a completely different climate and vegetation—that of Peninsular India. The climate is dry for about nine months of the year, and the forests show a totally different composition and character. In the extreme south-east and north-west, in the neighbourhoods of Hambantota and Mannar respectively, the drought is so extreme that the climate and flora may be described as "desert," and very fairly compared with those of parts of the Mediterranean region. In the mountain ranges that occupy the centre of the Island may be found every variety of climate and of flora from tropical through sub-tropical and temperate almost to sub-alpine, and both forest and grass land, both wet districts and dry, each with their characteristic peculiarities of flora. On the southern and western shores of the Island may be seen the characteristic Indo-Malayan shore flora,—the mangroves, the beach-jungle (Barringtonia formation of Schimper), the Ipomœa and the Nipa formations, &c. To the north the flora of the coast changes to a more Indian type, and in the far north may be found magnificent salt-lagoon floras. Water plants abound in the coast lagoons, in the paddy fields, and in the great irrigation lakes of the dry country, Podostemaceæ in the mountain streams; sea-weeds are plentiful on the south coast and in the great harbour of Trincomalee; ferns, mosses, liverworts, and fungi in the mountains and in the south-western plains. Besides the rich flora of the Island itself (over 3,300 species of flowering plants and ferns), the visitor can in a very short time reach from Colombo any part of India or the Malay Peninsula. The splendid jungles of the Anamalais and other southern Indian mountains have been but little explored, and can be reached in two or three days from Colombo; Assam, Burmah, and Malaya in a week.

The traveller to Ceylon has the choice of numerous good and swift steamship lines to Colombo. The four great mail companies, the Peninsular and Oriental, the Orient, Norddeutscher Lloyd, and Messageries Maritimes, run steamers at frequent intervals from London, Bremen, Antwerp, Southampton, Marseilles, Genoa, and Naples. The return fares are from London or Bremen about £80 first, £50 second class. The latter is quite comfortable, especially on the French and German lines. A very popular line is the Bibby, from Liverpool and Marseilles (return fare, first class only, from Liverpool £74 10*s*., from Marseilles £69 10*s*.). Other well-known lines are the British India, the City, the Nippon Yusen Kaisha or Japanese line (noted for its cheapness), and the Austrian Lloyd (from Trieste, return fare from Trieste £42 10*s*., from London, including rail viâ St. Gothard, £55). The fares to Colombo are high compared with those to Australia, and the traveller with time at his disposal should take a through ticket to Brisbane, costing a mere trifle more, and break journey at Colombo, afterwards proceeding to the Straits, Java, or Australia.

It is a great mistake to suppose that any "outfit" is necessary to come to Ceylon. All that is needed is a supply of the ordinary clothing worn in summer in Europe. Khaki, drill, and flannel clothes can be obtained, if needed, more cheaply in Colombo than in Europe, and also sunhats and a few necessary articles. There are good shops in the chief towns of the Island, and almost everything may be purchased as required at reasonable rates.

Living in Ceylon, though increasing in expense as elsewhere, is still cheap enough. At hotels in the chief towns it costs on the average about 7 to 8 rupees per day (the rupee equals 1*s*. 4*d*. English money), but at resthouses* it is considerably less, especially if the traveller take his own linen

* These are small furnished bungalows, with servants in charge, provided by the Government in all important towns and villages and at intervals of 14–15 miles along all chief roads, rendering travelling and botanising in almost all parts of the Island a simple matter.

(sheets, towels, &c.) with him. Hotel, resthouse, and bungalow servants speak English, so that there is rarely any need for a personal servant, unless perhaps when travelling in out-of-the-way districts. Travelling expenses are moderate; the most interesting regions in the Island, except the north, may be reached by rail, and a line to the northern extremity is now being made. Coaches run on the principal routes not served by rail, and the roads are excellent for bicycling, so that it is easy to travel by this method, sending heavy luggage in advance by coach. Steamers run round the Island weekly calling at Galle, Hambantota, Batticaloa, Trincomalee, Point Pedro, Jaffna, Paumben, and Colombo.

The best time, in general, to leave Europe for Ceylon is September, but, except for a somewhat hot three days in the Red Sea, July or August is equally good. The stay in Ceylon may last till March or April. April is a hot month here, and after the middle of May the weather in the Indian Ocean is usually very rough till the end of July. June and July are wet but cool months at Peradeniya, and the weather does not become at all unpleasantly warm till March or April. The hotter weather may be easily avoided by going "up-country" to work at Hakgala or elsewhere in the mountains. There is, however, no reason for fearing the heat at Peradeniya; the temperature in the laboratory never exceeds 84° F., and is usually between 75° and 80° (24–27° C) in the middle of the day. Working hours are usually arranged to suit the climate. A light "early tea" at 6 or 6.30 A.M. is followed by a walk in the garden, or collecting, and work in the herbarium or laboratory from 7.30 or 8 till 11, when breakfast is taken. Work may be resumed at 1 and continued till 5 or after. There is no afternoon sleep in Ceylon as in the Dutch colonies. Exercise (tennis, cycling, &c.) is usually taken early in the morning or after 4.30. Dinner is usually about 7.30. There is a good English Club in Kandy, and also tennis and sports clubs, where cricket, football, golf, &c., may be obtained.

Assuming that the absence from Europe is six months, the cost of the trip need not much exceed £130, made up thus :—

Voyage, second class, and expenses on ship	...	£ 60
Sixteen weeks at Peradeniya or other garden	...	„ 50
Three weeks' travelling ...	...	„ 15
Miscellaneous necessary articles ...	...	„ 5
		£ 130

For first class on voyage add £20-35, and for more travelling in Ceylon increase proportionately. The cost will be proportionately less if a longer time be spent in Ceylon.

The best headquarters for the scientific visitor will in general be at Peradeniya. A resthouse will shortly be opened there, and other accommodation is often available. The centre of Kandy town lies only four miles off, and there are frequent trains from a station near the gardens. In Kandy there are three excellent hotels, at which board and lodging for visitors working at the gardens may be had at Rs. 5–6 per day in periods of not less than a month at a time. These rates do not include midday breakfast or tiffin, which is assumed to be taken at Peradeniya. The resthouse at Peradeniya lies immediately outside the garden gate, and rooms in it will be specially reserved for scientific visitors.

The Botanic Garden at Peradeniya comprises an area of over 140 acres (58 hectares), and contains a large collection of tropical plants which are mostly carefully labelled. Being laid out with large lawns and open spaces, the trees are seen to advantage. In the centre of the garden lie the buildings of the Scientific Department, comprising :—

(1) The Economic Museum, containing a very complete collection of the Economic Products of Ceylon, systematically arranged ; in this building are also the offices of the Director.

(2) The Library and Herbarium, containing on the ground floor the offices of the Entomologist and Mycologist, the

Lithographic Press room, and the duplicate collections from the herbarium, and on the upper floor the Library, consisting of about 3,000 books and papers and supplied with most of the current botanical and economic literature of the day, a complete and separate Ceylon herbarium, a general herbarium, and a herbarium of the plants cultivated in the gardens. The identification of plants in which visitors are interested is thus rendered simple, especially as Ceylon possesses a complete Flora, written by the late Director and Sir J. D. Hooker.

(3) The Botanical Museum, not yet completed, but to contain a Ceylon Botanical Collection, systematically arranged.

(4) The Research Laboratory. This contains rooms for general microscopic and morphological work (places for four workers), for physiological work (two places), chemical work (two places), economic (two places), and a private laboratory for the Director, as well as a good photographic darkroom and verandahs for experiments in the open air. It contains a good supply of all the essential apparatus and reagents, but workers from abroad must bring their own microscopes, or at least lenses, and should bring what alcohol and bottles they require for carrying away material. Such alcohol will be admitted free of duty on certificate from the Director; the amount of duty must be deposited on entry, but is returned when the alcohol is removed from Ceylon. To the laboratory is attached, besides the attendant, a plant collector, whose services are within certain limits at the disposal of visitors on payment of the cost. Coolies for special work can be obtained on payment of their wages, usually about 37 cents a day, or 6*d.* in English money. Workers in physiology or other lines requiring special apparatus should bring such things with them, but for most work the laboratory is well furnished with essentials.

The neighbourhood of Peradeniya is mountainous, and mostly cultivated, but within a few miles there are some interesting pieces of wild country, and a short excursion by road or rail brings many good collecting grounds within reach.

Next to Peradeniya, the most important garden is at Hakgala, about six miles from the great mountain sanitarium of Ceylon, Nuwara Eliya. The garden lies on the steep side of Hakgala mountain, at an elevation of 5,600 feet (1,680 m.), and in a very good centre for exploring the mountain vegetation of Ceylon. On the west the hill jungles stretch away in an almost unbroken sweep for 25 miles, and on the east lies a vast expanse of dry grass country, with a peculiar and interesting vegetation. The garden itself contains a large reserved area of both jungle and grass (patana), and a very interesting collection of plants, from Europe, Australia, South Africa, the Himalayas, and other tropical mountains. It contains a small laboratory with living accommodation attached to it. The laboratory has two working places, and contains a small local herbarium of the plants of the hills and those cultivated in the garden. It has also a small dining room and two small bedrooms, so that, by taking a servant and arranging for supplies from Nuwara Eliya twice a week, it is possible to live and work there in comfort. A charge of one rupee a day is made for the use of the building by visitors, who must supply their own linen and knives and forks, but everything else is provided.

Another interesting station is the branch garden at Henaratgoda, 17 miles by rail from Colombo on the Kandy line, and reached in three hours from Peradeniya. There is a rest-house close to the station, and the garden lies about ¾ mile away. It contains among other things a piece of untouched jungle. The climate here is very hot and steamy, the garden lying almost at sea level. Many interesting plants are cultivated in it, and it contains a little working room, with a few simple necessaries for botanical work; anything required can however easily be taken from Peradeniya. From here an excursion may be made to the lagoon at

Negombo to see mangrove vegetation, but this vegetation is still more easily seen by taking the railway along the south-west coast to Bentota (resthouse) or Ambalangoda (resthouse). Nipa vegetation and many fine pieces of high forest may be seen near Matara, the terminus of the line on the south coast (resthouse), and the desert region of Hambantota (resthouse) may be reached from here by coach.

There is another branch garden at Badulla (resthouse), reached by rail and coach, on the eastern side of the mountains; the vegetation here is very interesting, and excursions may be made into the low-country east of the mountains, where the dry zone flora may be seen very well. Another branch lies at Anuradhapura, in the north of the Island, in the hot dry zone (resthouse), and may be reached by rail and coach from Peradeniya. The town itself is extremely interesting, being one of the famous "Buried Cities of Ceylon." In the neighbourhood there is interesting jungle, and the flora of the great irrigation lakes is also of interest. Another coach journey, soon to be replaced by railway, to the north, brings the traveller to Elephant Pass (resthouse), where the salt marsh flora may be seen to perfection, and beyond this lies the interesting Tamil country of Jaffna, richly cultivated. From Jaffna the return may be made by steamer, direct to Colombo, or to Trincomalee, returning thence to Kandy by coach and rail.

While the laboratories and other facilities are primarily intended for botanical work, there is no intention of excluding workers in other branches of science. Zoologists, Entomologists, Geologists, and others will be cordially welcomed, and places in the laboratories put at their disposal so long as there is room. Of the eleven working places in the principal laboratory at Peradeniya, about five are used by the staff of the Department, leaving six available for workers from abroad. Intending visitors should communicate with the Director some months in advance when possible, mentioning the line of work they wish to take up, and whether they wish any arrangements made before their arrival, such as the planting of particular plants or seeds, &c. The intending visitor would do well to read up beforehand as much as possible about the flora and vegetation, which will render it easier to carry on work here on arrival.

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Fungus Cultures in the Tropics.*

(*Preliminary Note.*)

BY

CARL HOLTERMANN.

(With Plate I.)

IN the introduction to my "Mycologische Untersuchungen aus den Tropen" I have briefly indicated that during my first visit to Ceylon I was successful in discovering a nutrient substratum, which proved to be extremely favourable for cultures of fungi. I am anxious, before proceeding to the publication of my recent work on the transpiration relations of tropical plants, to give an account of this, in the hope of thereby inciting others to test and further extend my mycological results.

The nutritive solution which afterwards proved so useful to me was accidentally discovered. At the commencement of my tropical studies in 1895–96 I directed my attention, in the first place, to the so-called Hemiascus fungi. Since these were, according to my supposition, to be especially looked for in the gummy excretions of trees, I allowed no opportunity to pass of making investigations in this direction. Excretion of gum from trees is a far more common phenomenon in the tropics than with us. In it there is always a rich growth of bacteria and the lower fungi. In this respect the well-known sugar palms, Arenga saccharifera

* "Pilzkulturen in den Tropen," translated by J. C. Willis at the author's request.

and Caryota urens, are particularly remarkable. A reddish brown gelatinous mass of varying size is, as a rule, to be seen on wounded stems. This is the sweet sap, which often flows in great quantity, especially from the cut ends of young inflorescences. In it I always found the spores of fungi, in one case of no fewer than twenty-six species, and all were more or less germinated, some even with a large mycelium. The species found were Basidiomycetes, Mucorineæ, Ustilagineæ, and others. My first attempts to use this exudation for fungus cultures were without success, and need not be described here.

The sap of Arenga saccharifera and Caryota urens is dried by the natives and brought to market, without further purification, as palm sugar, consisting of sugar, vegetable acids, and salts. It was a dilute solution of this in water which proved so excellent a medium for the cultivation of different genera of fungi. Palm sugar is everywhere common and cheap in Java and Ceylon, and is not difficult to obtain in Europe. The various genera of fungi require different degrees of concentration of the medium. Some fungi germinate easily in a 25 per cent. solution, others only in one of 5–6 per cent. Definite rules can hardly be laid down. I have been in the habit, when the spores will not germinate in a 10–11 per cent. solution, of trying a weaker one.

The sap, being an excretion product of the plant, naturally contains salts and other chemical combinations besides sugar, and it is to this that its great advantages as a nutritive medium are to be attributed—sugar alone would not be so suitable. Only in rare cases must anything be added to it to ensure germination.*

On account of the impurity of the Java and Ceylon sugar, the watery solution must be filtered before use, and various measures must be taken to free it from the numerous

* *E.g.*, see my "Mycologische Untersuchungen," p. 20.

foreign micro-organisms. Of the different well-known sterilization methods, it is, as a rule, sufficient for mycological purposes in the tropics to use the so-called fractional method, which was invented by Tyndall—the boiling of the nutritive medium four or five times, with an interval of one or two days between each two operations. This, however, is not always sufficient for the above-mentioned palm sugar solutions. A bacterium occurs regularly in the solution of Arenga (not of Caryota)* sugar, which has a great similarity to the common hay bacillus, and which is distinguished by the great capacity of resistance of its germs. It is particularly resistant to heat, and makes the sterilization of the solutions—a necessary preparation for the success of mycological cultures—very difficult. I endeavoured repeatedly to confine myself to the convenient fractional sterilization method. Although the boiling in glass flasks was repeated for several weeks, and the temperature raised to 100° C. on the first occasion, I was not successful in attaining my object—the bacteria appeared again and again, and as there were no other organisms to affect their successful growth, they soon took possession of the entire fluid and made it quite unsuited for cultures. The other micro-organisms, though at first often present in large quantity, were more sensitive to outside influences, and a heating three or four times repeated in four or five days was enough to kill them.

In the case of the nutritive solution under consideration it is in general best to kill the resistant spores of the bacteria by heating to about 110° R. in an autoclave. After this process has been once employed, it will suffice to employ a fractionated sterilization to 70° R. for the three or four further heatings. The solution can indeed be easily freed from all germs by an immediate heating and the first necessity for a pure culture be thus obtained, but experience shows that its nutritive capacity is thus seriously lessened.

* For clearness' sake I repeat of Arenga (not of Caryota).

As has already been mentioned, the solution contains, besides sugar, other organic compounds, including proteid. The proteid is not indeed present in such quantity as to coagulate on heating, but its composition is apparently altered, for in the solution sterilized only by means of the autoclave many spores failed to germinate.

Just as is the case with the bacteria, there is no universal nutritive solution for fungi. It has long been well known that many spores, *e.g.*, those of Coprinus and other coprophilous fungi, can only be cultivated on a decoction of dung. It has been noticed, in the course of my experiments, that a considerable number of dung-inhabiting fungi will germinate easily in my solution, if there be added to it a small proportion of meat extract, about 2 gm. to 50 gm. of the solution. The mycologist in the tropics cannot be too strongly advised to prepare a dung solution in Europe and take it with him for all purposes. I have easily succeeded in making such a solution in the Berlin Institute under great pressure (3–4 atmospheres) in an autoclave. The method has been long since described by other authors ; horse dung is placed in a vessel with about one-third of its weight of water, and heated for about a quarter of an hour under the pressure mentioned. The solution is filtered and sterilized in the flasks to be described below. In these it can be easily carried without fear of contamination.

Provided with these two solutions it is possible to undertake in the tropics many interesting developmental investigations of the fungi.

There are many fungus forms in the tropics which cannot be brought to germinate by the means at present available, *e.g.*, the Phalloideæ, most Clavarieæ, the red-spored Basidiomycetes, &c. With these I had no success. A satisfactory explanation of this passive behaviour towards all the nutritive solutions employed is not at present forthcoming. Nevertheless, I would urge further investigation into the germinative capacities of fungus spores, and do not doubt that a solution may be found suitable for the growth of these forms, which have as yet proved resistant to all methods tried. The period of germination varies much; some spores, such as those of the Mucorineæ, form long hyphæ after a few hours, while others only show the first phenomena of germination after three or four days. According to my experience, spores which remain unaltered after a week in the solution usually remain permanently in this condition. A certain amount of foresight must also be exercised in the choice of spore material. A few fungi, especially among the Myxomycetes, seem to lose their capacity for germination in a few days, and this again may vary in the same species. For instance, I found an Ustilago very common in Java on a Polygonum: the fresh material only germinated very slowly, while later experiments tried in Berlin succeeded admirably. In Arcyrea punicea (a Myxomycete), on the other hand, the fresh material was preferable, for in the course of only an hour and a half after sowing the slide was full of swarm spores, while a few months later the results were entirely negative, and no efforts would induce germination of the spores, which formerly had proved so easily manipulated. Other species, again, retained their capacity for germination for a long period, but became sluggish, *i.e.*, their germination was later. In many Ascomycetes in particular I frequently found that freshly collected material was most satisfactory, but that after the lapse of 6–12 months the germination was much slower. In the Myxomycetes the spores particularly soon lose their capacity for germination. As is well known, the growth of the higher plants in the tropics is much more rapid than with us. Judging from cultivation experiments this is not the case with the fungi, or at any rate the germination and the subsequent formation of mycelium proceeded, with the same species, just as rapidly in the Berlin Institute as in Colombo or in Batavia. It was also impossible to find any distinction in this respect between Colombo and Nuwara Eliya, although the mean temperature in the former was 27° C., in the latter only 15° C., and the experiments were carried on in both places with the same species (Schizostega, Dacryomycetes, and Mucorineæ).

As has just been pointed out, many fungi can never be germinated in the usual nutrient solutions. To my great disappointment this was also partially the case with Hemileia vastatrix, a fungus which has, as is well known, caused immeasurable damage to coffee trees ; it has almost totally destroyed the cultivation of coffee in Ceylon and other colonies by injuring the leaves. I take this opportunity of describing my cultivation experiments in the hope that others may carry them further. The yellowish spores occur in great numbers on the under sides of the leaves. Their detailed description is already sufficiently well known. The outer coat of the spore is covered with small papillæ, between which, as a rule, small particles of dust adhere to the spore, so that it is in consequence a matter of great difficulty to obtain pure spore material ; but success may be attained by causing the spores to fall into a drop of a mixture of water and alcohol by giving a gentle fillip to the leaf. The solution should contain only about 6–8 per cent. of alcohol, and must be made with sterilized water. It frequently happened that even in this very weak solution of alcohol young spores completely lost their capacity for germination. It is necessary to work with great care to prevent the influence of the solution from being too intense.

The first stages of germination showed themselves in my experiments after a couple of hours, one or two hyphæ appearing. These grew longer and longer, and finally grew upwards out of the solution into the air. Great masses of hyphæ appeared there, proportional to the number of spores sown. In other cases these remained upon the solution, and there showed much branching. It is of special interest to note that *the hyphæ never showed any transverse walls.*

As is well known, it has been shown by De Bary that *this is only the case with the lower fungi.* Hitherto Hemileia has been counted among the Uredineæ, but whether this is really the case must remain very doubtful after the observations above mentioned, for, as is well known, the hyphæ of the other Uredineæ possess distinct transverse walls. It is further to be noted that the hyphæ always remain sterile; in spite of all attempts I failed to obtain any form of fructification; as long as the culture remained alive, it continued sterile, although at times small swellings appeared at the tips; it is probable that these would have developed into spores had it been possible to keep the cultures alive longer, but as they were always killed through contamination with Bacteria and Penicillium, I was at the most only able to study them for a fortnight. The spores appear only to germinate in presence of plenty of free oxygen, for the above-mentioned phenomena of germination only appeared in those which were swimming on the surface of the solution, those which were submerged all remaining unaltered. Although these cultivation experiments afford but little of interest, I have taken the opportunity of describing them, in order to point out that it is certain that with modern methods important contributions may be made to the developmental history of Hemileia; the principal difficulty is to obtain pure cultures, and for this there are still many untried methods available; once let the developmental history of this fungus be made out, and we can then hope to find means of limiting the devastations of this formidable disease. The nutritive solution was always used in a very dilute form; the best results were obtained with solutions which had not been heated for some months.

Sterilization naturally plays a great part in mycological investigations in the tropics. In the rainy seasons almost everything is infested with fungi; I have always and in all cases used alcohol. Brightly polished instruments were kept in spirit, and before use passed through a flame, and coverslips were kept germ-free in the same way. Microscope slide glasses were taken out of the alcohol with forceps and at once passed through a flame; if they are then laid upon one another in a sterilized vessel they can be preserved for a long time. Flasks, after careful washing, were thoroughly washed out with alcohol and stood bottom upward, but in such a way that the alcohol could evaporate, and afterwards closed with a plug of wadding, which had been previously freed from germs with a solution of corrosive sublimate in alcohol (1 part in 1,000). Other means of disinfection for glasses and instruments are not to be recommended; I must particularly utter a warning against the use of carbolic acid, corrosive sublimate, and hydrochloric acid, as this involves the risk of spoiling the culture experiments. In Europe, where as a rule all kinds of drying ovens, autoclaves, &c., are available, other methods may indeed be used, but even here alcohol is to be recommended to the mycologist in most cases. It is obvious that by this method all such articles as corks, filter papers, &c., which cannot be exposed to high temperatures, may easily be freed from germs. The remarkable efficacy of alcohol has long been known. Some authors indeed consider even a 14 per cent. solution as sufficient; in the tropics this is, however, often not strong enough to kill the bacteria. The bacterium above mentioned as occurring in palm sugar showed itself particularly resistant, and only lost its germinative capacity when the solution reached a strength of 20 per cent. In general, I have used 75 per cent. alcohol, in which the germs are at once destroyed.

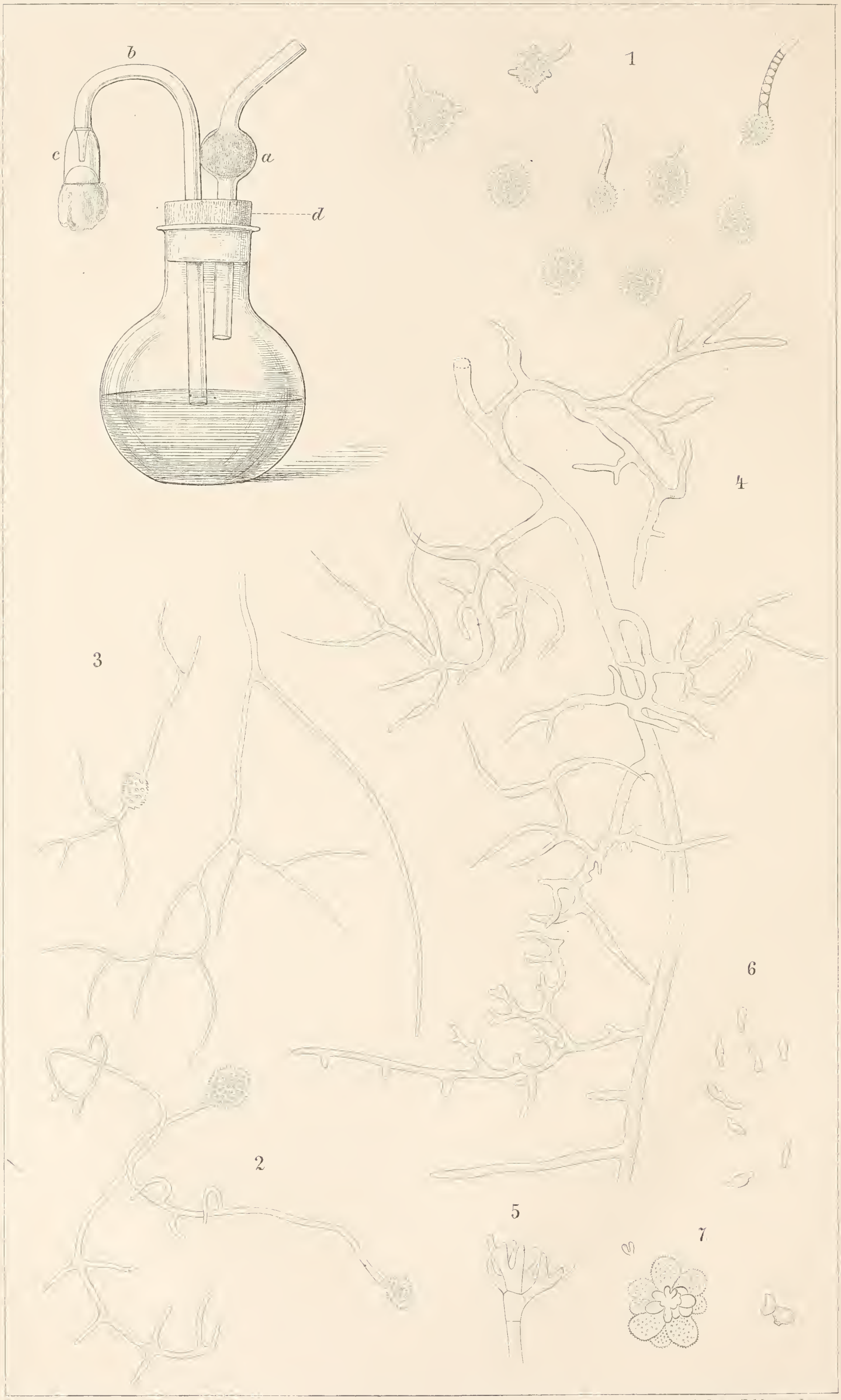
When we have thus freed the nutritive solution from all germs, and so fulfilled the first condition for the establishment of a pure culture, every possible care must be taken to preserve it from any subsequent contamination from without. For this purpose I recommend a specially constructed flask, which is illustrated in the figures. It is an ordinary washbottle, whose blow-tube (*a*) is blown out into a spherical bulb, which is filled with wadding. The other tube (*b*) is drawn out to a point and covered by a protecting tube (*c*). The jet must be so fine, that when used it shall only give one or two drops ; fungus cultures being usually made on the slide in a drop of nutrient solution, the flask must not furnish too great a quantity. In order to keep out particles of dust the protecting tube (*c*) is closed with a plug of wadding damped with alcohol. The wadding in the blow-tube (*a*) is sterilized with corrosive sublimate before being used. Wadding is an excellent bacterium filter in Europe without further treatment, but in the tropics, where the air is so damp, especially in the wet season, mould fungi are easily able to get through it ; in a few days the ubiquitous spores begin to germinate and send their hyphæ through the thick tissue of the wadding, and in a very short time the under side is quite green with the plentifully formed conidia of Penicillium. Against this danger the sublimate is a protection. The cork or rubber stopper of the flask must be protected in the same way against the entrance of spores or hyphæ. If these precautions are carefully attended to, the flask may be used for years without any fear of contamination.

It is obvious that the nutritive solution should be sterilized only after it has been introduced into the flask, and that the wadding in the blow-tube (*a*) should not be inserted till after this has been done, otherwise the steam will carry particles of the corrosive sublimate into the solution. The cork of the flask (*d*) may be fastened down with a thread to keep it permanently in one position, and the flask should never be opened without real necessity, and for a short time only. In this case care should be taken to hold the flask erect, to hinder the entrance of the countless spores of the tropical air. A fresh sterilization is to be recommended after even a single opening. It is also necessary to examine the fluid microscopically from time to time to make sure that it is completely sterile and contains at most only dead germs.

Modern mycology operates in Europe principally with very fluid nutrient solutions. As is mentioned on page 2 of the introduction to my "Mycologische Untersuchungen," such were but little used in my work. For as the cultures even in moist chambers are easily exposed to evaporation, the nutritive solution must be supplied in a form in which its concentration and composition may remain unaltered. I employed an addition of various Tremella or Auricula decoctions with good results. The mass appeared almost as clear as water, and possessed more or less viscosity according to the concentration, but, finally, I was successful in the hottest season at Buitenzorg with a little gelatine. The nutritive substratum is not rendered solid by the addition of the gelatine as in our climate, but in the warm tropical regions remains always more or less viscous. To prepare a firm substratum it is necessary to add a mixture of agar-agar with gelatine. Obviously, in employing viscous fluids, the jet of the flask (*c*) must be correspondingly enlarged, or better, the flask may be slightly warmed till the solution has the necessary fluidity.

The influence of daylight on the cultures, especially in the tropics, is very injurious, and they must therefore be kept in semi-darkness. The injurious effect is to be chiefly attributed to the fact that the solution loses water in light, thus producing an unsuitable degree of concentration. It is the more necessary to protect the cultures from evaporation, as a subsequent addition of solution is disadvantageous, the currents thus induced often affecting the culture. To obtain absolutely pure cultures is an operation attended by great difficulties, and in the tropics particularly, if errors are to be avoided, it is necessary to work with extreme care and cleanliness. A culture should contain only one species. A strange germ is capable within a short time of altering and destroying this. Certain fungi, *e.g.*, some Dacryomycetes, showed themselves, however, capable of overcoming all intruders, even Penicillium, which as a rule destroys everything.

Botanical Institute of the Royal University,
Berlin, Autumn, 1901.



C. Holtermann del. Lith. Anst. v. E. A. Funke, Leipzig

Explanation of Figures in Plate I.

Fig. a-d. Flask for nutritive solution. x ½.

Figs. 1–7. HEMILEIA VASTATRIX.

1. Germinating spores in nutritive solution, 1–24 hours after sowing. x 230.
2. The same spores after 36 hours. x 230.
3. Germinating spores, 48 hours after sowing. x 230.
4. Mycelium, 14 days old. x 300.
5. Mycelium from a coffee leaf, showing transverse walls ; the only case that I have observed. x 180.
6. Very young, unripe spores. Exhibited slight germination phenomena in the nutritive solution, but soon died. x 230.
7. Spores on a coffee leaf. x 180.

Note on the Flora of Minikoi.

BY

J. C. WILLIS.

IN his "Botany of the Laccadives,"* to which Minikoi politically belongs, though it is nearer to the Maldives and has a Maldivian population, Dr. Prain enumerates the plants hitherto known to grow wild or to be cultivated on this island. The total number is 113. During the south-west monsoon of 1899 the island was visited by Mr. J. Stanley Gardiner, in the course of his work on Coral Islands.† A collection of fifty-three plants was made by him, and has since been worked out in the herbarium at Peradeniya by Mr. W. de Alwis and myself; for determinations of two or three doubtful specimens I am indebted to Dr. Prain. Sixteen new plants are thus added to the list, raising the total to 129, and there are also 5 others with doubtful names, but certainly other species. The total is therefore 134. The island of Minikoi lies in the route between Colombo and Aden, in latitude 8·15° N. and in longitude 73° E. Upon the island is a large lighthouse, during the building of which there was constant communication with Ceylon, which will account for many of the introduced weeds. The island is a very typical coral atoll island, and is about 6 miles long.

* Prain: Botany of the Laccadives, Journ. Bombay N. H. Soc., VII., VIII., 1893.

† Gardiner: The Atoll of Minikoi, Proc. Camb. Phil. Soc., XI., 1900, p. 22
Idem, The Fauna and Geography of the Maldives and Laccadives. Cambridge, 1901 (in progress).

The natives are adventurous sailors, and are largely employed in ocean-going steamers; this, with the trade kept up with Calcutta and elsewhere, will also help to account for the numerous introduced plants.

The following list gives the entire flora of Minikoi, so far as at present known. Cultivated species, or species that have without doubt been introduced for purposes of cultivation, though they may since have become wild, are printed in capitals. Those quoted from Dr. Prain's list are marked P. Those collected by Mr. Gardiner are marked G. Native names are given by Mr. Gardiner for many of his species. They mostly agree with those in the Maldive Islands.*

ANONA MURICATA, *L.*	P. Soursop
Portulaca oleracea, *L.*	P.
Calophyllum Inophyllum, *L.* ...	P.
Sida humilis, *Willd.*	P. G. 18 (Mabulan)
Abutilon indicum, *G. Don.*	P. G. 16 (Mabulan)
Hibiscus Solandra, *L'Herit.* ...	P.
tiliaceus, *L.*	P. G. 37
ROSA-SINENSIS, *L.* ...	P. (Shoe Flower)
Thespesia populnea, *Corr.*	G.
GOSSYPIUM HERBACEUM, *L.* ...	P. (Indian Cotton)
BARBADENSE, *L.* ...	P. (Barbados Cotton)
Corchorus acutangulus, *Lam.* ...	P. G. 22 (Gethawcoley)
Triphasia trifoliata, *D.C.*	P.
MURRAYA KOENIGII, *Spreng.* ...	P. (Curry Leaf)
CITRUS MEDICA, *L.*, var. ACIDA, *Brandis.*	P. (Sour Lime)
DECUMANA, *L.* ...	P. (Shaddock)
ÆGLE MARMELOS, *Corr.* ...	P. (Bael)
Suriana maritima, *L.*	P.
Allophylus Cobbe, *Blume.*	P. G. 50 (Dom Musa)
Dodonæa viscosa, *L.*	G. 35
MANGIFERA INDICA, *L.* ...	P. (Mango)
MORINGA PTERYGOSPERMA, *Gaertn.*	G. 10 (Muranga)
SESBANIA GRANDIFLORA, *Pers.* ...	P.
ARACHIS HYPOGÆA, *L.* ...	P. (Ground nut)

* Willis and Gardiner: Botany of the Maldives, Ann. Perad. I., to follow.

Desmodium triflorum, *DC.*...	...	P. G.
Canavalia turgida, *Grah.* ...	...	P.
obtusifolia, *DC.* (lineata, *DC.*)	...	P.
ensiformis, *DC.*, cult. var.	...	G.
PHASEOLUS CALCARATUS, *Roxb.*	...	P.
Vigna lutea, *A. Gray* ...	...	P.
Cassia occidentalis, *L.* ...	...	G. 2 (Kuhada)
Terminalia Catappa, *L.* ...	...	P.
PSIDIUM GUAJAVA, *L* ...	...	P. (Guava)
EUGENIA JAMBOS, *L.* ...	...	P. (Rose Apple)
JAMBOLANA, *Lam.*	...	P. (Black Plum)
Pemphis acidula, *Forst.* ...	...	G. 20 (Kuradu)
LAWSONIA ALBA, *Lam.*	...	P. (Henna)
PUNICA GRANATUM, *L.*	...	P. (Pomegranate)
CARICA PAPAYA, *L.* ...	...	P. (Papaw)
LUFFA ÆGYPTIACA, *Mill.*	...	P. (Loofah)
MOMORDICA CHARANTIA, *L.*	...	P.
CUCUMIS MELO, *L.* ...	...	P. (Sweet Melon)
SATIVUS, *L.* ...	...	G. 48 (Kekurivur, Cucumber)
CUCURBITA MAXIMA, *Duchesne*	...	P. (Gourd)
Sesuvium Portulacastrum, *L.*	...	P.
Oldenlandia diffusa, *Roxb.* ...	...	P.
biflora, *L.* ...	...	G. 52 (Eyaganawatura, Kudingaybelama)
Guettarda speciosa, *L.* ...	...	G.
IXORA COCCINEA, *L.* ...		P.
Morinda citrifolia, *L.*, var. bracteata, *Hk f.*	...	P. G. 1 (Ah-he)
Vernonia cinerea, *Less.* ...	...	P. G. 13 (Kambulichi)
Adenostemma viscosum, *Forst.*	...	P.
Ageratum conyzoides, *L.* ...	...	P.
Wedelia biflora, *DC.* ...	...	P. G. 49 (Merihi)
Launaea pinnatifida, *Cass.* ...	...	P. G. 8 (Kadapi)
Scævola Koenigii, *Vahl.* ...	...	P. G. 29 (Magu)
Ochrosia borbonica, *Gmel.* ...	...	P.
Tournefortia argentea, *Linn. f.*	...	P.
Ipomæa denticulata, *Choisy.*	...	P.
biloba, *Forsk.* ...	...	P. G. 19 (Thaburu)
sinuata, *Ortega.* ...	...	P. G. 47
Convolvulus parviflorus, *Vahl.*	...	P.
Solanum torvum, *Sw.* ...	...	P.

MELONGENA	...	G. (Brinjal)
Physalis minima, *L.* ...	...	P.
CAPSICUM FRUTESCENS, *L.*	...	P. (Chillies)
Datura fastuosa, *L.* ...	...	P. G. 36
Ruellia prostrata, *Lam.* ...	...	P.
Barleria Prionitis, *L.* ...	...	P. G. 25 and 44 (Hai Kurudo)
Lippia nodiflora, *Rich.* ...	...	P. G. 12 (Hunigunditila)
Stachytarpheta indica, *L.*, var. jamaicensis...	...	G. 3 (Nunnay)
Premna integrifolia, *L.* ...	...	P. G. 25 (Gelavalie, Kude)
Clerodendron inerme, *Gaertn.*	...	G 21 (Dugajde)
FRAGRANS, *Willd.? fl. pl.*	...	G 33
Ocimum gratissimum, *L.* ...	...	P.
Basilicum, *L.* ...	...	G 24 (Gandakoli)
Anisomeles ovata, *R. Br.* ...	...	P. G. 30 (Maskota)
Mirabilis Jalapa, *L.* ...	...	P.
Boerhaavia repens, *L.*, var. diffusa	...	P. G. 14 (Nanubedi)
Amarantus viridis, *L.* ...	...	P. G. 23 (Sagu)
Aerua lanata, *Juss.* ...	...	P. G. 39 (Hudufipila)
Achyranthes aspera, *L.* ...	...	P.
PIPER BETLE, *L.* ...	...	P. (Betel)
Hernandia peltata, *Meissn.*	...	P. G. 51 (Kadu)
Euphorbia hypericifolia, *L.*, var. parviflora		P. G. 15 (Kerutina)
pilulifera, *L.* ...	...	P.
thymifolia, *L.* ...	...	P.
Phyllanthus maderaspatensis, *L.*	...	P. G. 46 (Kudingki)
Urinaria, *L.* ...	...	P.
Niruri, *L.* ...	...	P.
DISTICHUS, *Muell.-Arg.*	...	P.
Claoxylon mercurialis, *Thw.*	...	P.
Acalypha indica, *L.* ...	...	P.
fallax, *Muell.-Arg.*	...	P. G. 4 (Cave)
RICINUS COMMUNIS, *L.*	...	P. G. 6 (Amanaka, Castor Oil)
Ficus bengalensis, *L.* ...	...	P. (Banyan)
retusa, *L.* ...	...	P.
ARTOCARPUS INCISA, *Forst.*	...	P. (Bread-fruit)
Pouzolzia indica, *Gaud.* ...	...	P.

MUSA SAPIENTUM, *L.*	...	P. (Plantain)
Pancratium zeylanicum, *L.*	...	P.
Tacca pinnatifida, *Forst.* ...	...	P. G. 44 (Heith thala)
Dioscorea bulbifera, *L.* ...	...	P. G. 42 (Kattala)
Aneilema ovalifolium, *Hk. f.*	...	P.
Cyanotis cristata, *R. & S.* ...	...	P.
ARECA CATECHU, *L.* ...	...	P. (Areca palm)
Cocos nucifera, *L.* ...	...	P. (Cocoanut)
Pandanus odoratissimus, *Linn. f.*	...	P.
COLOCASIA ANTIQUORUM, *Schott.*	...	P.
Cyperus polystachyus, *Rottb.*	...	P.
Mariscus Dregeanus, *Kunth.*	...	P. G. 28 (Kalanduru gundi)
albescens, *Gaud.*	...	P.
Kyllinga brevifolia, *Rottb.*	...	P.
Panicum sanguinale, *L.*, var. ciliare.	...	P.
trigonum, *Retz.*	...	G. 32 (Hue)
Oplismenus Burmanni, *Beaub.*	...	P.
compositus, *R. & S.*	...	P.
Thuarea sarmentosa, *Pers.*	...	P.
Spinifex squarrosus, *L.* ...	...	P.
SACCHARUM OFFICINARUM, *L.*	...	P. (Sugar cane)
Ischæmum muticum, *L.* ...	...	P.
SORGHUM VULGARE, *Pers.*	...	P (Sorghum)
Apluda aristata, *L.* ...	...	P. G. 31 (Ona hui)
ELEUSINE CORACANA, *Gaertn.*	...	P. (Kurakkan)
indica, *Gaertn.* ...	...	P.
Eragrostis plumosa, *Steud.*	...	P. G. 27 (Sannipoo)
Lepturus repens, *R. Br.* ...	...	P.
Psilotum triquetrum, *Sw.* ...	...	P. G. 7 (Prumo)
Nephrolepis tuberosa, *Presl.*	...	G. 53(Hondikunavoo)

In addition to the above, the following probably occur :—

Portulaca tuberosa (*Roxb.*), *Trim.*, Fl. Ceylon, I., 90.

Wissadula rostrata, *Planch.*

Zizyphus Jujuba, *Lam.*

DOLICHOS LABLAB, *L.* (Veya hemaria, *M.*).

Cordia subcordata, *Lam.*

The general botanical bearings of the facts above enumerated will be considered in the subsequent paper on the Botany of the Maldives.

Peradeniya, June 16, 1901.

The Botany of the Maldive Islands.

BY

J. C. WILLIS

AND

J. STANLEY GARDINER

(*Balfour Student of the University of Cambridge*).

(With Plate II.)

CONTENTS.

I.—INTRODUCTORY.

OUR knowledge of the Flora of this interesting group of islands has hitherto been extremely limited. Although tributary to Ceylon, the Maldives lie in an unfrequented part of the Indian Ocean, and have but little communication with the outer world. They were visited by Ibn Batuta in 1343–44. Pyrard de Laval spent the years 1602–07 upon the islands, and has left an account of their general features and condition, but his descriptions of the vegetation are confined to the cultivated or useful plants, and are very fragmentary.

[Annals of the Royal Botanic Gardens, Peradeniya, Vol. I., Pt. II., December, 1901.]

Short papers were published in the Trans. Bombay Geog. Soc., 1836–38, first by Capt Moresby, then by Mr. Christopher and Lieut. Young. Bell, in the Ceylon Sessional Papers (XLIII. of 1881, not published till 1883), has compiled an account of the islands, chiefly from the authors already cited and information obtained at Malé, but even at this late period practically nothing was known about the vegetation. In 1888 Capt. Christopher made a small collection of plants on Malé island, and a few more were collected there in 1892 by Haly. These collections were determined and described by Dr. Trimen, whose "Preliminary List of Maldive Plants" in the Journal of Botany, 1896, p. 3, contains all that was up to that time certainly known about the vegetation. All the plants in this list are from Malé, the island on which stands the capital, and to which converges most of the commerce with the outer world. In 1896 a considerable collection of plants (174 numbers) was made in the islands by Ibrahim Didi, late Prime Minister to the Sultan. These he kindly presented to the Peradeniya herbarium through Mr. Bell. The late Dr. Trimen, we believe, made a cursory examination of this collection, but has left no notes nor determinations. Unfortunately no definite localities are given with these specimens; probably all of them are from Malé, or from Funadu, where Ibrahim Didi has a herb garden.* During the north-east monsoon of 1899–1900 one of us (J. S. G.) has made several large collections on different islands of the group, in the course of an expedition undertaken for the study of the formation and fauna of the reefs. Copious notes were at the same time made on the occurrence of the plants, their special habitats, order of appearance, &c.

*I made inquiries about these specimens, and find the above to be substantially accurate. Malé island has no waste land which may be supposed to have retained an indigenous flora. Funadu is within a mile of Malé, and has a very famous herb garden, where Ibrahim Didi has introduced a large number of cultivated plants. Many of the names given with his specimens are undoubtedly inventions. I did not attempt to make a full collection of the introduced plants, but the natural flora is fairly complete.—J. S. G.

It thus became possible at last to construct a fairly complete flora of the islands. Since this expedition the islands have been visited by Mr. J. J. Thorburn in August, 1901. He very kindly collected information about a few of the still doubtful economic plants. Captain Simons of H.M.S. Pomone, who visited Malé at the same time, collected a few new species there. Finally, Mr. F. Lewis of the Forest Department visited Malé in October, 1901, and made a large collection there and on two neighbouring islands, from which five further species, including the Baobab, have been added to the list. It is improbable that a further survey of the islands would add many more species. We are much indebted to the gentlemen mentioned for kindly undertaking these collections.

The preliminary naming of the plants was done by W. de Alwis, Mudaliyar, Draughtsman at Peradeniya, to whom we are much indebted ; his very complete knowledge of Ceylon plants enabled him to recognize many species which were represented by the merest fragments. The ultimate determination was made by one of us (J. C. W.), and for naming a few difficult forms not suitably represented in the Peradeniya herbarium we have to thank Dr. D. Prain, Prof. C. Mez, and Mr. C. B. Clarke. The specimens are preserved at Peradeniya, and a few duplicates have been distributed to Kew, Calcutta, &c.

General Description of the Archipelago.

The Maldives or Maldive Islands are a large archipelago of coral islands lying between 7·6° N. and 0·42° S. lat., and between 72·33° and 73·44° E. long. The northernmost atoll is about 300 miles south-west of Cape Comorin in India, and the nearest point to Ceylon is distant about 400 miles. There are a large number of banks, some atolls with more or less perfect encircling reefs, but others made up of a vast number of small ring-shaped reefs (faro), which dot the whole, but may at the circumference tend to form a rim. North of, and separated by a wide stretch of sea from, the northernmost bank lies the atoll of Minikoi, which politically belongs to the Laccadives, but geographically to the Maldives. This island was also visited by Mr. Gardiner, and a number of plants collected there prove to be additions to the flora as hitherto known from Dr. Prain's* descriptions.

The atolls, working from north to south, are in order, the following (see map) :—

Ihavandifulu, Tiladumati, Miladumadulu (small collections made on Landu and Mafaro Islands), Makunudu, North Mahlosmadulu (collection from Limbo Kandu and from Fainu and Kenurus, incomplete), Fadiffolu, South Mahlosmadulu (complete collection from Hedufuri Island on the south side, and a few plants from Turadu), Horsburgh or Goifurfehendu (complete collection from Goidu and two other islands), North Malé (complete collections from Malé, if those mentioned above be put together, and complete collection from Hulule by Gardiner), South Malé, Ari, Felidu, North and South Nilandu, Mulaku, Kolumadulu (moderately complete collection from Veimandu, and a plant from Buruni), Haddumati (a few plants from Kadu), then after a wide interval of sea, Suvadivs (many plants from Wiligili), and again after a wide stretch of sea, Addu, the southernmost atoll (a fairly complete collection of the more interesting forms).

We have thus before us the possibility of making what is probably a nearly complete flora of the archipelago, and at the same time of comparing the floras of different parts of the group.

The northern atolls, from Ihavandifulu to Goifurfehendu, are separated from the central by the Kardiva Channel, 35 miles wide, and with very strong currents in the monsoons. The central, from North Malé to Haddumati, form another well-marked group, and in the south we find the two isolated groups, Suvadiva and Addu.

* Botany of the Laccadives, Jour. Bombay Nat. Hist. Soc., VII., VIII. 1892–93.

Willis : Note on the Flora of Minikoi, Ann. Perad. I., 1901, p. 39.

The islands vary in size, from mere tiny banks that barely escape being awash, to such islands as Ghang in Haddumati atoll, which is 5 miles long. It appears that some islands are in process of formation, and are constantly increasing in size, while others are washing away. The islands are rarely more than about 5 feet above high water mark.

Many islands contain fresh water lagoons, and most have fresh water at a little depth, easily obtainable by sinking wells. The surface soil is, as might be expected when we know that all the islands are of purely reef formation, a light sandy loam, but much of the surface is bare coral rock on which a little humus has collected.

The sand where it is most fertile invariably overlies coral rock ; the latter retains the water to some extent and seems richer than the sand in the necessary chemical constituents (or the plant obtains them more easily).

The climate is that of similar regions in other parts of the globe ; equatorial, moist, equable, with a mean temperature probably of about 81° F., a climate in fact like that of the extreme south-west of Ceylon. The rainfall is greater in the southern atolls, probably about 150 inches in Addu, and there is less violent wind and a more equable humidity. The northern are more subject to the regular Indian monsoons, and hurricanes are sometimes experienced.

All islands that have any available ground for vegetable growth are more or less covered with plants, often with a dense jungle of the same general type as the coast jungle of south-west Ceylon. Most of the islands of any size are inhabited and cultivated. The most conspicuous cultivation is that of cocoanuts. The cultivations carried on are mentioned in detail below. The northern and the southern atolls are more fertile than the central, and the eastern than the western islands of all atolls. A few islands produce plants which have not been successfully cultivated in others of the group ; thus Furadu, in the central portion of Ari atoll produces pineapples of very poor quality.

Possibilities of the Flora.

A considerable interest attaches to the possibilities of the Maldive flora. As has often been pointed out, *e.g.*, by Trimen,* the floras of Ceylon and India contain a small African-Mascarene element, and those of the African Islands a larger Asiatic element. The origin of these is one of the great problems in connection with the flora of these countries. Remembering that the Maldives form a fairly continuous group of islands 400 miles long and lying between India and Ceylon and the African islands mentioned, it is conceivable that they might have formed a half-way station in the great gap. We might further expect to find on them some intermediate forms of life between those found in India and Africa, or a more pronounced African type of flora. It is highly improbable, now that we know the islands to be mere coral islets, that any intermediate forms should occur on them, unless the subsidence theory of coral reefs, enunciated by Darwin, be the true one, and even then we must suppose two difficult circumstances to occur in combination, viz., that the subsidence of the land should have been so slow, that there would always have been fresh land piled up by the waves ready to receive the old flora, and that the intermediate forms mentioned or forms common to both regions should be capable of growing upon the coral reefs. If we suppose such forms to have continued upon the reefs, we must postulate for them an unbroken existence, since the breaking down of the land connection between Ceylon and Madagascar, *i.e.*, probably since early Tertiary or Upper-Cretaceous times at least.†

The flora of the Maldives, however, proves to contain no peculiar forms, and to be chiefly the familiar Indo-Malayan Coast Flora, such as has been described by Schimper. It contains some interesting plants, *e.g.*, Cladium jamaicense, not known in India and Ceylon except in Kashmir, but

* Remarks on the Composition, Geographical Affinities, and Origin of the Ceylon Flora: Journ. R. As. Soc., Ceylon Branch, 1885.

† Blanford: Anniversary Address. Proc. Geol. Soc., London, 1890, p. 68.

which occurs in Mauritius. The questions raised above will be dealt with again below.

II.—THE FLORA OF THE MALDIVES, LACCADIVES, AND CHAGOS.

A list of all recorded plants from the islands follows, arranged in the order followed in Hooker's Flora of British India. For the sake of completeness the plants of the Laccadives and Chagos have also been included. The scientific name is followed by the Maldivian name, taken from notes on the specimens collected by Ibrahim Didi and Mr. Gardiner ;* after this is given the Sinhalese (occasionally also Tamil, Persian, or Hindustani) name for comparison, as the two languages are allied. There follows a list of the localities (specimens authenticated by J. C. Willis are marked !), and notes by Mr. Gardiner on their occurrence, distribution, uses, &c. After this is given the general distribution of the species, with special reference to Ceylon, India, Minikoi, and the Laccadives, and also notes on the probable method of its introduction to the islands. Species occurring only in the Laccadives (including Minikoi) or Chagos are placed in brackets. Cultivated species are printed in small capitals. An index of names follows the systematic list, and the general discussion of the facts terminates the paper.

PHANEROGAMS.

DICOTYLEDONS.

ANONACEÆ.

ARTABOTRYS, *Br.*

ODORATISSIMUS, *Br.;* Chunpápool, M.

I. Didi, 63 !

Presumably introduced from India or Ceylon for garden cultivation.

* The names given by me are those in common use in Nolewangfaro in Tiladumati Atoll. The Hulule collection was checked by five men of that island. For many plants the common people have no names, and if too much pressed will invent them. The same name to two or three plants is not uncommon in different parts of the Maldives.—J. S. G.

ANONA, *L.*

MURICATA, *L.;* Anona (I. D.) or Ata (J. S. G.), M.; the Soursop.

I. Didi, 72! "Cultivated. Fairly common in house compounds throughout the northern atolls; scarce in Suvadiva and Addu; fruit small and poor."—J. S. G. One tree in Minikoi (Prain).

SQUAMOSA, *L.;* Ata, M.; Ata, S.; the Custard Apple.

I. Didi, 88! Malé, Gardiner! Christopher, 1888!
"Recently introduced. Only seen in Malé, and in one island in Addu Atoll, Huludu."—J. S. G.

Menispermaceæ.

Tinospora, *Miers.*

cordifolia, *Miers.*

Malé Atoll, F. Lewis!
Ceylon and S. India.

Papaveraceæ.

Argemone, *Tourn.* ex *L.*

mexicana, *L.;* Zaggumu, M.

I. Didi, 152! Malé, Gardiner! Haly, 1892!
"Malé and Addu in the open spaces by mosques."—J. S. G.
Common in dry places in India and Ceylon. Probably unintentionally introduced as a weed of cultivation.

Cruciferæ.

Brassica, *L.*

juncea, *Hk. f. & Th;* Revi, M.; Aba, S.; Rai, Hind.; Indian Mustard.

I. Didi, 114!
Cultivated from China to Egypt, and commonly in India and Ceylon.

Perhaps an introduced weed, as, though cultivated in India and Ceylon, it is also a common weed there. "Almost certainly introduced by Ibrahim Didi himself. I did not see it."—J. S. G.

Capparidaceæ.

Cleome, *L.*

viscosa, *L.;* Rábeburi, M.; Wal-aba, S.

I. Didi, 149 ! Hedufuri, Goifurfehendu Atoll, Gardiner ! "Only seen in N. Maldives; very common in Miladumadulu; not seen in Hulule."—J. S. G.

A common weed of cultivation, universal in the tropics, Laccadives, in Ameni, Anderut, Akati, and Kiltan (Prain). Not recorded for Minikoi.

Gynandropsis, *DC.*

pentaphylla, *DC.*

Hedufuri, Goifurfehendu Atoll, Veimandu in Kolumadulu, Gardiner !

A cosmopolitan tropical weed. Not recorded for the Laccadives or Minikoi.

[*Bixaceæ.*

BIXA ORELLANA, *L.*

Annatto is cultivated in Ameni (Laccadives).

Flacourtia Sepiaria, *Roxb.*

Common in Kadamum (Laccadives); in dry jungles, India, Ceylon, Java, &c.]

Polygalaceæ.

Polygala, *L.*

erioptera, *DC.*

Hedufuri, Goifurfehendu Atoll, Gardiner ! Fairly common everywhere in the north, but not in Suvadiva or Addu Atolls.—J. S. G.

India, Burmah, Arabia, Africa, a weed, probably unintentionally introduced. Not recorded from Ceylon nor from Minikoi, Laccadives, in Kadamum (Prain).

Portulacaceæ.

Portulaca, *L.*

oleracea, *L.;* Rai-geda, M.; Genda-kola, S.

I. Didi, 133 !

A common weed of cultivation in the tropics, but also littoral and probably bird- or sea-borne. Minikoi, Prain.

quadrifida, *L.;* Makunu-fila, M.; Hin-genda-kola, S.

I. Didi, 129 !

A common weed of cultivation in Asia, Africa, Ceylon, Diego Garcia ; not recorded from Minikoi or the Laccadives.

tuberosa (*Roxb.*), *Trim.*, in Fl. Ceylon, I., 90; Riindu-filia, M. ; Ura-genda, S.

I. Didi, 89 ! Hedufuri, Hulule 75, Veimandu in Kolumadulu ! In the same positions as Launæa pinnatifida, and very common, but appearing later than the Launæa.

A littoral plant, probably introduced by birds or by the sea. Ceylon, India (S.W. and Sind), Minikoi ? (Prain's description of some of his specimens seems to agree with this) ; not recorded from the Laccadives.

Guttiferæ.

Calophyllum, *L.*

Inophyllum, *L.;* Funa, M.; Domba, S.; Punnai, T.*

I. Didi, 56 ! Christopher, 1888 ! Kenurus, in N. Mahlosmadulu, a large clump ! Hulule 47, a great clump in the centre of the west coast, Gardiner ! Very common in the S. of the group ; the oil (from the seeds) is used in cases of injury to the arms or legs.

A littoral species, introduced in all probability by the sea ; coast, Ceylon to Orissa and Bombay, Malay Pen., E. African Is., N. Australia, Polynesia, &c. ; Laccadives (Prain), in Ameni, planted, Kalpeni, indigenous, and Akati, planted ? Minikoi.

Malvaceæ.

Sida, *L.*

humilis, *Willd.;* Veyo-diggá, M. (Mabulan in Minikoi, J. S. G.); Bevila, S.

* Called Duburi in Bell's Report, p. 83; this name seems to apply to Ochrosia borbonica, *q.v.*

I. Didi, 155! Malé, Christopher, 1888! Hedufuri, Addu, Gardiner!

A common field and roadside weed of Tropical Asia, Africa, and America; Minikoi, Prain, Gardiner; Laccadives, in Kadamum and Akati, Prain.

carpinifolia, *L.* (*acuta*, *Burm.*); Mirajjé sai, M.: Gas-bevila, S.

I. Didi, 138! Kaddu, in Haddumati Atoll, Gardiner!

A common tropical weed.

[**S. diffusa**, *H. B. K.*, of the Seychelles, in Diego Garcia.]

Abutilon, *Gaertn.*

indicum, *G. Don;* Má-bulá, M. (Mabulan in Minikoi); Anoda, S.

I. Didi, 153! Malé, Christopher, 1888! Goifurfehendu Atoll, Hulule 44, Gardiner! Very common everywhere by villages.

A cosmopolitán weed of cultivation in the tropics; Minikoi, Gardiner, Prain; Laccadives, in Kadamum and Akati, Prain.

[**Urena sinuata**, *L.;* a cosmopolitan tropical weed, in Kalpeni (Laccadives).]

Hibiscus, *L.*

Solandra, *L'Herit.;* Nagu-kandi, Kukulufaifila, M.

I. Didi, 6! Hedufuri, Goifurfehendu Atoll, Malé, Hulule 69, Veimandu in Kolumadulu, Gardiner! Sparingly everywhere in group, especially near mosques; on edges of any partially cleared place in Hulule, well away from sea.

A common weed of roadsides and waste places; India, Burmah, Tropical Africa; common in the dry region of Ceylon; Minikoi, common, Prain; not recorded for the Laccadives or Diego Garcia.

tiliaceus, *L.;* Diga, M.; Beli-patta, S.

I. Didi, 131! Malé, Christopher, 1888! Hedufuri, Goifurfehendu, Hulule 23, Veimandu in Kolumadulu, Gardiner!

Common throughout the group; the bark used for rope and fishing lines.

A littoral species, probably introduced by the sea; cosmopolitan on tropical coasts; Minikoi, Gardiner, Prain; Laccadives, in Akati, Prain.

Abelmoschus, *L.?*

Gaddu in Suvadiva, Veimandu in Kolumadulu, Gardiner. Leaves only, but almost certainly this sp. Not cultivated.—J. S. G.

Everywhere cultivated in the tropics.

ROSA-SINENSIS, *L.;* the Shoe-flower.

Rimbadu in S. Nilandu. Here and there near mosques.—J. S. G.

Cultivated all over the tropics. Minikoi, Prain.

Thespesia, *Corr.*

populnea, *Corr.;* Hirundu, M.; Suriya, S.; the Tulip Tree.

Hulule 28, Gardiner! Malé, Trimen. Semi-wild all over the Archipelago, by villages.

A littoral species, common from Africa to Polynesia. Minikoi, Gardiner. Laccadives, in Kiltan, Akati, Kadamum, Prain. Probably sea-borne.

GOSSYPIUM, *L.*

HERBACEUM, *L.;* Indian Cotton; Kafa, M.; Kapu, S.*

I. Didi, 85. Fainu in N. Mahlos, Gardiner!

A native of the Old World, cultivated in India and Ceylon; Laccadives, in Anderut, Minikoi, Prain.

BARBADENSE, *L.*, var. ACUMINATUS; Barbados Cotton; Bodu kafa, M.*

I. Didi, 86! Goifurfehendu Atoll, Malé, Veimandu in Kolumadulu, Gardiner!

* G. herbaceum was formerly cultivated all over the group, but its place was taken by G. barbadense. Now the latter is displaced by imported cotton, though still grown for use in surgery. It is also used in Addu for a coarse kind of loin cloth.—J. S. G.

Sparingly cultivated in the whole group, and near houses. A native of America, cultivated in India and Ceylon. Cultivated in Minikoi and Anderut, Prain.

Adansonia, *L.*

digitata, *L.;* the Baobab ; Foh, M.

On a small island near Malé, F. Lewis. The largest tree 17 ft. 6 in. in girth at the base.

A tropical African species, occurring at Mannar in Ceylon, where it it supposed to have been introduced by the Arabs. If so, probably the same explanation applies to the Maldives.

STERCULIACEÆ.

ABROMA, *Jacq.*

AUGUSTA, *L.;* Garada, M.

I. Didi, 108.

Cultivated in Ceylon gardens. Probably introduced by Ibrahim Didi.

[Heritiera littoralis, *Dryand.;* Etuna, S.

The absence from the recorded flora of the Maldives, Laccadives, and Diego Garcia, of this cosmopolitan littoral plant, is remarkable.]

Tiliaceæ.

Corchorus, *L.*

capsularis, *L.;* Bulúkiya, M. ; Jute.

I. Didi, 150 !

Cultivated in India ; doubtfully native and rare in Ceylon. Almost certainly introduced for cultivation purposes within the last twenty years. "Does not flourish."—J. S. G.

acutangulus, *Lam.;* Nanubeddi, Hiridigga, M. (I. Didi) ; Kaduru, M. (J. S. G.) ; Gethawcoley, M., in Minikoi (J. S. G.) [First and last names, *cf.* Index.]

I. Didi, 99, 152 ! Goifurfehendu Atoll, Hulule 70, 71, Veimandu in Kolumadulu, Gardiner !

A cosmopolitan tropical weed ; abundant in Ceylon, Minikoi, Gardiner, Prain ; Laccadives, in Kadamum and Akati Prain.

[**Triumfetta procumbeus,** *Forst.;* in Diego Garcia. Occurs in Seychelles, Polynesia, America.]

Tribulus, *L.*

terrestris, *L.;* Sembu-nerinchi, S.

Malé, Gardiner! Only in Malé.—J. S. G.

A cosmopolitan tropical weed. Abundant in Ceylon and India; not recorded for the Minikoi or the Laccadives.

GERANIACEÆ.

AVERRHOA, *L.*

CARAMBOLA, *L.;* Kamaraga, M.; Kamaranga, S.

I. Didi, 68!

Cultivated for its edible fruit in India, Ceylon, and other tropical countries. Native country unknown.

BILIMBI, *L.;* Bilimagu, M.; Bilin, S.; Blimbing.

I. Didi, 92! Malé, Christopher, 1888!

Cultivated for its fruit, like the last. Native country unknown.

Rutaceæ.

MURRAYA, *Koen.*

KOENIGII, *Spreng.;* Hikundi, M.; Karapincha, S.; the Curry Leaf.

I. Didi, 100! "Generally speaking, unknown in the Maldives."—J. S. G.

Rare in Ceylon, but much cultivated in Ceylon, India, &c., the leaves being used in curries. Cultivated in Minikoi, Prain.

Triphasia, *Lour.*

trifoliata, *DC.;* Kudalimbo, M. (= small lime).

I. Didi, 46! Malé, Christopher, 1888! Hulule 20, Gardiner! Very scarce in the N., and not in the S., of Archipelago; under the shade of large trees in damp places.

Commonly cultivated in the tropics, and probably originally introduced for purposes of cultivation, but now apparently an escape and wild. Minikoi, Prain.

CITRUS, *L.*

MEDICA, *L.*, var. ACIDA, *Brandis;* Lime, Limbo, M.; Limbu, Hind. Generally cultivated.—J. S. G.

Cultivated in the tropics. Ameni, Anderut, Kiltan (Laccadives), Minikoi.

Var. LIMONUM; Lemon; Bodu Limbo, M. (=big lime).

Cultivated in Landu.—J. S. G.

AURANTIUM, *L.;* Orange; Moli, M.

"Cultivated in Fua Muluku, from which the fruit is sometimes brought to Malé."—J. S. G.

Cultivated in warm countries. Anderut (Laccadives).

DECUMANA, *L.;* Niyaduru, M.; Shaddock, Pumelo.

I. Didi, 25! Trimen's list. Malé and Addu, Gardiner.

Cultivated in Trop. Asia, &c. One tree on Minikoi, Prain.

[ÆGLE MARMELOS, *Corr.;* the Bael. Cultivated in Minikoi, Prain.]

Simarubeæ.

Suriana—

maritima, *L.;* Hala veli, Halia veli, M.

I. Didi, 137! Goifurfehendu Atoll, Hulule. At the extreme S.W. corner, a little way back from the beach; sparsely distributed in the group, never in large masses, Gardiner!

A cosmopolitan littoral tropical species; rare in Ceylon, known only from Jaffna and Trincomalee; Minikoi, Prain. Laccadives, in Bitrapar, Bangaro, and Kadamum, Prain. Diego Garcia, Hemsley.

Meliaceæ.

AZADIRACHTA, *A. Juss.*

INDICA, *A. Juss.;* Hiti, M.; Kohomba, S.; the Margosa.

I. Didi, 64! "Not seen."—J. S. G.

Native of India and Ceylon, commonly cultivated for the sake of the medicinal bark and oil (obtained from the seeds).

[Carapa moluccensis, *Lam.;* occurring on shores of Ceylon, Africa, Asia N.; might occur in the Maldives.]

[Celastraceæ. **Pleurostylia Wightii**, *W. & A.;* in Kadamum (Laccadives), Prain.]

Rhamnaceæ.

Zizyphus, *L.*

Jujuba, *Lam.;* Kunnáru, Konara, M.; Maha-debara, S.; Ilantai, T.; Kumára, Persian.

I. Didi, 147! Malé, Christopher, 1888! Goifurfehendu Atoll, Hulule 16, Veimandu in Kolumadulu Atoll, Gardiner!

"Cultivated and common in the whole group, a few trees in every village. The fruit is eaten."—J. S. G.

Native of, and largely cultivated in, India and Ceylon. Probably introduced for cultivation, especially as it is absent from the Laccadives. Minikoi?

sp.?

A fragment from Hulule, collected by F. Lewis, is a second species of Zizyphus.

Colubrina, *Rich.*

asiatica, *Brongn.;* Ra-rohi, M.; Tel-hiriya, S.

I. Didi, 122! Turadu in S. Mahlos, Hulule 27, Gardiner!

Covers nearly the whole of the centre of the eastern side of Hulule, but not on the beach; not common in other islands, except in Limbo Kandu (N. Mahlos).

A littoral species common in S. Africa, the Mascarene Is., S. India, N. Ceylon, Malaya, N. Australia. Not recorded for Minikoi; Laccadives, in Akati and Kiltan, Prain.

Ampelideæ.

Vitis, *L.*

Linnæi, *Wall?*

Malé, Trimen; no specimens in the herbarium at Peradeniya. "Not seen."—J. S. G.

The occurrence of this species must be regarded as doubtful. Perhaps bird introduced. Native of dry regions of Ceylon and S. India.

[**V. quadrangularis,** *Wall*, in Kalpeni, **V. carnosa,** *Wall*, in Kiltan (Laccadives), Prain.]

Sapindaceæ.

Cardiospermum, *L.*

Helicacabum, *L.*

Small island off Malé, F. Lewis ! Cosmopolitan, tropical. Laccadives, in Ameni and Kalpeni, Prain.

Allophylus, *L.*

Cobbe, *Bl.*; Dom Moussa, M. (Dom Musa in Minikoi); Kobbé, S.

I. Didi, 167 ! Hedufuri, Goifurfehendu Atoll, Hulule 26 and 40, Veimandu in Kolumadulu Atoll, Gardiner ! "In the densest jungle on Hedufuri."—J. S. G. "A big tree by the village on Hulule, introduced by Dom Moussa."—J. S. G. A littoral and inland species, common in India, S.W. Ceylon, Malaya, N. Australia. It may quite possibly be native in the Maldives, perhaps introduced by birds or sea, but was most probably introduced artificially. Minikoi, Prain, Gardiner; probably, as the name there is the same, and quite unlike the Sinhalese or Tamil names, this plant was introduced there from the Maldives. It can hardly be accepted as an undoubted native for either place, especially as it is not found in the Laccadives. The fruit is edible.

Dodonaea, *L.*

viscosa, *L.*; Kudiruvali, M.; Eta-werella, S.; Virali, T.

I. Didi, 139 ! Goifurfehendu Atoll, Veimandu in Kolumadulu Atoll, Gardiner ! Very characteristic of rocky jungly area in most of the Archipelago.

A cosmopolitan tropical shrub, both in dry inland spots and on the coast; probably sea-borne. Minikoi, Gardiner, 35. Not recorded for the Laccadives.

ANACARDIACEÆ.

MANGIFERA, *L.*

INDICA, *L.;* Amba, S.; the Mango.

"No trees; a few young plants in the Malé. The introduction of this tree has been tried many times, but it will not flourish."—J. S. G.

Universally cultivated in the tropics. One tree in Minikoi, Prain ("None now."—J. S. G.).

MORINGEÆ.

MORINGA, *Burm.*

PTERYGOSPERMA, *Gaertn.;* Muranga, M.; Murunga, S.; the Horse Radish Tree.

I. Didi, 4! Hulule, Veimandu in Kolumadulu, Gardiner! Common in all the group near the villages; seeds, &c., used in curries.—J. S. G.

A native of N. India; much cultivated in India and Ceylon. Minikoi, cultivated, Gardiner, 10; Laccadives, cultivated in Ameni and Kiltan, Prain.

Leguminosæ.

Crotalaria, *L.*

retusa, *L.;* Viha-giguni, M.; Kaha-andana-hiriya, S.; Kilukiluppai, T.

I. Didi, 31! Kaddu in Haddumati Atoll, Gardiner!

A native of Tropical Asia and Australia, now a cosmopolitan tropical weed. Laccadives, in Akati, Prain.

[**C. verrucosa,** *L.;* in Ameni and Kadamum (Laccadives), Prain.]

Indigofera, *L.*

tinctoria, *L.;* Vihafilia, M.; Nil-awari, S.; the Indigo plant.

I. Didi, 77! Hedufuri, Goifurfehendu, Veimandu in Kolumadulu, Gardiner; not cultivated! Malé, Trimen.

Universally cultivated in India, and probably originally introduced with a view to cultivation.* Laccadives, in Kadamum and Akati, Prain.

[**I. cordifolia**, *Heyne;* in Kiltan and Kadamum (Laccadives), Prain.]

Tephrosia, *Pers.*

tenuis, *Wall;* Fesko, M.

I. Didi, 10 (Prain)!

A cultivation weed, native of N.W. India. Laccadives, in Kadamum and Akati, Prain.

purpurea, *Pers.*, var. **pumila**, *Baker.*

Hedufuri, Gardiner! Frequent in paths in low jungle; not in Addu.—J. S. G.

A cosmopolitan tropical weed. Laccadives, in Kadamum and Kiltan, Prain.

[**Sesbania aculeata**, *Pers.;* in Kalpeni (Laccadives), Prain.]

[SESBANIA GRANDIFLORA, *Pers.;* in Kiltan, Kadamum, Akati (Laccadives), and in Minikoi, all cultivated, Prain.]

[ARACHIS HYPOGÆA, *L.;* the Ground Nut; cultivated in Minikoi, Prain.]

Desmodium, *Desv.*

umbellatum, *DC.*

Goifurfehendu Atoll, Gardiner. On rocky land. Very common in the Archipelago.—J. S. G.

Ceylon, Mascarene Is., Burmah, Malaya, Polynesia. Perhaps sea-borne.

gangeticum, *DC.*

Hedufuri, Gardiner (Prain)!

A weed, Tropical Africa and Asia, Ceylon. Possibly seaborne.

triflorum, *DC.;* Hekoopie, M. (Minikoi); Hin-undu-piyali, S.

* Probably so: it was certainly very common in Hedufuri and the other islands in S. Mahlos, where cloth is extensively made, and was probably introduced for its dye (*filia* = cloth or thread, while *feli* is a particular garment)—J. S. G.

Buruni in Kolumadulu, Gardiner! Never seen elsewhere; grows on the broad mass of roots of the cocoanut tree.

Cosmopolitan tropical littoral and inland weed. Laccadives, in Akati, Kiltan, and Kadamum, Prain. Minikoi, Prain, Gardiner. Perhaps sea-borne.

(MUCUNA CAPITATA, *W. & A.;* in Ameni (Laccadives), Prain.)

Erythrina, *Linn.*

indica, *L.;* Berebedi, M.; Erabadu, S.

I. Didi, 13 (Prain)!

India, Ceylon, Burmah, Malaya, Polynesia. Probably intentionally introduced, but perhaps sea-borne.

Canavalia, *DC.*

ENSIFORMIS, *DC.*, cultivated var.; Talafuri, M. (Minikoi).

Veimandu in Kolumadulu, Gardiner (Prain)! On waste land, not on the beach.

Cultivated and more or less wild in India and Malaya. Minikoi, Gardiner. Not recorded for the Laccadives.

lineata, *DC.*(*obtusifolia*, *DC.*, of *Fl. Br. I.*); Manifa, M.

Hedufuri, Hulule 13, Gardiner (Prain)!

Coasts of Tropical Asia, Minikoi, Prain. Sea-borne.

(**turgida,** *Grah.;* in Minikoi, Prain.)

PHASEOLUS, *L.*

LUNATUS, *L.;* Himeri, M.

I. Didi, 54!

Cultivated all over the tropics. Not recorded for the Laccadives or Minikoi.

(**calcaratus,** *Roxb.;* an escape in Minikoi, Prain.)

Vigna, *Savi.*

lutea, *A. Gray.*

Veimandu, Gardiner (Prain)!

A littoral species, cosmopolitan in the tropics; not in India or Ceylon, Minikoi, Prain.

[CATIANG, *Endl.;* cultivated in Ameni and Kadamum (Laccadives), Prain.]

PACHYRHIZUS, *Rich.*

ANGULATUS, *Rich.;* Viha-toli, M.

I. Didi, 96!

Universally cultivated in the tropics.

CLITORIA, *L.*

TERNATEA, *L.*

Horsburgh Atoll, Gardiner! By mosques in Goidu, and in the south.—J. S. G. Ceylon and the tropics generally, often cultivated. Probably introduced intentionally. Cultivated in Ameni, Laccadives, Prain.

DOLICHOS, *L.*

LABLAB, *L.;* Himerri, M.

Hulule 39, Kaddu in Haddumati, Gardiner (Prain)! Malé, Trimen's list; no specimens. Cultivated all over the tropics. Probably introduced for cultivation. Not recorded for the Laccadives or Minikoi.

Sophora, *L.*

tomentosa, *L.*

Goifurfehendu Atoll, Gardiner! Not seen elsewhere except at Malé.—J. S. G.

Cosmopolitan on tropical coasts; sea-borne. Ceylon, India. Not recorded for the Laccadives or Minikoi.

Cæsalpinia, *L.*

Bonducella, *Fleming;* Karikuburu, M.

Hedufuri, Goifurfehendu, Veimandu in Kolumadulu, Gardiner! Didi, 60! Common on sandy shores behind the Scævola in the whole Archipelago.

Cosmopolitan in the tropics, on the coast and inland. Not recorded for Ceylon or Minikoi. Laccadives, in Bangaro, Kadamum, Akati, Prain.

Bonduc, *Roxb.?*

A fragment found among the former species appears to be this?

PULCHERRIMA, *Sw.;* Fatangu, M.; Peacock Flower.

I. Didi, 51 !

Cultivated for its ornamental flowers in all tropical countries.

POINCIANA, *L.*

REGIA, *Boj.;* Kandi-toli, M.; Flamboyante.

I. Didi, 3, a fragment, appears to be this. "One tree in one of the Sultan's house compounds, and one by a mosque bathing pool near the W. of Malé."—J. S. G.

Cultivated in all tropical countries for ornament.

Cassia, *L.*

occidentalis, *L.;* Kuhada, M. (Minikoi); Penitora, S.

Miladumadulu, Gardiner (Prain)! Malé, Capt. Simons!

A cosmopolitan tropical weed. Minikoi, Gardiner; Laccadives, in Akati, Prain.

Sophera, *L.;* Rana-rua, M.; Ura-tora, S.

Goifurfehendu, Hulule, Malé, Veimandu in Kolumadulu, Gardiner! Malé, Trimen. No specimen in the Peradeniya herbarium. "Grown as an ornamental plant round the mosques, especially in Addu and Suvadiva; in the latter it is reported to be connected with the Shastras."—J. S. G. Cultivated and semi-wild.

A cosmopolitan tropical weed. Not recorded for Minikoi or the Laccadives.

Tora, *L.*

Goifurfehendu, by mosques, Gardiner!

An almost cosmopolitan tropical weed. Laccadives, in Kalpeni, Kadamum. Akati and Kiltan, Prain.

auriculata, *L.;* Ranawia, M.

Malé, Trimen. No specimens.

glauca, *Lam.*, var. **suffruticosa**, *Koenig;* Rana-ura, M.

I. Didi, 105 (Prain)!

A weed; India, Ceylon at Trincomalee? Malaya, Australia, Polynesia.

TAMARINDUS, *L.*

INDICA, *L.;* Helebeli, M.; Siyambala, S.; Puli, T.; the Tamarind.

I. Didi, 44! Horsburgh Atoll, Gardiner! Sparsely near villages everywhere, common in Addu.—J. S. G. Trimen; no specimen.

Cultivated in the eastern tropics. Laccadives, in Akati and Ameni, Prain.

(**Afzelia biguja**, *A. Gray;* in Diego Garcia; found in the Seychelles, Madagascar, Malaya, Polynesia.)

PARKIA, *R. Br.?*

I Didi, 58, a fragment, with the native name Bés-góbili (*cf.* Acacia), seems to be a Parkia, sp.; planted in all probability as a shade tree, as in Ceylon.

Adenanthera, *Royen.*

pavonina, *L.*

Trimen's list; no specimen seen. Perhaps planted.

[**Entada scandens**, *Benth.;* seeds were found on Hulule beach by Mr. F. Lewis.]

Mimosa, *L.*

pudica. *L.;* Ladu, M.; Nidi-kumba, S.; Lajalu, Hind.

I. Didi, 21! "Only seen near E. end of Malé, where there is a single clump."—J. S. G.

A cosmopolitan weed in the tropics. Not recorded in Minikoi or the Laccadives.

Acacia, *L.*

Farnesiana, *Willd.;* Bés-góbili, M.; the Cassie Flower.

I. Didi, 127! Goifurfehendu, Veimandu in Kolumadulu, Gardiner! Common in the south of the group by mosques and in the jungle, rare in the north.

Cosmopolitan in the tropics, often planted; naturalized in Ceylon. Not recorded for the Laccadives or Minikoi; possibly intentionally introduced in the Maldives, but more probably native sea-introduced.

ROSACEÆ.

Rosa, *L.*

I. Didi, 81, is a species of Rose! Native name, Fini-fenma. In Malé and Miladumadulu by mosques.—J. S. G.

Crassulaceæ.

Bryophyllum, *Salisb.*

calycinum, *Salisb.;* Fatunfaifila (D.); Bodu faru (G.) M.; Akkapana, S.

I. Didi, 14! Malé, Haly, 1892, Gardiner! Hulule, 18, Gardiner! "Not cultivated; along paths near villages where the path passes into jungle. Not on the beach. Very sparsely through the group."—J. S. G.

Cosmopolitan in the tropics. Not in the Laccadives or Minikoi.

Rhizophoraceæ.

Rhizophora, *L.*

mucronata, *Lam.;* Kadol, S.; Mangrove.

Addu Atoll, Wiligili in Suvadiva Atoll, Gardiner! "In the jungle of Maradu I.; here there is no definite swamp, but the whole is very dank. In damp jungle all over the group." —J. S. G.

Sea shores of the eastern tropics. Not recorded for the Laccadives or Minikoi.

Bruguiera, *Lam.*

caryophylloides, *Blume;* Kandu, M.

Goifurfehendu Atoll, Veimandu in Kolumadulu, Gardiner! Large mangrove swamps (in Maldivian, Kandufa = mangrove or mangrove swamp) in Goidu in Goifurfehendu; no Rhizophora seen. Also in Miladumadulu. The young rootlet when still green and hanging from the plant is very generally eaten.

Sea shores, in mangrove swamps, not common, S. India, Ceylon, Malaya. Not recorded for the Laccadives or Minikoi.

Combretaceæ.

Terminalia, *L.*

Catappa, *L.;* Midili (Didi); Medili (in Nudun, G.); Dommadu (in Hulule, G.); Gobu (in Haddumati), M.; Kottamba, S.; the Country Almond.

I. Didi, 22! Malé, Christopher, 1888! Hulule 5, Veimandu in Kolumadulu, Gardiner! Also in Goifurfehendu Atoll, Suvadiva, Addu, Gardiner. Abundant all over the group, especially in dense high jungle. Always found on beaches growing outwards by sand additions, a little back from the beach proper. Seeds much eaten in Suvadiva and Addu, where the tree attains a great size, and is one of the most important constituents of the jungle.

A littoral species; not known wild in India or Ceylon, though often planted. Common in the Andamans, Nicobars, Malaya, Mauritius, &c. Minikoi, Prain; Diego Garcia, Hemsley. It is probably native in the Maldives, introduced by the sea.

Lumnitzera, *Willd.*

racemosa, *Willd.*

Gaddu in Suvadiva, Gardiner! Also in Wiligili, Suvadiva.—J. S. G. I. Didi, 12. May be this, or may be L. coccinea.

Mangrove swamps of the eastern tropics. Ceylon. Not recorded for the Laccadives or Minikoi.

coccinea, *W. & A.*

I. Didi, 12. Native name Kandu (*cf.* other mangroves) is very probably this sp. Found in mangrove swamps, Ceylon, Burmah to Polynesia.

Gyrocarpus, *Jacq.*

Jacquini, *Roxb.*

Maldives, Gardiner (Prain)! One of our specimens was identified as this species by Dr. Prain, but has unfortunately become mislaid. "The specimen was no doubt from Hedufuri, where it occurs on the sandy part of the island. It is not an uncommon bushy tree on the same area through the whole group, often growing on the driest part of a sand flat." —J. S. G.

Cosmopolitan in the tropics. The wood is used for outriggers and catamarans in Ceylon, and perhaps the tree may have been intentionally introduced, but it is more probably sea-borne.

Myrtaceæ.

PSIDIUM, *L.*

GUYAVA, *L.;* Féru, M.; Pera, S.; the Guava.

I. Didi, 83! Trimen's list; no specimen seen. In Malé, Gardiner.

Cultivated in all hot countries. Cultivated in Minikoi, but not in the Laccadives.

EUGENIA, *L.*

MALACCENSIS, *L.;* Jumbu, M.? the Malay Apple.

I. Didi, 50, a fragment, appears to be this. Fruiting in Malé, and a few young trees in Addu.—J. S. G.

A Malayan species, commonly cultivated in India and Ceylon.

JAMBOS, *L.;* Jumbu, M.? Jambu, S.; the Rose Apple.

Trimen's list; no specimen seen. Malé and Addu.—J. S. G.

Malayan; cultivated in India and Ceylon. Minikoi, cult., Prain.

JAVANICA, *Lamk.?* Jamburool, M.

I. Didi, 53, a fragment, is perhaps this species.

JAMBOLANA, *Lamk.;* Lami, M.; Ma-dan, S.; Naval, T.; the Black Plum.

I. Didi, 19!

Common in Tropical Asia, Ceylon, &c. Probably introduced for its fruit. Cultivated in Minikoi.

Barringtonia, *Forst.*

speciosa, *Forst.;* Kimbi (G.), M.; Mudilla, S.

I. Didi, 9! Hulule 6, Gardiner! Two or three trees in the S.W. of Hulule; rare in the group, especially in the north. Heebahdu in the north of Suvadiva Atoll covered with it; four or five trees in Midu in Addu Atoll. Also on Turahdu in S. Mahlos.—J. S. G.

Sea shores, Ceylon, S.W., very rare, but now often planted. Andamans to Polynesia, a littoral species, probably introduced by the sea. Not recorded for Minikoi or the Laccadives. Diego Garcia, Hemsley.

Lythraceæ.

(**Ammania baccifera**, *L.*; in Kalpeni, Laccadives, Prain.)

Pemphis, *Forst.*

acidula, *Forst.*; Dhadukuradi, Kuredi, Kuradu, M.

I. Didi, 28! Malé, Christopher, 1888! Goifurfehendu Atoll, Hulule 4, Veimandu in Kolumadulu, Gardiner! Also in Turahdu, South Mahlos, Gardiner. All along the western beach of Hulule, a narrow belt one shrub thick, the roots washed by every high tide. The shore washes away, and bushes may be seen growing right out in the water. Common in all the Maldives. Infested with Sphinxes and small moths at night; it is useless to try any other plant for them if there be Pemphis near.—J. S. G.

A littoral species, common on the shores of the Old World tropics.

Minikoi, Gardiner. Not recorded for the Laccadives.

LAWSONIA, *L.*

ALBA, *Lam.*; Heena (Innapa, *Pyrard*; misprinted Junapa in Trimen's list), M.; the Henna.

I. Didi, 130! Trimen; no specimen. Pyrard de Laval. Goifurfehendu Atoll, Gardiner! "In cultivated land, scarce in the Archipelago."—J. S. G.

Ceylon and India, frequently cultivated. Minikoi, cultivated, Prain.

Sonneratia, *Linn. f.*

acida, *Linn. f.*; Kulowa, M.; Kirilla, S.

I. Didi, 30! Cultivated in Landu, Malé, and Addu, Gardiner. Trimen's list; no specimens.

With the mangroves, Ceylon Bengal to Java. Not recorded for Minikoi or the Laccadives. Most likely introduced into the Maldives, but possibly brought by the sea.

PUNICA, *L.*

GRANATUM, *L.;* Annáru, M.; Anár, Hind.; Delun, S.; the Pomegranate.

I. Didi, 115! Trimen's list (mentioned by Ibn Batuta). Fainu in North Mahlos, Turahdu in South Mahlos, Veimandu in Kolumadulu, Gardiner! Cultivated by the villages in many parts of the Archipelago.

Cultivated in all tropical and subtropical countries. Minikoi and Laccadives (Ameni, Akati), Prain.

Passifloraceæ.

PASSIFLORA, *L.*

COERULEA, *L.*

Malé, Gardiner! Only seen in Malé.—J. S. G.

An American species; cultivated in Ceylon for its pretty flowers.

[**suberosa**, *L.;* in Diego Garcia, Hemsley.]

CARICA, *L.*

PAPAYA, *L.;* Falo, M.; Papaiya, Hind.; the Papaw.

I. Didi, 1! Turahdu in South Mahlos, Goifurfehendu, Hulule, &c.—J. S. G.

"Three kinds are cultivated, one with long large fruits on the main stem (falo), one with round small fruits on the main stem (kuda falo), and a third (veo falo) with many fruits on pendulous shoots. In Horsburgh Atoll the fruit only reaches a small size."—J. S. G.

Cultivated in all tropical countries. Minikoi, Laccadives, in Kiltan, Anderut, Akati, and Kadamum, Prain.

CUCURBITACEÆ.*

TRICHOSANTHES, *L.*

CUCUMERINA, *L.*

Fainu in North Mahlos, Gardiner! Rare, and in Addu. Cultivated and wild in India, Malaya, North Australia. Almost certainly introduced intentionally.

BENINCASA, *Savi.*

CERIFERA, *Savi.;* Fufu, M.; the Ash Pumpkin.

I. Didi, 102. A fragment, is probably this species. Cultivated in the eastern tropics. "Not seen."—J. S. G.

MOMORDICA, *L.*

CHARANTIA, *L.;* Faga, M.; Karivila, S.; Pakal, T.

I. Didi, 61!

Cosmopolitan in the tropics. Cultivated in Minikoi.

CUCUMIS, *L.*

SATIVUS, *L.;* Kekuri, M.; Kekiri, S.; the Cucumber.

Hedufuri, Hulule 12, Veimandu in Kolumadulu, Gardiner. "Extensively cultivated in Miladumadulu and the north, not seen in the south."—J. S. G.

Cultivated in all hot countries. Minikoi, Gardiner; Laccadives, in Kiltan, Prain.

(MELO, *L.;* the Melon, in Kadamum, Kiltan, and Akati (Laccadives), and in Minikoi, Prain. Perhaps mistaken for the preceding in some of the Maldives.)

(LUFFA ÆGYPTIACA, *Mill.* Cultivated in Minikoi, Prain. I. Didi, 42., a mere fragment, native name Tora, may possibly be this.)

CITRULLUS, *Schrad.*

COLOCYNTHIS, *Schrad. ?*

I. Didi, 48, native name Kara, may perhaps be this.

VULGARIS, *Schrad.;* the Water Melon.

* A considerable variety of Cucurbitaceæ have in recent years been introduced to Malé, partly for ornamental purposes and partly as possible food. The soil is too poor in most islands for them, and they are generally pronounced to be no use for eating.—J. S. G.

Commonly cultivated in the Archipelago.

CUCURBITA, *L.*

MOSCHATA, *Duch.;* the Musk Melon.

Trimen's list; no specimens. Maradu and other islands in Addu Atoll.—J. S. G. Cultivated in warm countries.

? PEPO, *L.;* the Pumpkin; Burubo, M.

Two sorts of pumpkin with yellow flowers are cultivated, and known as Burubo in Hulule and elsewhere.—J. S. G.

I. Didi, 78. With native name Kadu, is probably some kind of Cucurbita.

? MAXIMA, *Duchesne;* the Gourd or Giant Pumpkin.

This is cultivated in Minikoi (Prain), and mentioned, but without confirmatory specimen, in Trimen's list, as seen by Mr. Bell. The remarks just made about C. Pepo may refer to this species. On trellises in Addu (? this species).—J. S. G.

[**Cephalandra indica**, *Naud.* Occurs in Akati, Laccadives, Prain.]

Ficoideæ.

Sesuvium, *L.*

Portulacastrum, *L.;* Mapijja, M.

Hulule, F. Lewis!

Cosmopolitan tropical littoral. Minikoi, Prain.

ARALIACEÆ.

PANAX, SP.? A fragment from Malé, Gardiner, growing near mosques, appears to be a Panax. Probably cultivated for ornament.

ARALIA, *L.*

GUILFOYLEI, *F. von M.*

Kaddu, in Haddumati Atoll, Gardiner! Evidently introduced from Ceylon as an ornamental plant.

GAMOPETALÆ.

Rubiaceæ.

(**Dentella repens**, *Forst.* Occurs in Anderut, Laccadives.)

Oldenlandia, *L.*

corymbosa, *L.?*

Malé, 1892, Haly. A somewhat doubtful fragment, named by Trimen. A cosmopolitan tropical weed. Laccadives, in Kalpeni, Kadamum, Kiltan, Prain.

(**diffusa,** *Roxb.;* in Anderut (Laccadives) and Minikoi, Prain.)

umbellata, *L.;* Emmuli, M.; Saya, S.; Chaya, T.; Chay Root.

I. Didi, 135! Hedufuri, on cleared grain land, not common. Goifurfehendu Atoll, Gardiner! Trimen's list.

A weed of sandy ground, especially near the coast, Ceylon, India, Burmah. The root yields a dye, formerly much used in Ceylon. "May have been introduced as dye-plant, but certainly not now used as such."—J. S. G.

biflora, *L.;* Beem magu (Hulule), Eyaganawatura, Kudingaybelamaw (Minikoi), M.

Trimen's list; no specimen. Goifurfehendu Atoll, Hedufuri, on cleared grain land, not common, Hulule 52, in dry sandy paths, Veimandu in Kolumadulu, Gardiner! "In suitable places throughout the group."—J. S. G.

Common near the coast in Ceylon and Tropical Asia. Laccadives, in Kalpeni and Kadamum, Prain; Minikoi, Gardiner.

HAMELIA, *Jacq.*

PATENS, *Sw.*

Malé, F. Lewis.

S. America; cultivated in Ceylon.

Guettarda, *L.*

speciosa, *L.;* Uni, M.; Nil-pitcha, S.; Panir, T.

I. Didi, 166! Pyrard de Laval. Hedufuri, Hulule 61. Veimandu in Kolumadulu, Gardiner! Very common throughout the group; occupies any position not upon the beach. Sweet-scented flowers, occasionally used.

A cosmopolitan tropical littoral species ; Ceylon only on the S.W. coast ; Laccadives, in Kadamum, Prain ; Minikoi, Gardiner ; Diego Garcia, Hemsley.

(IXORA COCCINEA, *L.;* in Kadamum, Anderut, Kalpeni (Laccadives), and Minikoi, Prain.)

Morinda, L.

citrifolia, *L.*, var **bracteata,** *Hk. f.;* Ahi, M. ; Ahu, S.

I. Didi, 148 ! Goifurfehendu Atoll, Hulule 38, Veimandu in Kolumadulu, Gardiner !

"This species and Ochrosia borbonica very quickly make their way to any fresh sandbanks that form—a common occurrence—and these two alone very often form a belt separating the cocoanuts from the sea. Scævola commonly grows between them again and the water."—J. S. G.

"Very numerous in Hedufuri, to some extent planted by the people for the root, from which a permanent red dye for cloth is obtained by mixing a decoction with lime."—J. S. G.

A littoral species, common in the tropics of Asia and Australia. Ceylon, from Colombo to Tangalla. Laccadives, in Bangaro, Kalpeni, Kiltan, Akati, and Kadamum, Prain ; Minikoi, Gardiner, Prain ; Diego Garcia, Hemsley.

Spermacoce, *L.*

ocymoides, *Burm. f.*

Hedufuri, Gardiner ! Near mosques in cleared land in many islands, but not abundant.

A common weed in Tropical Asia and Australia, rare in Ceylon. Not recorded for the Laccadives of Minikoi.

Compositæ.

Vernonia, *Schreb.*

cinerea, *Less.;* Walu Kafa, M. (Kambulichi, Minikoi); Monarakudimbiya, S.

Hedufuri, Goifurfehendu Atoll, Hulule 51, 68, Veimandu in Kolumadulu, Gardiner ! Common in cleared land throughout the group.

A common palæotropical weed. Laccadives, in Ameni, Anderut, Kadamum, Kiltan, and Akati, Prain ; Minikoi, Gardiner, Prain ; Diego Garcia, Hemsley.

Adenostemma, *Forst.*

viscosum, *Forst.;* Foni-loli, M.

Hedufuri, Hulule 58, Veimandu in Kolumadulu, Goifurfehendu Atoll, Gardiner !

I. Didi, 16, 121 ! Common in the north and very common in Addu ; in the lower part of the jungle.

A cosmopolitan tropical weed. Laccadives, in Kalpeni, Prain ; Minikoi, Prain.

Ageratum, *L.*

conyzoides, *L.;* Kochché-fai, M. ; Hulantalla, S. ; Pumpullu, T.

I. Didi, 73 ! Malé, Christopher, 1888, Gardiner ! Kaddu in Haddumati Atoll, Gardiner !

A cosmopolitan tropical weed, probably of American origin. Laccadives, in Ameni, Anderut, Kalpeni, and Kiltan; Minikoi, Prain ; Diego Garcia, Hemsley.

Blumea, *DC.*

(**laciniata**, *DC.;* in Kiltan and Akati, Laccadives, Prain.)

membranacea, *DC.*

Veimandu in Kolumadulu, Kaddu in Haddumati, Gardiner! The forms collected closely resemble those found in Ceylon.

A common Asiatic tropical weed.

Eclipta, *L.*

alba, *Hassk.;* Kalukadili, M. ; Kikirindi, S.

I. Didi, 62 ! Veimandu in Kolumadulu, Gardiner !

A cosmopolitan tropical weed. Laccadives, in Kadamum and Kiltan, Prain.

Wedelia, *Jacq.*

(**calendulacea**, *Less.;* in Anderut, Laccadives, Prain.)

biflora, *DC.;* Mirihi, M.

I. Didi, 43 ! Hedufuri, Goifurfehendu Atoll, Hulule 57, 62, Veimandu in Kolumadulu, Gardiner ! Common in the entire group.

A littoral species, common from Ceylon to Singapore. Laccadives, in Kadamum, Anderut, and Kiltan, Prain ; Minikoi, Prain, Gardiner.

(**Bidens pilosa**, *L.;* in Kadamum, Laccadives, Prain.)

(**Crepis acaulis**, *Hk. f.;* in Kiltan, Laccadives, Prain.)

Tithonia, *Desf.*

diversifolia, *A. Gray;* Bodu-mirihi, M.

I. Didi, 47 !

A native of the Southern United States and Mexico, now very common in Ceylon ; probably intentionally introduced into the Maldives. " Not seen."—J. S. G.

Artemisia, *L.*

vulgaris, *L.;* Mirajjé Kochchefai, M.; Wal-kolundu, S.

I. Didi, 34 !

A weed of Europe, temperate Asia, Siam, and Java ; an escape in Ceylon. Probably intentionally introduced for its fragrant leaves.

Emilia, *Cass.*

sonchifolia, *DC.;* Hirikulla, M. ; Kadupara, S.

I. Didi, 124 ! Goifurfehendu Atoll, Gardiner ! " Common in the south of the Archipelago."—J. S. G.

A common weed of the Old World tropics.

Lactuca, *L.*

polycephala, *Benth.*

Goifurfehendu Atoll, Gardiner. A somewhat abnormal specimen is this species in all likelihood, according to Dr. Prain. It is a native of North India.

Launæa, *Cass.*

pinnatifida, *Cass.;* Dandu filia ; Kulla fila, Kadapi (Minikoi), M.

I. Didi, 18 ! Goifurfehendu Atoll, Hulule 56, Gardiner ! North Mahlos.—J. S. G.

"One of the first to appear on a bare sandbank, and the outermost on a growing sandy beach."—J. S. G.

A littoral species, common on the coasts of Ceylon, India, Egypt, Mauritius, and E. Africa. Laccadives, in Bitrapar and Kadamum, and in Minikoi, Prain, Gardiner.

Goodeniaceæ.

Scævola, *L.*

Koenigii, *Vahl.;* Magu, M.; Takkada, S.

Hedufuri, Goifurfehendu Atoll, Hulule 49, Veimandu in Kolumadulu, Gardiner!

I. Didi, 142! Trimen's list; no specimen. The most numerous shrub in the group; wherever a sandy beach is growing outwards it lines the shore. (See under Pemphis, Morinda, Ochrosia, and below.)

A littoral species, common in E. Tropical Africa, Asia, and Australia, and in Polynesia. Common in Ceylon, especially in the S.W.; Laccadives, in Bitrapar, Kadamum, Kiltan, and Akati, Prain; Minikoi, Prain, Gardiner; Diego Garcia Hemsley.

(*Plumbaginaceæ.*

Plumbago zeylanica, *L.;* in Ameni, Laccadives.)

Myrsinaceæ.

Ardisia, *Sw.*

humilis, *Vahl.*

Suvadiva Atoll, very abundant; the undergrowth mostly composed of it; Addu Atoll, common in all the jungles, Gardiner (C. Mez)!

Ceylon S.W. and Batticaloa, India to China. The Ceylon distribution would seem to indicate sea-carriage, but it may have been introduced by birds.

(The absence of Ægiceras majus, *Gaertn.*, one of the palæotropical mangroves, from the Maldives, as well as from the Laccadives and Minikoi, is noteworthy. It may however very likely have been overlooked.)

Sapotaceæ.

Chrysophyllum sp. ?

I. Didi, 45, native name Sabudeli, is probably a sp. of Chrysophyllum.

Mimusops, *L.*

Elengi, *L.;* Munima, M.; Munamal, S.

I. Didi, 116 !

Ceylon, India, Malaya, often cultivated, and probably introduced into the Maldives intentionally, for the sake of its timber.

OLEACEÆ.

JASMINUM, *L.*

SAMBAC, *Ait.;* Irudema, Re Irudema, M.; Pichcha, S.; Arabian Jasmine.

I. Didi, 87 ! Pyrard de Laval (onudemaus). Hedufuri, Goifurfehendu Atoll, Hulule 25, 35, Veimandu in Kolumadulu, Kaddu in Haddumati, Addu Atoll, common in the jungle of the whole atoll, Gardiner! Male, Christopher, 1888 !

An Indian species, commonly cultivated in Ceylon and India. Most likely or certainly introduced for cultivation, but now more or less wild.

AURICULATUM, *Vahl.;* Kudima, M.

I. Didi, 46 !

Common in the dry parts of Ceylon and in India.

GRANDIFLORUM, *L.;* Huwanduma, M.

I. Didi, 80 ! Hedufuri, Goifurfehendu Atoll, Hulule 24, Veimandu in Kolumadulu, Gardiner ! "Cultivated round mosques and holy men's graves. The flowers are soaked in fine cocoanut oil, to which a trace of ambergris is added. With this mixture the natives rub themselves after washing to scent themselves before going into the mosques."—J. S. G.

A native of N.W. India, cultivated in India and Ceylon, and evidently intentionally introduced.

Apocynaceæ.

THEVETIA NERIIFOLIA, *Juss.?*

I. Didi, 66, native name Hinbatu, is almost certainly this species, which is cultivated in Ceylon as an ornamental plant.

Ochrosia, *Juss.*

borbonica, *Gmel.;* Dhumburi, Dumburi, M.; Mudu-kaduru, S.

I. Didi, 27! Male, Capt. Simons! Hedufuri, Hulule 43, Gardiner! This and Morinda citrifolia very quickly make their way to any fresh sandbanks that form, and these two alone often form a belt separating the cocoanuts from the sea with Scævola between them and the water.

A littoral species, Mascarene Is., Ceylon on the S.W. coast, Andamans, Nicobars, Singapore, Java. Not in India or the Laccadives. Minikoi, Prain; Diego Garcia, Hemsley.

Vinca, *L.*

rosea, *L.;* Maliku ruva, M.

Malé, Haly, 1892. Christopher, 1888. Gardiner!

I. Didi, 170! Cultivated almost everywhere.

A cosmopolitan tropical weed. Abundant on the S.W. coast of Ceylon.

PLUMERIA, *L.*

ACUTIFOLIA, *Poir.;* Gulu sampa, Semper Beddha, M.; the Temple Tree.

I. Didi, 26! Veimandu in Kolumadulu, Gardiner! Trimen's list, no specimen. Cultivated and semi-wild in Ceylon. Probably introduced intentionally for its scented flowers, which in Ceylon are very largely used as temple offerings by the Buddhists. Two or three trees by every mosque in the group. The flowers used like those of Jasminum grandiflorum, *q.v.*

Asclepiadaceæ.

Calotropis, *Br.*

gigantea, *Br.;* Ruva, Hudu ruva, Rua, M.; Wara, S.

Malé, Haly, 1892! Hulule 36, 78, Gardiner! I. Didi, 49 and 74, fragments, are almost certainly this species. Cultivated by every large village. The milk is used for wounds, and rubbed with a decoction of tea under the eyes for sun.—J. S. G. The stem fibre used for fishing lines, and the floss of the seeds for charms in magic (J. J. Thorburn).

Common in Ceylon, India, Malaya, S. China, Laccadives, in Kadamum, Prain. Probably intentionally introduced into the Maldives.

(**Asclepias curassavica**, *L.*; in Diego Garcia, Hemsley.)

(**Tylophora asthmatica**, *W. & A.*; in Kadamum, Anderut, Kiltan, and Akati, Laccadives, Prain.)

(**Leptadenia reticulata**, *W. & A.*; in Kadamum and Kiltan, Laccadives, Prain.)

Boraginaceæ.

Cordia, *L.*

subcordata, *Lam.*; Kani, M.

I. Didi, 165! Goifurfehendu Atoll, Hulule 17, Veimandu in Kolumadulu, Gardiner! In Suvadiva Atoll.—J. S. G. A regular constituent of dense jungle wherever it is found in the Maldives.

A littoral species of the eastern tropics. Ceylon only at Trincomalee. Diego Garcia, Hemsley. Not recorded for Minikoi or the Laccadives.

I. Didi, 55, native name Ragunda, a mere skeleton of a leaf, is a Cordia, perhaps another sp.

Tournefortia, *L.*

argentea, *L. f.*; Bori, Mabori, M.; Karan, S.

I. Didi, 107! Hedufuri, Goifurfehendu Atoll, Hulule 60, Veimandu in Kolumadulu, Gardiner! Malé, Christopher, 1888! Also in N. Mahlos.—J. S. G. Contests the shore with Scævola in the same positions—the only plant which does so. Also with Pemphis, but its roots cannot stand the direct tidal action like those of that genus.

A littoral species, Mauritius, Ceylon, rare on the S.W. coast and at Trincomalee, not in India; Nicobars, Malaya, Australia, Andamans, Minikoi, Prain; Laccadives, in Bitrapar, Kiltan, Kadamum, Akati (seedlings germinating on the shore), Prain; Diego Garcia, Hemsley.

Trichodesma, *Br.*

zeylanicum, *Br.;* Ma-lebu, M.

I. Didi, 172! Fainu, in N. Mahlos, on land gone out of cultivation, Goifurfehendu Atoll, Addu Atoll, Gardiner!

A common weed, Mascarene Is. to Australia.

Convolvulaceæ.

Ipomœa, *L.*

grandiflora, *Lam.*

Goifurfehendu Atoll, Addu Atoll (common in the jungle everywhere), Gardiner! In the jungle on rocky land, and creeping over rocky beaches being washed up.

A littoral species, E. Africa and Mascarene Is. to Polynesia. Diego Garcia, Hemsley; Laccadives, in Bitrapar (densely draped over the clumps of Scævola and Tournefortia) and Kadamum, Prain.

BATATAS, *Lam.;* Oludukattala, M.; Battala, S.; Sweet Potato.

I. Didi, 75! Hulule, scarce, Gardiner! Grown here and there throughout the whole group, especially in Addu.

Cultivated in all warm countries. Laccadives, in Ameni, Anderut, Akati.

QUAMOCLIT, *L.;* Kudiraima-veyo, M.

I. Didi, 33!

An American species, naturalized in Ceylon, with pretty flowers.

Turpethum, *Br.;* Kurifila, M.

I. Didi, 23!

Cultivated and wild in the tropics of the Old World. Perhaps an accidental, but more probably an intentional, introduction.

denticulata, *Chois.*

Veimandu in Kolumadulu, Gardiner !

A littoral sea-borne plant, Seychelles to Polynesia ; not in India. S.W. Ceylon (rare). Minikoi, Prain.

biloba, *Forsk.* **(Pes-capræ**, *Roth.*)*;* Taburu, Thaburu, M.; Mudu-bin-tamburu, S.

I. Didi, 41 ! Goifurfehendu Atoll, Gardiner ! Very uncommon, not seen elsewhere ; common on the lagoon side of Goidu.—J. S. G.

Cosmopolitan on tropical shores. Laccadives, in Bitrapar, Kalpeni, Akati, and Kadamum, Prain ; Minikoi, Prain, Gardiner ; Diego Garcia, Hemsley.

(**sinuata**, *Ortega ;* in Minikoi, Prain, Gardiner.)

Hewittia, *W. & A.*

bicolor, *W. & A.*

Hedufuri, Gardiner ! Only seen in Mahlos.—J. S. G.

Ceylon, S.E. India, Malaya, Tropical Africa. Probably unintentionally introduced with cultivated plants.

Convolvulus, *L.*

parviflorus, *Vahl.;* Walu mirihi, M.

Hedufuri, Goifurfehendu Atoll, Hulule 32, 53, Veimandu in Kolumadulu, Gardiner ! Kitchen middens throughout the group.—J. S. G.

Ceylon, rare, S. India, Malaya, Australia, Tropical Africa, Minikoi, Prain. Probably introduced by the sea, but perhaps introduced with cultivated plants.

Evolvulus, *L.*

alsinoides, *L.;* Veo magu, Meia limbo, M.

Hedufuri, Hulule 50, 64, Kaddu in Haddumati Atoll, Gardiner ! On sandy paths which are periodically cleared. In the N. chiefly.—J. S. G.

A weed of dry places, cosmopolitan in warm countries. Laccadives, in Kadamum.

Solanaceæ.

Solanum, *L.*

MELONGENA, *L.;* Bari, Kara, M.; Wambatu, S.; the Brinjal.

I. Didi, 112! Trimen's list. Veimandu in Kolumadulu, Gardiner! Cultivated in the whole group, very abundant in Addu.—J. S. G.

Cultivated in all warm countries. Minikoi, Gardiner. Not recorded for the Laccadives.

(**torvum**, *Sw.;* in Minikoi, Prain.)

Physalis, *L.*

minima, *L.;* Muraki, M.; Mottu, S.

I. Didi, 94! Malé, Christopher, 1888! Goifurfehendu Atoll, Hulule 11, Veimandu in Kolumadulu, Gardiner! Sparsely by villages in the whole group, the fruit eaten in curry.

A common weed in the tropics of the Old World. Perhaps introduced by birds or by the sea. Laccadives, in Bangaro, Anderut, Kadamum, Kiltan; Minikoi, Prain.

(PERUVIANA, *L.;* cultivated in Ameni, Laccadives, Prain.)

CAPSICUM, *L.*

MINIMUM, *Roxb.;* Mirus, M.; Nayi-miris, S.; Bird Pepper.

I. Didi, 106! Horsburgh Atoll, Malé, Veimandu in Kolumadulu, Gardiner! Mahlos, Miladumadulu, Gardiner! Everywhere cultivated.

Cultivated in all hot countries. Laccadives, in Akati, Prain.

(FRUTESCENS, *L.;* cult. in Minikoi, Prain.)

Datura, *L.*

fastuosa, *L.;* Orhani, M.; Attana, S.

I. Didi, 132! Landu in Miladumadulu, Veimandu in Kolumadulu, Gardiner! Also in Addu Atoll.—J. S. G.

A cosmopolitan tropical weed, possibly introduced by birds or with cultivated plants. Laccadives, in Ameni, Anderut, Akati, Kiltan, Prain; Minikoi, Gardiner, Prain.

SUAVEOLENS, *H. & B.*

Malé only, Gardiner ! Cultivated in Ceylon, &c., round native houses.

NICOTIANA, *L.*

TABACUM, *L.;* Dumpai, M. ; Dun-kola, S. ; Tobacco.

Many plants in Malé, in house enclosures, and a few in Mahlos and Miladumadulu.—J. S. G.

Everywhere cultivated. Not in Minikoi or the Laccadives.

Scrophulariaceæ.

(**Linaria ramosissima,** *Wall.;* in Kiltan, Prain.)

Herpestis, *Gaertn. f.*

Monniera, *H. B. & K.;* Veppila, M. ; Lunu-wila, S.

I Didi, 145 ! Landu, in Miladumadulu, in yam patches, Gardiner !

A cosmopolitan tropical weed. Common in marshy places near the coast in Ceylon. Laccadives, in Anderut, Prain ; Diego Garcia, Hemsley.

[**Striga lutea,** *Lour.;* in Akati, Kadamum, Kiltan, Laccadives, Prain ; Diego Garcia, Hemsley.]

Acanthaceæ.

Ruellia, *L.*

ringens, *L.* (**prostrata,** *Lam.*, var. dejecta); Nita bodi, Nitu badi, M. ; Nilpuruk, S.

I. Didi, 5 ! Hedufuri, Horsburgh Atoll, Malé near mosques. Hulule 76, Veimandu in Kolumadulu, Kaddu in Haddumati, Gardiner ! Also in Mahlos in many islands. —J. S. G.

A common weed in India, Ceylon, N. Africa. Minikoi, Prain.

Barleria, *L.*

Prionitis, *L.;* Ma tumba, Hai kurudo (Minikoi), Dai kurandu, M. ; Katu-karandu, S.

I. Didi, 173! Mafaro in Miladumadulu, Hulule 77, Goifurfehendu Atoll, Veimandu in Kolumadulu, Gardiner! Cultivated by villagers everywhere.—J. S. G. Used in native medicine (J. J. Thorburn).

Tropical Africa and Asia, often cultivated for medicinal uses, and perhaps or probably intentionally introduced into the Maldives. Laccadives in Ameni; Minikoi, Gardiner, Prain (planted as a hedge).

Justicia, *L.*

procumbens, *L.*

Trimen's list; no specimens.

A common weed in Tropical Asia and Australia.

Rungia, *Nees.*

parviflora, *Nees.*

Hulule 55, Gardiner! "Very common on the roots of the cocoanut trees; frequent in the group (Addu, Landu in Miladumadulu, &c.)"—J. S. G.

A common weed of Tropical Asia. Laccadives, in Ameni, Akati, Kadamum, Prain.

(**linifolia**, *Nees;* in Kadamum and Akati, Laccadives, Prain.)

(**Peristrophe bicalyculata**, *Nees;* in Ameni, Kadamum, Kiltan, Laccadives.)

Verbenaceæ.

Lantana, *L.*

mixta, *L.*

Hedufuri, Gardiner! Common in cultivated land all over the north of the Archipelago.—J. S. G.

An abundant weed in Ceylon, S. India, &c. Not recorded for the Laccadives or Minikoi. Probably carried by birds in the first place.

Lippia, *L.*

nodiflora, *Rich.;* Hunigunditila, M.; Heri-menadetta, S.

I. Didi, 162 ! Malé, Trimen ; no specimen. Veimandu in Kolumadulu, Addu Atoll, Gardiner ! A very common yam garden and jungle weed all over Addu.—J. S. G.

A cosmopolitan tropical weed, especially near the sea in Ceylon. Perhaps introduced by birds (Prain). Minikoi, Gardiner, Prain ; Laccadives, in Akati, Prain ; Diego Garcia, Hemsley.

Stachytarpheta, *Vahl.*

indica, *Vahl.*, var. **jamaicensis** ; Malaembu, Nunnay (Minikoi), M. ; Bala-nakuta, S. ; Nai-oringi, T.

I. Didi, 136 !

A common tropical weed, possibly intentionally introduced. Minikoi, Gardiner; Laccadives, in Anderut, Prain.

TECTONA, *L.f.*

GRANDIS, *L.* ; Teak.

Malé, cultivated, Capt. Simons !

Premna, *L.*

integrifolia, *L.*; Kude, Gelavalie (both Minikoi), M.; Midi, S.

Goifurfehendu Atoll, Gardiner ! Common in the densest jungle, especially in Suvadiva. On rocky ground, one of the first bushes to appear on a rocky bank. Very common in N. Mahlos.

A littoral and inland species, common in Ceylon, India, the Malay Peninsula, Andamans, Nicobars, Laccadives, in Kadamum and Kalpeni, Prain ; Minikoi, Gardiner, Prain ; Diego Garcia, Hemsley.

Vitex, *L.*

Negundo, *L.* ; Dunnika, M. ; Nika, S. ; Vennochi, T.

I. Didi, 123 ! Turahdu in S. Mahlos, Veimandu in Kolumadulu, Gardiner ! Malé, Christopher, 1888 ! Used in medicinal baths (J. J. Thorburn).

Common in Tropical Asia. Used medicinally in Ceylon and possibly intentionally introduced into the Maldives.

Clerodendron, *L.*

inerme, *Gaertn.;* Dugeti, Dugajde (Minikoi), M.; Wal-gurenda, S.

Malé, Haly, 1892! I. Didi, 118!

A littoral species, abundant on the coasts of Ceylon, India, and Burmah. Probably introduced by the sea. Minikoi, Gardiner, Prain; Laccadives, in Kalpeni, Prain.

[The absence from the Maldives, Laccadives, &c., of Avicennia officinalis, *L.*, one of the common mangroves, is noteworthy.]

Labiatæ.

Ocimum, *L.*

basilicum, *L.;* Gandakoli (Minikoi), M.; Suvanda-tala, Tala-kola, S.; the Sweet Basil.

I. Didi, 84! Fainu in N. Mahlos, Hedufuri, Goifurfe-hendu Atoll, Gardiner!

Tropical Asia, Africa, America, often cultivated. Minikoi, Gardiner.

gratissimum, *L.;* Fonitulá, M.; Otaka, S.

I. Didi, 134!

Tropical Asia, Africa, America, naturalized in Ceylon. Minikoi, Prain; Laccadives, in Bitrapar, Kadamum, Kalpeni, Prain.

sanctum, *L.;* Kulitulá, Gai Kehabuli, M.; Maduru-tala, S.; the Tulsi.

I. Didi, 59! Turahdu in N. Mahlos, Hulule 73, only by villages, Gardiner!

Tropical Asia and Australia. Sacred to Hindus. Here perhaps originally intentionally introduced; now a weed.

Plectranthus zeylanicus, *Benth.?*

Fragments, I. Didi, 125, native name Huvadukotun, and Kaddu in Haddumati, Rimbudu in S. Nilandu (Huvaduka, M.), Gardiner, are perhaps this species.

Anisomeles, *Br.*

ovata, *Br.;* Muskotan, Maskota (Minikoi), M.; Yakwanassa, S.

I. Didi, 90! Hedufuri, Goifurfehendu Atoll, Hulule 48, Veimandu in Kolumadulu, Gardiner! Also in Addu.—J. S. G.

A common weed of Tropical Asia. Laccadives, in Kadamum and Akati, Minikoi, Gardiner, Prain.

Leucas, *Br.*

biflora, *Br.;* Veo miri, Veo mirihi, M.; Getatumba, S.

Hulule 54, 74, 78, only on damp paths scarce; Wiligili in Suvadiva, Gardiner! "On the roots of cocoanuts by the kuna (Cyperus polystachyus) swamp in Wiligili. Common also in the jungle of Maradu in Addu Atoll."—J. S. G.

A common weed of Ceylon and S. India. Not in the Laccadives or Minikoi.

zeylanica, *Br.*

Landu in Miladumadulu, in yam patches, Gardiner! Also in other islands where yams are cultivated.—J. S. G.

A common weed of Tropical Asia. Not in the Laccadives or Minikoi.

(**aspera**, *Spreng.;* in Ameni, Anderut, Akati, Kadamum, Kiltan, Laccadives, Prain.)

INCOMPLETÆ.

Nyctagineæ.

Boerhaavia, *L.*

diffusa, *L.* (**repens**, *L.*, var. **diffusa**, *Hk. f.*); Burandagondi, Nanubedi (Minikoi), M.; Pita-sudu-pala, S.

I. Didi, 20! Goifurfehendu Atoll, Veimandu in Kolumadulu, Gardiner! Common in sandy sunny beaches throughout the Archipelago.

A cosmopolitan tropical littoral species, introduced possibly by the sea, but probably by birds. Laccadives, in Bitrapar, Anderut, and Kadamum, Prain ; Minikoi, Gardiner, Prain ; Diego Garcia, Hemsley.

(**repens**, *L.;* in Akati and Ameni, Laccadives, Prain.)

Mirabilis, *L.*

Jalapa, *L.;* Asuraffole re (red), Asuraffole hudu (white), Re asaruma, Asarumu, M.; Sendrikka, S. ; Pattaráshu, T. ; Marvel of Peru.

I. Didi, 71, 119, 114 ! Hulule 21, Gardiner ! Common near villages, cultivated. Mentioned by Pyrard de Laval, 1602–7.

A native of Peru, cultivated and escaped in all tropical lands. Very common in Ceylon. Probably originally introduced intentionally for cultivation. Laccadives in Akati, Minikoi ; Prain.

BOUGAINVILLÆA, *Comm.*

SPECTABILIS, *Willd.*

Malé, cultivated, Capt. Simons.

Pisonia, *L.*

aculeata, *L.?*

A leafy bit from Veimandu, Gardiner, is probably this species. Cosmopolitan in the tropics.

morindæfolia, *Br.* (**alba**, *Span.*, probably = **inermis**, *Forst.*) *;* Los, M. ; the Lettuce Tree of Ceylon.

I. Didi, 7 ! Veimandu, Gardiner ! Malé, east end.—J. S. G

A littoral species, Andamans, Nicobars, Malayan, and Polynesian Is. Laccadives, in Bitrapar, Prain ; Diego Garcia, Hemsley. Probably sea-borne.

Amarantaceæ.

Celosia, *L.*

argentea, *L.*

Kaddu in Haddumati, Gardiner !

Cosmopolitan tropical weed, often cultivated.

Amarantus, *L.*

spinosus, *L.*

Malé, near mosques, Gardiner !

A cosmopolitan tropical weed.

CAUDATUS, *L.;* Raidadisagu, M.

I. Didi !

Often cultivated in tropical and warm countries.

gangeticus, *L.*

Malé, Trimen ; no specimen. "Not seen."—J. S. G.

A cosmopolitan tropical weed, often used as a potherb.

viridis, *L.;* Sagu (Minikoi) ; Massagu, M. ; Kurutampala, S. [Ság = potherb, Hind.]

I. Didi, 128 ! "Not seen."—J. S. G. Probably intentionally introduced.

A cosmopolitan tropical weed, used as a potherb. Minikoi, Prain, Gardiner.

Nothosaerua, *Wight.*

brachiata, *Wight.*

Malé, Haly, 1892 !

A weed of dry places and sea shores, Tropical Asia and Africa.

Aerua, *Forsk.*

lanata, *Juss.;* Hudufupila, M. ; Pol-kudu-pala, S.

I. Didi, 151 ! Malé, Christopher, 1888 ! Hedufuri, Goifurfehendu Atoll, Hulule 67, 72, Veimandu in Kolumadulu, Gardiner ! Very common everywhere except in Addu.

A common weed, also littoral, in Tropical Africa and Asia, probably introduced by the sea (see notes on Atolls, below). Laccadives, in Bitrapar, Kalpeni, Kadamum, Akati, Prain ; Minikoi, Gardiner, Prain.

Achyranthes, *L.*

aspera, *L.;* Karhi léibú, M. ; Gas-karal-heba, S.

I. Didi, 160! Hedufuri, Gardiner! Only seen in Mahlos. —J. S. G.

This specimen seems nearer to the type form than to the littoral and inland var. porphyristachya. A cosmopolitan tropical weed. Minikoi, Prain. The var. in Bitrapar, Bangaro, Kalpeni, Kiltan, Kadamum, Akati, and in Minikoi, Prain; Diego Garcia, Hemsley.

Polygonaceæ.

ANTIGONON, *Endl.*

LEPTOPUS, *H. & A.*

Cultivated in Malé, Capt. Simons.

(**Polygonum barbatum**, *L.;* in Kalpeni, Laccadives, Prain.)

PIPERACEÆ.

PIPER, *L.*

BETLE, *L.;* Billi, M.; Bulat-wel, S.; Betel Pepper.

I. Didi 111! A few islands in Miladumadulu, and all atolls. Plentiful in Addu. The leaf chewed. The leaf is termed Wang, or in Addu Billaton.—J. S. G.

Everywhere cultivated in the tropics. Minikoi and Akati Kiltan, Kadamum, Laccadives, Prain.

NIGRUM, *L.;* Pepper.

Trimen's list; no specimens.

A native of India, &c., everywhere cultivated in the tropics, Not recorded for Minikoi or the Laccadives.

Lauraceæ.

Cassytha, *L.*

filiformis, *L.;* Dom velam buli (= white sandhook). Vele buli, M.; Aga mula neti wela, S.

I. Didi 8! Hedufuri, Goifurfehendu Atoll, Hulule 31, Veimandu in Kolumadulu, Gardiner! Common in all the islands where land is forming. Appears very early on a new sandbank with the first shrubby vegetation, and dies out when cultivation begins.

Parasitic, rootless. Cosmopolitan on tropical shores. Laccadives, in Kadamum and Kiltan, Prain. Not recorded for Minikoi. Diego Garcia, Hemsley. Probably sea-borne in the first instance and subsequently carried from island to island by currents and birds.

Hernandia, *L.*

peltata, *Meissn.;* Kando, Maskando, Kadu (Minikoi) M.; Palatu, S.

I. Didi 97! Hedufuri, Goifurfehendu, Hulule 46, Veimandu in Kolumadulu, Gardiner! The first large tree to appear on a sandbank, where it occupies the very centre. Fishing lines are made from the bark. Common in the whole group.

A littoral species, Trop. E. Africa, Mascarene Is., Ceylon S.W. coast, but not India, Andamans, Nicobars, Malay Peninsula and islands, N. Australia, Polynesia. Laccadives in Korat, Prain; Minikoi, Prain, Gardiner; Diego Garcia, Hemsley.

(**ovigera**, *L.;* in Diego Garcia, Hemsley.)

Euphorbiaceæ.

PEDILANTHUS, *Neck.*

TITHYMALOIDES, *Poit.;* Kala kiru, M.

Hulule 14, Gardiner! Two houses at Malé, bathing tank at Hulule, and one house in Huludu, Addu Atoll.—J. S. G.

An American species, intentionally introduced for garden use.

Euphorbia, *L.*

Atoto, *Forst.;* Kiru tina, M.

Goifurfehendu Atoll, Hulule 19, Gardiner! "Frequent in the group. Common in cultivated land near mosques."—J. S. G.

A littoral sea-borne species, India (S.W. coast), Ceylon, Malaya to Polynesia. Laccadives, in Ameni, Prain.

hypericifolia, *L.*, var. **parviflora**, *L.;* Kerutina, M. (Minikoi); Eladada-kiniya, S.

Hedufuri, in cleared grain land, not very common; Veimandu, in Kolumadulu, Addu Atoll, very common weed, Gardiner!

A common tropical weed. Laccadives, in Kadamum and Kiltan. Minikoi, Prain, Gardiner.

pilulifera, *L.* (*hirta*, *L.*); Kirutina, M.; Budadakiniya, S.

I. Didi, 104! Hedufuri, cleared grain land, not common, Gardiner!

A cosmopolitan tropical weed. Laccadives, in Anderut, Kadamum, Kiltan, and in Minikoi, Prain; Diego Garcia, Hemsley.

thymifolia, *L.*

Veimandu in Kolumadulu, Gardiner!

A weed of the tropics, except Australia. Minikoi, Prain.

Agyneia, *Vent.*

bacciformis, *A. Juss.*

Addu Atoll, common in yam gardens and by villages, Gardiner!

A littoral species, India, Ceylon, Java, Mauritius.

Phyllanthus, *L.*

(EMBLICA, *L.*; cultivated in Ameni, Laccadives, Prain.)

maderaspatensis, *L.*; Meia limbo, Kudingke (Minikoi), M.

Hedufuri, Goifurfehendu Atoll, Hulule 63, Veimandu in Kolumadulu, Gardiner! Fairly common in the north.

A common weed of the tropics of Africa, Asia, Australia, Minikoi, Prain, Gardiner. Laccadives, in Ameni, Anderut, Bitrapar, Kiltan, Kadamum, Prain.

Urinaria, *L.*

Hedufuri, Goifurfehendu Atoll, Gardiner!

A cosmopolitan tropical weed. Minikoi; Laccadives, in Kalpeni, Prain.

Niruri, *L.*

Malé, Trimen ; no specimen. Goifurfehendu Atoll, Veimandu in Kolumadulu, Gardiner !

An almost cosmopolitan tropical weed. Minikoi ; Laccadives, in Anderut, Akati, Kadamum, Kiltan, Prain. Diego Garcia, Hemsley.

(**rotundifolius,** *Klein ;* in Kiltan, Laccadives, Prain.)

DISTICHUS, *Muell-Arg. ;* Gobili, M. ; Rata-nelli, S.

I. Didi, 82 (Prain) !

Cultivated in Tropical Asia and the Mascarene Is. and in Minikoi.

Glochidion, *Forst.*

? **littorale,** *Forst. ;* Emboo, M.

I. Didi, 36, a leafy fragment, appears to be this species.

CROTON, *L.*

TIGLIUM, *L. ;* the Croton-oil plant.

Veimandu in Kolumadulu, Gardiner !

Cultivated in the tropics for its medicinal seeds.

(**Claoxylon Mercurialis,** *Thw. ;* in Akati, Bitrapar, Kadamum, Kiltan, Laccadives, and in Minikoi, Prain.)

MANIHOT, *Tourn.*

UTILISSIMA, *Pohl. ;* Cassava.

Malé, Gardiner ! Only seen in Malé.—J. S. G. Trimen ; no specimen.

Cultivated in all hot countries.

Acalypha, *L.*

paniculata, *Miq. ;* Dagundi kandi, Meia-ságu, M.

I. Didi, 169 ! Hulule 66, by paths through dense shady jungle, Gardiner ! A weed of Tropical Asia and Africa.

indica, *L. ;* Vaffufuli, M. ; Kuppameniya, S.

I. Didi, 161 ! Malé, Christopher, 1888 ! Goifurfehendu Atoll, Addu Atoll, a very common weed. Gardiner !

A weed of Tropical Asia and Africa. Diego Garcia, Hemsley; Minikoi, Prain ; Laccadives in Akati and Kadamum, Prain.

fallax, *Muell.-Arg.;* Bissagu, Cave (Minikoi), M.

I. Didi, 154 ! Goifurfehendu Atoll, in jungle outside the mangrove swamp, Veimandu in Kolumadula, Gardiner ! Also in Addu and Suvadiva Atolls.—J. S. G.

A common weed of Tropical Asia. Laccadives in Anderut and Akati, Prain ; Minikoi, Prain, Gardiner.

Trewia, *L.*

? **nudiflora**, *L.;* Varukundu, M.

I. Didi, 103, leaves only, appears to be this species. It occurs in Ceylon, India, and Malaya.

RICINUS, *L.*

COMMUNIS, *L.;* Amanaka, M.; Endaru, S.; Amanakkam, Chittamanaka, T.; Castor-oil.

I. Didi, 143 ! Malé, Gardiner, Christopher, 1888 ! Goifurfehendu Atoll, Hulule 45, Veimandu in Kolumadulu, Gardiner ! Cultivated all over the islands. The seeds are beaten up, and the natives oil themselves with the oil.

Cultivated in all hot countries. Laccadives, in Kiltan, Anderut, Kadamum, Ameni, Bitrapar, Prain ; Minikoi, Prain, Gardiner.

Urticaceæ.

Ficus, *L.*

benghalensis, *L.?* Nika, M.; Mahanuga, S.; the Banyan.

sp. ? Fili, M.; a Banyan.

Two banyans are found in Hulule, and there are large banyans in Kenurus and other islands of N. Mahlos, well back from the beach. Also in other atolls. Probably one of these is F. benghalensis, and perhaps it is intentionally introduced, as apparently in Ameni, Kadamum, and Minikoi (Prain). A banyan is found in Diego Garcia (Hemsley, *l.c.* 334).

"The long roots of these are used as poles for building purposes, and also, *I was told*, for masts. Some of the trees are very large, and must be of great age."—J. S. G.

RELIGIOSA, *L.;* Boi, M. (in this case always used with the suffix gas=tree); Bo, S.; the Bo or Peepul.

I. Didi, 32 ! "One tree only, of large size, near the palace at Malé. There is said to be a second tree in Fua Mulaku, but I did not see it."—J. S. G.

Another is stated by Christopher in his report of 1836 to be on the uninhabited Kedera I. in Suvadiva Atoll.

retusa, *L.?* or **tsiela**, *Roxb.?*

I. Didi, 70, native name Kudehi, may be one of these. F. retusa, *L.;* in Minikoi, Prain.

infectoria, *Roxb.;* Dumbu, M.

I. Didi, 17 !

Ceylon, rare.

ARTOCARPUS, *Forst.*

INCISA, *L. f.;* Bambukea (Banke in Addu Atoll), M.; the Bread-fruit.

I. Didi, 120 ! Hedufuri and Turahdu in S. Mahlos, Limbo Kandu in N. Mahlos, Goifurfehendu Atoll, Hulule, Gardiner ! At least a few trees in nearly every inhabited island of the group. The fruit is largely dried in segments, and kept against famine.

Cultivated throughout the tropics. Laccadives, in Kiltan, Ameni, Anderut, Akati, Prain; Minikoi, Prain.

INTEGRIFOLIA, *L. f.;* Sakkeyo, M.; Kos, S.; the Jak.

Trimen's list. "I saw a few seedlings in Malé. I have never heard of any coral islands on which this flourishes, though attempts have been made to introduce it into nearly every one in the Pacific."—J. S. G.

Cultivated in the tropics. Anderut, Laccadives ? Prain.

Fleurya, *Gaud.*

interrupta, *Gaud.;* Gakehebuli, M.; Wal-kahambiliya, S.

I. Didi, 101 ! Veimandu in Kolumadulu, Gardiner !

A weed from Tropical Africa to Polynesia.

Pouzolzia, *Gaud.*

indica, *Gaud.;* Giteyokoli, Gitakoli (Minikoi), M.

I. Didi, 95! Goifurfehendu Atoll, Veimandu in Kolumadulu, Gardiner! Not seen elsewhere except at Malé.—J. S. G.

A common, weed, Ceylon to China. Laccadives, in Kalpeni, Kiltan, Akati, Kadamum, Prain; Minikoi, Prain.

(**Casuarina equisetifolia,** *Forst.;* in Diego Garcia, Hemsley.)

MONOCOTYLEDONS.

(The entire absence of Orchids, both here and in the Laccadives, may be noted.)

SCITAMINEÆ.

MUSA, *L.*

SAPIENTUM, *L.;* Keo, Dongkeo, M.; Kehel, S.; the Plantain (Banana).

Tiladummati Atoll is famous for its plantains. Those of Limbo Kandu, in N. Mahlos, are of good quality and of luxuriant growth. They are cultivated in most islands, often in pits two or three feet deep. See notes on Suvadiva, below.

Cultivated in all hot countries. Laccadives and Minikoi, Prain.

BROMELIACEÆ.

ANANAS, *L.*

SATIVUS, *L.;* Anana, M., S.; the Pineapple.

Cultivated in Furadu Island of Ari Atoll, but of poor quality.—J. S. G.

Amaryllidaceæ.

Crinum, *L.*

asiaticum, *L.*

Goifurfehendu Atoll, Gardiner (Prain)! Everywhere in the Archipelago, sparsely, especially near to swamps with no mangroves.—J. S. G.

A littoral species, common on the coasts of Ceylon and India.

Pancratium, *L.*

zeylanicum, *L.;* Wal-lunu, S.

Wiligili in Suvadiva, Gardiner! In damp jungle near the village of Wiligili; seen also in Kondai and Gaddu in the same atoll.—J. S. G.

Common in grassy places in Tropical Asia. Minikoi, Prain.

sp. ?

Didi, 11, native name Gul-hajaru, and Didi, 113 (Nargis M.), appear to be fragments of spp. of Pancratium.

(AGAVE VIVIPARA, *L.;* cultivated in Anderut and Kiltan, Laccadives.)

Taccaceæ.

Tacca, *Forst.*

pinnatifida, *Forst.;* Hitala, Hittala,* Heith-thala, M.; Garandi-kidaran, S.; Arrowroot.

I. Didi, 57! Goifurfehendu Atoll, Hulule 15, Gardiner! Common in the whole Archipelago. The roots are scraped and daily washed and dried in the sun for a week. They are also used for poultices with chillies and cocoanut. They form one of the staple foods of the natives against famine. It is nowhere cultivated, but grows wild in nearly every island in the group of any size. The near proximity of coral rock is almost essential for its proper growth.

A littoral species, cultivated in Tropical Asia and Polynesia. Probably sea-borne to the Maldives. Cultivated in the Laccadives, in Anderut, Chitlac, and Akati, Prain. Also in Minikoi, Prain, Gardiner.

DIOSCOREACEÆ.

DIOSCOREA, *L.;* the Yam.*

PENTAPHYLLA, *L.;* Kattella, M.; Katawala, S.; Yam.

* Trimen gives Hittala as the Maldivian name for the Dioscorea yams, his informant evidently describing Tacca as a "yam."

I. Didi, 37 (Prain)! "I think this must be the common yam, cultivated in large gardens, especially in Tiladummati, whence it is exported all over the N. part of the group. In Addu it forms the chief food of the people."—J. S. G.

Cultivated and semi-wild in the Old World tropics.

ALATA, *L.*; Billi-kattala,* M.; Yam.

I. Didi, 39 (Prain)! "Cultivated in house compounds all over the group: trained over fences and up cocoanuts or other trees."—J. S. G.

Cultivated in Tropical India.

FASCICULATA, *Roxb.*; Kurukuru, M.; Yam.

I. Didi, 140 (Prain)!

Cultivated in Lower Bengal.

GLOBOSA, *Roxb.*? Mativa, Mathe-wa, M.

RUBELLA, *Roxb.*? Kattala, M.

PURPUREA, *Roxb.*? Bilek-kattala, M.

I. Didi, 158, 42, and 159, mere fragments, are possibly these species, Dr. Prain suggests. Cultivated in Bengal. "I do not know these."—J. S. G.

(SATIVA, *L.*; cultivated in Ameni, Laccadives.)

(**bulbifera**, *L.*; in Minikoi, Prain.)

Liliaceæ.

Asparagus, *L.*

racemosus, *Willd.*; Satavaru, M.; Hatawariya, S.; Chattavari, T.

I. Didi, no number (Prain)! "I saw this or a closely allied form in several house compounds in Malé."—J. S. G. Ceylon Tropical Africa to Australia. Almost certainly intentionally introduced.

Gloriosa, *L.*

superba, *L.*; Wihelia-gundi, M.; Niyangala, S.; Ventonti, S.

I. Didi, 156! Malé, Trimen! Hedufuri, Goifurfehendu Atoll, Hulule 9, Gardiner! On kitchen middens, all over the northern half of the Archipelago.

* So called from the leaves resembling those of the betel.

Tropical Africa to Cochin China, Ceylon, Andamans, Nicobars, Anderut (Laccadives). Often littoral, *e.g.*, in Ceylon. Probably sea-borne.

Commelinaceæ.

Commelina, *L.*

benghalensis, *L.;* Diyamudoli, M.; Diyameneriya, S.

I. Didi, 2! Malé, Gardiner! Malé only, near mosques.—J. S. G.

A grass weed, Tropical Africa and Asia. Possibly intentionally introduced.

Kurzii, *Clarke;* Tilo lagundi, M.

Hedufuri, Hulule 41, Kaddu in Haddumati, Gardiner! Common in shade by villages in all S. Mahlos, and in Suvadiva and Addu Atolls.

A weed of Ceylon and S. India; not common.

sp. ?

Didi, 40 and 171 (Dikkunfati, M.), and 24 (Vakkunfati, M.), are probably species of Commelina.

(**Aneilema ovalifolium**, *Hk. f.;* in Minikoi, Prain)!

Cyanotis, *Don.*

cristata, *Schultes f.*

Kaddu in Haddumati, Gardiner!

A weed in grass, Mascarene Is., Ceylon, India, Malaya, Minikoi, Prain; Laccadives in Kadamum and Kiltan, Prain.

Rhæo, *Hance.*

discolor, *Hance.;* Re Kandolu, M.

Hulule 29, Gardiner! "In a patch of jungle in the middle of the cocoanut area: seen nowhere else except in Addu; quite wild. The thick lower stem roots are boiled and rubbed on to cure rheumatism and sciatica."—J. S. G.

Palmæ.

Areca, *L.*

Catechu, *L.;* Femfora, M.; Puwak, S.; Areca Palm, Betel Nut.

"In the eastern islands of Miladumadulu, Malé, scarce in Suvadiva, luxuriant in Addu. The nut is called Fo or Fuakou."—J. S. G.

Cultivated in all tropical countries. Ameni, Anderut, Kiltan, Minikoi.

Cocos, *L.*

nucifera, *L.;* Khari (Kairi in Addu); another variety Bo, M.; Pol, S.; Tenga, T.; the Cocoanut.

"Cultivated and wild in practically all the islands other than mere sandbanks. There are several kinds of the oil nut (khari) in cultivation, distinguished by their length and shape. They are noted for great size in Addu and Mulaku and to a less extent in Suvadiva as compared with other atolls. They are always exported in the shell, copra not being made. Addu nuts fetch in Calcutta about Rs. 40, Northern Atoll and Minikoi nuts about Rs. 25, Nicobar nuts about Rs. 45 per thousand. Another variety, of which the flesh near the attaching stem is quite sweet, is grown in a few islands and called Bo (head). The small sweet yellow nut (kurumba) is probably only a recent introduction from Ceylon; a few are grown in the villages for drinking only. The palm, as in other tropical countries, supplies many of the necessaries of life, food, fibre, thatch, &c. Its stems, &c., are largely used in boat-building."—J. S. G.

It is impossible, with the knowledge at our disposal, to say whether this species was introduced deliberately by man, or by the sea. The latter is perhaps more probable, as the islands (see below) seem to lie so much in the track of the sea-borne species.

Pandanaceæ.

Pandanus, *L. f.*

odoratissimus, *L. f.*

sp.? (Hornei, Balf. f.? tall tree, leaf 15 ft. long.)

sp.? (Leaf spineless, 2 ft. long.)

There appear to be three species in the islands: a very large green-stemmed Pandanus (? P. Hornei, *Balf. f.*, of the Seychelles, P. Leram, *Jones*, of the Nicobars), reaching a height of over 50 ft., found in Hulule, Turadu, Goifurfehendu, Limbo Kandu, &c. (Gardiner), and known as Karikeo (Keeva in Addu Atoll); a small-leaved many-rooted species, Bokeo (Divihe keeva in Addu), in Turadu, &c.; and a third, Medu Mokaneo, in Turadu, &c., smaller than either of the above and more rooted and spreading. Trimen mentions P. odoratissimus under the name Ma-kahikeyo, but no specimen is extant. This species is found in Minikoi, and in Bangaro, Kadamum, Ameni, Kiltan, and Kalpeni in the Laccadives, Prain.

"The leaves of the Karikeo are drawn through the flames of a fire to kill them, and split horizontally into two halves, the spines being carefully cut off. They are then scraped and dried in the sun, to be steeped subsequently several times in salt water and re-dried. Thus prepared they are used in Tiladummati for making the large mat sails (rie), and in every part of the group, especially Addu, for coarse mats (santi) and pillows.

"The natives are very fond of chewing the segments of the fruit of the P. odoratissimus, and the ground under a dropping fruit is a great resort for hermit crabs (*Cœnobita*), which also climb the branches."—J. S. G.

ARACEÆ.

COLOCASIA, *L.*

ANTIQUORUM, *Schott.*; Ala, M.; Gahala, S.

Sparsely throughout the Archipelago, Gardiner. Cultivated and more or less wild. "Not regularly cultivated, except in Tiladummati and Addu, and not much in the former. In Maradu, Addu Atoll, there are plantations regularly irrigated from wells. A second kind known by its lighter coloured flesh is grown in some islands in brackish water, *i.e.*, in artificially or otherwise lowered ground below high tide limits. It is seldom used, being kept against famine. It appeared to me to be identical with the papoi of the Pacific, Cyrtosperma edule, *Schott.*"—J. S. G.

Cultivated in all hot countries. Minikoi; Laccadives, in Ameni, Anderut, Kalpeni, Kiltan, Kadamum, Akati, Prain.

ALOCASIA, *Schott.*

INDICA, *Schott.;* Ma ala, M.; Rata-ala, S.

I. Didi, 110!

Cultivated in Tropical Asia.

RAPHIDOPHORA, *Schott.*

PERTUSA, *Schott.*

Kaddu in Haddumati, Gardiner. A form with perforated leaves, like that cultivated in Colombo gardens, probably intentionally introduced.

ACORUS, *L.*

CALAMUS, *L.;* Huvago, M.; Wadakaha, S.

I. Didi, 15 (Prain)!

Cultivated in Ceylon and other warm countries.

Cyperaceæ.

Pycreus, *Beauv.*

pumilus, *Nees.* (**Cyperus hyalinus,** *Vahl.*).

Goifurfehendu Atoll, Gardiner! Dry places near the shore.

A weed of Ceylon, S. India, Timor, Laccadives in Kadamum, Prain.

polystachyus, *Beauv.* (C. B. Clarke)! Kuna, M.

Midu in Addu Atoll, Gardiner! A regular grass of swamps in Suvadiva and Addu Atolls. Used for the well known fine Maldivian mats.

Cosmopolitan in warm countries. Not recorded for the Laccadives; Minikoi, Prain.

Cyperus, *L.*

(**compressus,** *L.;* in Kalpeni, Laccadives, Prain.)

(**pachyrhizus,** *Nees;* in Bitrapar, Bangaro, and Kadamum, Laccadives, Prain.)

(arenarius, *Retz.*, a common littoral plant in Ceylon and India, is absent from the Laccadives and Maldives.)

(stoloniferus, *Retz.*, also a common littoral species of Trop. Africa, Mascarene Is., and Asia, is missing also.)

(**ligularis**, *L.;* in Diego Garcia, Hemsley.)

sp. ? Gokkuladuru, M.

I. Didi, no number. Perhaps a sp. of Cyperus, or the following.

Mariscus, *Vahl.*

Dregeanus, *Kunth.* (**Cyperus dubius**, *Rottb.*); Huiru, Kalandura gundi (Minikoi), M.

Hulule 42, Gardiner ! One of the first to appear on any sandbank that forms, outside the Scævola.

A littoral and inland species, Ceylon, India, Malaya, S. Africa. Evidently sea-borne, as indicated in the note above, and further described below. Minikoi, Prain, Gardiner.

albescens, *Gaud.?* (**Cyperus pennatus**, *Lam.*).

Goifurfehendu Atoll, Gardiner. Almost certainly this species, but a very reduced specimen. Near the shore, on dry sandy places.

A littoral and inland species, Mascarene Is. to N. Australia, Minikoi, and Laccadives, in Anderut, Kalpeni, Akati, Prain.

(**Kyllinga brevifolia**, *Rottb.;* in Minikoi, Prain.)

(**K. monocephala**, *Rottb.;* in Diego Garcia, Hemsley.)

Fimbristylis, *Vahl.*

spathacea, *Roth.*

Trimen's list ; no specimen. Goifurfehendu Atoll, Veimandu in Kolumadulu, Gardiner ! Dry places near the shore. Sometimes used for mat-making.

A littoral species, common in Ceylon, India, Malaya, &c.

(**diphylla**, *Vahl.;* in Kalpeni, Laccadives, Prain.)

(**glomerata**, *Nees;* in Diego Garcia, Hemsley.)

Cladium, *P. Br.*

jamaicense, *Crantz* (*Mariscus, R. Br.*).

Addu Atoll, Gardiner. (Prain! "As nearly as possible typical," C. B. Clarke!) Grows to a height of 4–5 ft., almost completely covering a large swamp in Midu island (water quite fresh).—J. S. G.

A cosmopolitan species, temperate and tropical. Not recorded for India or Ceylon, except from high elevations in Kashmir; Mauritius.

[Remirea maritima, *Aubl.*, a cosmopolitan tropical littoral species, common in Ceylon, is absent from the Maldives and Laccadives, so far as we know.]

Gramineæ.

Paspalum, *L.*

sanguinale, *Lamk.*

Goifurfehendu Atoll, Gardiner! Common in Suvadiva.

Cosmopolitan in warm countries. Minikoi, Akati (Laccadives), Prain; Diego Garcia, Hemsley.

Panicum, *L.*

MILIACEUM, *L.*; Bai, M.; Wal-meneri, S.; Millet.

Trimen's list; no specimens. See Bell, *l.c.* 84. Cultivated. "Formerly extensively cultivated throughout the whole group: only saw it in Kenurus (Mahlos) and Mafaro (Miladumadulu)."—J. S. G.

(**trigonum**, *Retz.*; Hue, in Minikoi, Gardiner.)

Spinifex, *L.*

squarrosus, *L.*

Common in N. Mahlos, Goidu (Horsburgh), &c.—J. S. G.

A littoral species, on sandy shores, Ceylon, India, Burmah to China, Minikoi, Prain; Laccadives, in Bitrapar, Prain. Sea-borne.

Oplismenus, *Beauv.*

(**Burmanni**, *Beauv.*; in Akati, Kadamum, Kiltan, Minikoi, Prain.)

compositus, *Beauv.*; Ona hui, M.

Hedufuri, Hulule 37, Veimandu in Kolumadulu, Gardiner ! A very common wet jungle grass, especially in Addu and Suvadiva.—J. S. G.

An almost cosmopolitan tropical grass. Laccadives, in Ameni and Akati, Minikoi, Prain.

Setaria, *Beauv.*

ITALICA, *Beauv.;* Ura, M.; Italian Millet.

Trimen's list; no specimens. "Not so common at any time as Panicum miliaceum. I was given a little at Raskateen, N. Mahlos, where some was growing half wild."—J. S. G. Cultivated in Ceylon and other warm countries.

(**verticillata,** *Beauv.;* in Ameni, Bangaro, Kadamum, Kiltan, Prain.)

Stenotaphrum, *Trin.*

complanatum, *Schrank.*

Veimandu in Kolumadulu, Gardiner !

Tropical Africa, Mascarene Is. to N. Australia. Diego Garcia, Hemsley. Perhaps sea-borne, like other grasses.

Thuarea, *Pers.*

sarmentosa, *Pers.*

Hedufuri, Goifurfehendu Atoll, Gardiner ! Common on sandy sunny beaches throughout the Archipelago; characteristic of the same area in Goidu as Ipomœa biloba.—J. S. G.

A littoral sea-borne species, Mascarene Is., Ceylon, Nicobars, Andamans, Malay Is., Polynesia. Not in India. Minikoi, Laccadives in Bangaro and Kadamum, Prain.

(ORYZA SATIVA, *L.;* Rice; Handu, M.; appears to be occasionally cultivated in some islands, but the bulk of the supply is imported from India. "The natives have tried to introduce this many times, but it will not grow and set seed."—J. S. G. Cultivated in Anderut, Laccadives.)

Zoysia, *Willd.*

pungens, *Willd.*

Trimen; no specimens. A common littoral grass in Trop. Asia, Australia, and Mauritius.

ZEA, *L.*

MAYS, *L.;* Donera, Donala, M.; the Maize.

I. Didi, 35? Cultivated in Landu, Gardiner.

Cultivated in all warm countries. Not in Minikoi or the Laccadives.

SACCHARUM, *L.*

OFFICINARUM, *L.;* Udandi, M.; Sugar-cane.

Trimen; no specimens. "A little grown in house enclosures in nearly all the larger islands of the group; may almost be said to be cultivated on a large scale in Landu and Mahugudu (both in Miladumadulu)."—J. S. G.

Cultivated in all warm countries. Minikoi, Prain.

Ischæmum, *L.*

ciliare, *Retz.;* Bileh-hui, M.; Rattana, S.

I. Didi, 126 (Prain)!

A common grass, Ceylon to Australia and China. Laccadives, in Kalpeni, Akati, Bitrapar, Kadamum, Kiltan, Prain.

muticum, *L.*

Hedufuri; very common along the S.E. line of islands of S. Mahlos on broad roads which have gone back to jungle; very sparingly elsewhere; Goifurfehendu Atoll, Gardiner!

Common from S. India to Australia. Laccadives in Kalpeni; Minikoi, Prain.

Apluda, *L.*

varia, *Hack.*, var. **aristata**, *L.;* Ona hui (Minikoi), M.

Hedufuri, Goifurfehendu Atoll, Hulule 8, Veimandu in Kolumadulu, Gardiner! Covers a large area in Hedufuri in a damp low area in Beembi land. The commonest grass by far in Hulule. Common in the whole group.—J. S. G.

A common grass from Ceylon to Polynesia. Minikoi, Laccadives in Kadamum, Prain.

[**Cynodon Dactylon**, *Pers.;* in Kelpeni, Laccadives.]

ANDROPOGON, *L.*

SORGHUM, *Brot.;* Zoowari, M.; the Juar or Jowari of India.

Formerly cultivated in the Maldives.—J. S. G.

SQUARROSUS, *L. f.;* Lancimo, Lunsimoo, M.; Saewandara, S.; the Khus-khus.

I. Didi, 29! Fainu in N. Mahlos, Gardiner (Prain)! Extensively cultivated in Suvadiva. The scented roots used as ornaments for the women's hair.

Cultivated, and wild in the Old World tropics. Laccadives, in Kiltan, Prain.

[**contortus**, *L.;* in Kiltan and Kadamum, Laccadives, Prain.]

NARDUS, *L.;* Kasinji, M.; Mana, S.; Citronella Grass.

I. Didi, 79 (Prain)!

Wild and in cultivated forms, Old World tropics.

Eleusine, *Gaertn.*

[**indica**, *Gaertn.;* in Minikoi, Prain.]

CORACANA, *Gaertn.;* Bimbi, Beembi, M.; Kurakkan, S.

"Formerly the most largely cultivated grain in the Archipelago, but now only a little grown here and there. The area to be planted is cut down and all burnt off by March. The surface is then smoothed over, and the grain is scattered by hand after the first rain of the S.W. monsoon. The crop is ready to cut in four months. The heads only are taken, the straw being left and reburnt."—J. S. G.

Cultivated in Ceylon, India, Egypt, Japan, &c. Minikoi, Laccadives, in Ameni, Anderut, Kadamum, Kalpeni, Prain.

Ægyptiaca, *Desf.*

Trimen; no specimens. Goifurfehendu Atoll, Gardiner! Common in cleared Bimbi land, especially in Miladummadulu.—J. S. G.

A weed, common in the Old World tropics, and naturalized in America. Laccadives, in Ameni and Kadamum, Prain.

Eragrostis, *Host.*

tenella, *R. & S.*, var. **plumosa,** *Stapf.;* Tubuli hui, Sannipoo (Minikoi), M.

I. Didi, 141! Goifurfehendu Atoll, Hulule 10, very common, Gardiner! One of the first grasses to reach a sandbank, followed by Scævola.

Common in Tropical Asia and Africa. Sea-borne. Minikoi, Prain, Gardiner.

Laccadives, in Kalpeni, Akati, Kadamum, Kiltan, Prain.

(**Lepturus repens,** *R. Br.;* in Minikoi, and Laccadives in Bangaro and Bitrapar, Prain. Littoral, a rare grass in Ceylon, Malay and Polynesian Is.)

BAMBUSA, *Schreb.*

ARUNDINACEA, *Willd.*, or VULGARIS, *Schrad.*, or both? or more?

Malé and other islands. A plain yellow bamboo, apparently *vulgaris*, is grown in Landu. A dwarf kind is more common, growing in many house compounds.—J.S.G.

GYMNOSPERMÆ.

Cycadaceæ.

Cycas, *L.*

circinalis, *L.*

Island near Malé, F. Lewis.

CRYPTOGAMÆ.

Filices.

(**Asplenium æquabile,** *Baker.*

longissimum, *Blume.*

falcatum, *Lam.;* all in Diego Garcia, Hemsley.)

Nephrolepis, *Schott.*

exaltata, *Schott.;* Kees fila, Makunu hungal, M.

I. Didi, 168 ! Hedufuri, Hulule 30, near the roots of the cocoanuts in damp sandy areas, Veimandu in Kolumadulu, Kaddu in Haddumati, Gardiner (Prain) ! Also in Suvadiva.—J. S. G.

Cosmopolitan ? in the tropics.

(**tuberosa**, *Presl.;* in Minikoi, Gardiner.)

(**cordifolia**, *Presl.;* in Anderut, Laccadives, Prain.)

Thamnopteris, *Presl.*

Nidus, *L.;* the Bird's Nest Fern.

Veimandu in Kolumadulu, Kaddu in Haddumati, Gardiner! Also in Suvadiva.—J. S. G.

Common in the tropics in very damp localities. Diego Garcia, Hemsley.

Nephrodium, *Rich.*

molle, *Desv.*

Kaddu in Haddumati, Gardiner !

Cosmopolitan in the tropics. Laccadives in Anderut, Prain.

(**unitum**, *R. Br.;* in Diego Garcia, Hemsley.)

(**Pteris marginata**, *Bory;* in Diego Garcia, Hemsley.)

Lycopodineæ.

Psilotum, *Sw.*

triquetrum, *Sw.;* Prumo (Minikoi), M.

Goifurfehendu Atoll, Kaddu in Haddumati, Gardiner.

Cosmopolitan in the tropics. Minikoi, Gardiner, Prain; Diego Garcia, Hemsley.

" In Goidu on the bases of cocoanuts close to the mangrove swamp. In every island of Suvadiva. Grows chiefly on cocoanuts, on the top of the basal mass of roots or in holes in the trunk."—J. S. G.

Finally there are three utterly indeterminable fragments :—

I. Didi, 38, Dakada, M.

67, Bambara, M.

157, Makumburuvani, M.

III.—NOTES ON THE VEGETATION OF THE VARIOUS ATOLLS.

(By J. S. GARDINER.)

Hulule Island.*

This is the S.E. island of Malé Atoll. On the E. and S. the reef is one-third to half a mile wide, on the W. about 100–150 yards, on the N. the island lies along the line of the reef. The soil is sand, very fine to the west, but to the east foraminiferal and coarse, with a little pumice. There are coral blocks in the sand along the cocoanut belt south of the village. The rainfall is probably about 110 inches; certainly considerably less than in islands lying further west and south.

Going to the land for a moment it is interesting to notice the distribution of some of the plants and trees. In the first place, the cocoanuts form a belt from the N.W. point of the island down to the village, and then along and across the island to the undermined beach. East of this—that is, a belt along the N.E. shore of the island—only small bushes occur, and no trees of any size. On the west side of the village is a belt of low scrub 30–40 yards broad, and south of the village is a dense jungle of Bambukeo (bread-fruit), Funa (Calophyllum Inophyllum), Karikeo (Pandanus Leram ?), Kandu (Hernandia peltata), two or three candle-nut trees (Barringtonia speciosa), with an odd Hibiscus tiliaceus here and there. The south point of the island has no large timber, and the whole west and south shores are fringed with Kuredi (Pemphis acidula), with an occasional Mabori (Tournefortia argentea) here and there. By the village is a zære (holy grave), and behind this is a small untimbered patch, really an old kitchen midden with

* I spent nearly six weeks on this island during January and February, 1900. One boy was employed solely in collecting and looking after the flora, always accompanying me. Although out daily I failed to add any plants in the last three weeks of our stay.

a large clump of jessamine (Jasminum grandiflorum) in the centre, the rest consisting principally of a yellow composite (Wedelia biflora), low shrubs, and climbing beans.

The whole west and south sides of the island, where the Pemphis forms a single line of timber on the top of the sandy beach, are slowly washing away. The same action is more rapid to the south-east, where fallen cocoanut palms strew the beach. Further north the beach is stationary or slightly growing out by the washing up of sand, which reaches its maximum in a broad blunt sandy point to the N.E. Pemphis gradually gives place to Scævola, with a clump of Tournefortia here and there, until these latter are alone found. At the point these shrubs have not been able to keep pace with the beach, and there is outside the line of advancing Scævola a low growth of Mariscus Dregeanus, Launæa pinnatifida, Eragrostis plumosa, with very numerous seedlings of Tournefortia, and a few plants of Aerua lanata. Behind, the Scævola line is very marked, merging in 30–40 yards into a low bush—continuous up to the cocoanut belt—formed almost entirely of Ochrosia borbonica and Morinda citrifolia, weighed down in many places with Cassytha filiformis.

The flora of Hulule, which lies very close to Malé Island itself, and thus in the track of trade, contains, as might be expected, many introduced weeds of cultivation. Apart from the strictly cultivated forms, it consists of 58 species, of which perhaps about 22 are man's weeds and about 24 littoral species, sea-introduced.

Goifurfehendu (Horsburgh) Atoll.*

The atoll consists of five islands : Goidu, Fehendu, Furudu, Inafuri, and Doru Kandu, the plants of which decrease in variety in the above order. Doru Kandu lies to the south, close to the outer part of the reef, and is all rocky ; it is

* Our visit was in November, 1899. The plants were carefully collected by myself alone. So far as the small herbaceous species are concerned, the collection is about complete.

destitute of all vegetation, except a few old Pemphis trees half growing in the water at the east end. All the other islands are formed entirely of sand, with the exception of Goidu, which has a rocky belt 30–40 yards broad at its extreme eastern end. This is largely fringed near the sea with Pemphis, while cocoanuts, small Pandani, Allophylus Cobbe, Hernandia peltata, Acalypha fallax, and Premna integrifolia form a dense jungle behind. The rocky and sandy areas join in a small mangrove swamp, west of which is a dense jungle of bread-fruit, cocoanuts, and large Pandani, with a few large banyans and Terminalia Catappa. The west shore of Goidu forms a slight bay, and is fringed with Pemphis acidula and Tournefortia argentea N. and S., and in the centre Scævola Koenigii and Suriana maritima, with a small growing area outside covered with dense Spinifex squarrosus. Contrasted with Goidu the other islands are noticeably poor in low herbaceous plants. Inafuri is merely a sandbank covered with low trees and bushes, Spinifex and Launæa being the only herbaceous plants observed.

Of food plants the cocoanut is alone of any importance, covering the greater parts of Goidu, Fehendu, and Furudu; plantains, yams, and grain of any kind do not grow, and the papaw only reaches a very small size. The flora of this atoll, collected on Goidu and Furudu, with a few plants from other spots, numbers, apart from the strictly cultivated forms, 67 species.

Mahlosmadulu Atoll.

This is divided into North and South Mahlos Atolls. Plants were collected from several islands in each.

Turadu,* in South Mahlos, is a small thickly inhabited islet with no indigenous foliage or jungle, the greater part planted with kurumba (yellow edible cocoanut), bread-fruit,

* Only a few plants, picked as not found or not common in Goifurfehendu.

papaw (falo and veofalo), Barringtonia speciosa, and various kinds of Pandanus (Karikeo, Bokeo, Medu Mokaneo), with various herbs used in curries. The whole of the south of the island is being very rapidly washed away by the sea, and there is a long point extending outwards, covered with Pemphis acidula, the stems of which are washed for two or three feet at high tide, and are very slowly being killed ; considerable changes took place here two years and five months before I visited the island, since when the natives say that they cannot see any further change.

Hedufuri, in S. Mahlos, is likewise a small thickly inhabited *very* dry sandy islet. The village is situated on the east side, and behind it is a small clump of cocoanuts, bread-fruit, &c. The rest of the island is very dry, sandy, covered with a low growth of Scævola, Ochrosia, Tournefortia, and small Pandanus, with grassy patches here and there. Morinda citrifolia is very abundant, being to some extent planted by the people for the root, from which a permanent red dye for cloth is obtained by mixing a decoction with lime.* The flora of this island numbers 46 species other than cultivated forms.

The islets along the south side of Mahlos Atoll may be divided by the vegetation at a glance into sandy and stony islets, or, if mixed, the two parts can be separated.

The sandy islets have, as a rule, a few semi-dwarfed cocoanuts and bread-fruit trees in the centre, surrounded by such low bushes as were mentioned under Hedufuri, with Scævola beaches.

The rocky islets, on the other hand, are covered with dense tall jungle of cocoanuts, large Pandani, Calophyllum, Barringtonia, with often a clump of banyans, and have Pemphis beaches.

* Probably some of the other plants were introduced as dyes and have now run wild. The whole population is engaged in cloth-making. The black thread is now imported as such, but was formerly dyed, the colour being obtained from the sap of the plantain. The collection from this island is fairly complete.

A marked increase in the size and luxuriance of the vegetation is noticeable in passing from the west to the east of Mahlos Atoll.

In North Mahlos the islands of the east side are formed for the most part of rock toward the seaward face with coarse sand inside. Compared with S. Mahlos, there did not appear to me to be nearly the variety in herbaceous plants, while woody plants are the same, the trees generally much taller and often of quite remarkable size. Kenurus in particular is covered in places with large banyans and Barringtonias. They everywhere keep well back from the beach, and avoid the sandy area, growing most luxuriantly at the line of junction of rock and sand.

The western and inner islands of N. Mahlos resemble the sandy islands of S. Mahlos for the most part; the majority are sandbanks forming or being washed away. Of these, I visited over thirty, and there seemed to me to be a definite order in which the plants came to them. All are at some time the resort at high tide of large flocks of terns, herons, and sandbirds, the common crow appearing only when they become inhabited. Herbaceous plants first appear, most commonly Spinifex squarrosus or Launæa pinnatifida, to be followed by Mariscus Dregeanus, Eragrostis plumosa, and perhaps Aerua lanata. Very quickly seedlings of Tournefortia argentea appear, and often these grow into large bushes before the Scævola arrives, and indeed this plant often remains for a long time absent, but as soon as it settles it at once spreads with great rapidity, only a relatively old Tournefortia tree being left here and there. On the first bushes Cassytha filiformis is sure to be found. Ochrosia borbonica, Terminalia Catappa, and small Pandani soon appear, and in large sandbanks the central part is often covered with Guettarda speciosa and Hernandia peltata. Cocoanuts do not, as a general rule, grow well on these islets, and the largest have seldom more than a few straggly trees in the centre. If the islets are washing away at all, Pemphis acidula is sure to be present above the beach, but if they are growing is very seldom found.

There are very few rocky islets in the whole group which did not exist when the charts were made in 1836, but Hura, to the west of the reef marked Wah-pure, was then devoid of foliage. It has now cocoanut trees said to have been planted about twenty years ago, before which it was all grass. Now Pemphis acidula and Tournefortia argentea occur about the beach abundantly to the east, while the west, where the island is still growing, is covered with Apluda aristata, Aerua lanata, with Canavalia lineata, Oldenlandia biflora, and Cassytha filiformis creeping over the rocks in every direction. The absence of Pandani is remarkable.

Limbo Kandu, in N. Mahlos, is remarkable as showing the richest vegetation we saw north of Malé. It is a round sandy island with a ridge of wind-blown sand all round, perhaps 12 feet above high tide level, below which there is little change taking place in the beach. Round the coast is a line of the ordinary sand bushes, 80–120 yards broad, in which the ridge above slopes to the central flat, which is 1–2 feet above high tide. This part is for the most part covered with large trees, cocoanut, banyan, bread-fruit, Barringtonia, with a number of very large limes and Pandani. Plantains of very good quality grow luxuriantly, and there are some yams (Ipomœa Batatas), pomegranates, a little ala (Colocasia antiquorum), and best of all, chillies. A noticeable point in the central clump is the extreme luxuriance of a certain creeper which has completely covered over some large Pandani and hangs from the Nika (banyan) in heavy festoons. The tropical appearance was only perhaps equalled in Addu Atoll, but the creeper was not seen elsewhere. It should be mentioned that the island was formerly inhabited, and the creeper may have been brought from Ceylon or India with the plantains, which are frequently brought over fresh for planting. Contrasting Mahlos with other atolls, the comparative absence of yams, plantains (with the sole exception of Limbo Kandu), ala (Colocasia), funa (Calophyllum Inophyllum), papaws, and indeed of all food plants is very noticeable. Hitala (arrowroot, Tacca pinnatifida) occurs in nearly every large island, but in no luxuriance; here only in the group is it regularly collected and eaten, the same remark applying to the mangrove also where it occurs. The cocoanuts are generally of small size, and the number per tree is considered by the natives very small. Generally the soil would not appear to be nearly as rich as in the eastern line of atolls.

S. Mahlos has been for many years closely connected with Malé, from which the inhabitants have obtained rice; there is only evidence of grain having been grown in Doomfang in recent (about twenty-five) years. In N. Mahlos grain (Eleusine Coracana and Panicum miliaceum) seems to have been grown in nearly all the islands within the last 8–10 years: in 1899, however, it was only grown in Kenurus, planted with the first rains of the little monsoon in April, and reaped in August. To plant it, the grass and shrubs being burnt off, the whole was surrounded by a cadjan fence 1–2 feet high to keep off the rats, the surface smoothed by a rake and the grain strewn on by hand. None of the western islands of N. Mahlos are inhabited, but a few inner ones have villages of manufacturing or fishing castes.

Ari and Nilandu Atolls.

The descriptions of North Mahlos apply equally well to these atolls. The Island of Furadu produces small pineapples of poor quality and flavour. We coasted Ari close to the eastern shore for 15 miles, and steamed through N. and S. Nilandu, visiting, however, only Rimbudu in S. Nilandu and Mahikaddu in Ari, which in the general appearance of their foliage, as well as in the plants, exactly resembled islands in the same position in N. Mahlos.

Fadiffolu, N. and S. Male, Felidu, and Mulaku Atolls.

Hulule in Malé is described separately; it is probably richer in variety of indigenous plants than any of the other islands, on account of its large size, position, small population of low caste, and little cultivation.

The atolls mentioned lie along the eastern side of the Archipelago. The islands of their western side are not inhabited, except in Fadiffolu, and are generally bare and sandy, with low trees and bushes only ; cocoanuts of small size are scattered over them, poor in quantity and in quality. The eastern islands are generally densely covered in cocoanuts grown for the nut and sugar, but plantains, yams, and vegetables of all sorts do not flourish, and are not found anywhere in luxuriance. All appear from the sea to be flat-topped high cocoanut islands fringed with Pemphis acidula generally ; banyans, Calophyllum, &c., very scarce ; the Areca palm not found.

Kolumadulu and Haddumati Atolls.

None of the islands of these atolls were visited by me, except Buruni in Kolumadulu ; a complete set of plants was collected on Veimandu in Kolumadulu, and a few from other places in that atoll. A collection was also made on Kaddu in Haddumati. The eastern islands of both atolls are densely covered with cocoanuts, but have a good deal of high timber as well. Buruni does not differ greatly from the generality of Mahlos islands, but struck me as being especially rich in small herbaceous plants and grasses ; all seemed familiar, however, except a "shamrock," Desmodium triflorum, which I saw nowhere else. The Veimandu flora, apart from cultivated forms, numbers fifty-five species.

Suvadiva Atoll.

As already mentioned, this atoll lies much to the south, separated by a wide channel from Haddumati to the north, and from Addu to the south. The eastern islands of this atoll are nearly all densely covered with large cocoanut trees, as are also some of the western islands, but many of the latter have only low trees and shrubs. The inner islands are, as a rule, covered with low trees and bushes, Heebahdu to the north with very large Barringtonia speciosa ; cocoanuts if present on these islands are of small size and scattered. A few plantains and food plants are found in every island, but they do not grow at all luxuriantly; the former are now planted in pits in the ground dug to below high tide level, and in Kondai I saw a man put in a basket of pumice from the beach ; this appeared on inquiry to be a regular custom of the island. A little grain is stated to have formerly been cultivated, but the people seem to have been for all time famous as daring navigators, and to have lived for the most part on rice obtained from India in exchange for cocoanuts, mats, and fish. Many of the islands of the outer reef have swamps overgrown completely or fringed with Kuna grass (Pycreus), used for their great industry of mat-making.

Wiligili has one such swamp now almost dry, covered with kuna, with Leucas biflora growing on the roots of the trees and on any drier spots. A clump of Nephrolepis exaltata and Thamnopteris Nidus also occur here. Round this the jungle is very thick and dense, the larger trees consisting for the most part of Cordia subcordata and Terminalia Catappa, the undergrowth being composed almost entirely of Ardisia humilis, with here and there a bush of Rhizophora mucronata and Lumnitzera racemosa; in certain places one sees a bush of Hibiscus tiliaceus and occasionally a giant cocoanut or Pandanus. The paths are fringed by Oplismenus compositus, and near the village Pancratium zeylanicum is very common.

On sandy islets the most striking feature compared to other atolls is the dominance of the Pandani to the detriment of Scævola and Tournefortia; Pemphis, too, is not abundant.

Collections of plants were made in Wiligili, where there is a large village, and in Gaddu. A kind of small Pampas grass called Lancimo (Andropogon squarrosus, the Khus-khus) is grown extensively throughout the whole atoll. Its fibrous root has a sweet somewhat lemon-like smell, and is used as ornaments for the women's hair. A kind of thyme, too (tulamu), is grown for the same purpose.

Addu Atoll.

This little atoll, situated 35 miles south of the Equator, is perhaps the most perfect of all I saw in the Maldives, having only two narrow passages to the north and two broader ones to the south. The encircling reef appeared from the ship to be covered with land, which but for the passages seemed to be continuous. It was really, however, broken up into numerous islands by channels which often could not be seen on account of smaller islets standing on the outer part of the reef behind. The islands of the east side each consist of sand and rock areas respectively against the lagoon and open sea; these areas are separated by a series of kuli or fresh water lakes in the centre of the islands. On the west side the sea has everywhere broken into these lakes, and two series of islands result, rocky patches against the sea and larger sandy islets by the lagoon. The difference between the two sides is probably due to the heavier weather which comes up from the west. The atoll is almost beyond the reach of the Indian monsoons, the north-east monsoon bringing only a few gales from the north in January and February, but in the greater part of the year the westerly trades prevail. The rainfall, too, being probably about 150 inches, is heavier than in any other part of the Maldives, and perhaps this is the cause of the exceptionally rich vegetation which characterizes the atoll.

North-east of the atoll is a large island with two densely inhabited villages, Midu to the north and Huludu to the south, having between them a population of about 3,000 people. Midu is entirely an agricultural village, but Huludu is inhabited by high caste people and sailors who trade up and down the group ; it usually also sends two or three ships a year to the Hooghly, and has traditions of an Arabian trade in times past. The village itself is full of fine houses with large compounds, in which one may recognize almost as great a variety of spices and other cultivated plants as at Malé. Every available inch of the island is cultivated, except a narrow debatable strip between the two villages. The people for the most part live on fish and on the vegetables they grow ; no grain was, so far as I could ascertain, ever grown, and rice is not much imported. Cocoanuts are planted right up to the beach on every side, and are of greater size and luxuriance than any I have seen in Ceylon or the Pacific. They also bear heavier crops both in number and size ; 60 trees are supposed to yield 1,000 nuts worth Rs. 45 in Calcutta, and about 4,750 nuts give a ton of copra. The kurumba or yellow form is not grown, but a green form with sweet husk is regularly cultivated for the crews of the vessels. The centre of the island has a great fresh water marsh overgrown with Cladium jamaicense, with Pycreus polystachyus near the edges. The north part of this has been reclaimed and turned into a great yam and sweet potato flat, the latter dug four times a year. Between it and the marsh long beds have been planted with Colocasia antiquorum, some of which is almost growing in the water. Near the village are extensive plantations of plantains, of which the people distinguish five varieties, and areca palms grow everywhere in competition with the cocoanut. Each house has its papaws and bread-fruits, and pumpkins, water melons, chillies, and betel grow almost semi-wild in their compounds. The debatable ground is covered with Hibiscus tiliaceus struggling with Hernandia peltata, both of which almost appear as if planted. The roads are everywhere well kept ; they are edged for the most part with grass, flowering dicotyledonous weeds being remarkably scarce and not as in the northern atolls struggling with and maintaining their position against the grass.

The islands to the south of Huludu have the usual trees and shrubs characteristic of rocky and sandy areas. Some are planted with cocoanuts. Most are very barren, the arrowroot (Tacca) being almost the only herbaceous plant found besides the grasses. Convolvulus and other creeping and climbing plants are practically non-existent on the shores of either side. Scævola and Tournefortia do not dominate any part. Pemphis grows against the sea, and has been planted in lines across the kuli. For the rest it is an open jungle of small Pandani and the usual shrubs, with the addition of Gyrocarpus Jacquini, Morinda citrifolia, and Thespesia populnea. The absence of mangroves from so suitable an area is most remarkable, it seems to me.

Maradu, one of the central islands of the west side, has perhaps an even more luxuriant vegetation than either Midu or Huludu. It is more dank and moist, pools of water standing everywhere. The village is shaded with immense bread-fruit trees, and every house has its trellis work of cucumbers, gourds, and pumpkins; water melons grow everywhere. Indeed, practically every vegetable which is at all extensively grown in the group flourishes here, the brinjals being as good as those of Ceylon. Behind the village is a dense tall jungle of cocoanuts, arecas, Calophyllum, Terminalia Catappa, Cordia subcordata struggling with an undergrowth of limes, Zizyphus Jujuba, and many other wild and semi-wild trees. The soursop, pomegranate, Sonneratia, and betel grow without being cultivated, and there are even said to be a few orange trees. Coarse grass covers the untilled ground everywhere, save in the densest shade. Herbaceous weeds are rare; almost the only flowers are the Rhœo discolor and the Pancratium zeylanicum. There was one single immense Barringtonia speciosa, but I do not remember to have seen a single banyan tree in Addu, and I think it is not found.

Miladumadulu Atoll.

Only two islands on the west side of this atoll are at present inhabited, while most of the outer western line of islands have people on them or are regularly visited. The western islands are generally covered with low trees and shrubs, while the eastern islands have large cocoanuts and a few banyans. The greater part of the eastern islands has at times been cultivated, but very many have large lakes (kuli, M.; kulam, T.) in the centre, surrounded by a thin fringe of mangroves, of which the natives distinguish three kinds according to their edible properties, Bruguiera caryophylloides being the most numerous.

Formerly these islands were nearly self-contained, all growing grain, yams, sweet potatoes, plantains, pumpkins, and Colocasia; arrowroot (Tacca) is very plentiful. The people seem to have been very industrious, and all the twenty-eight islands we visited seem to have been at some time cultivated. Compared with Mahlos Atoll, many of the islands exhibit almost as luxuriant a vegetation as Limbo Kandu, and surpass all the other islands of that atoll. Trees and shrubs are nearly the same, but Pandani, bread-fruit, and Calophyllum Inophyllum are dominant; herbaceous plants exhibit little variety in any one island. By the mosques sweet-smelling plants are much grown, poor varieties of the rose being dominant.

The stony eastern area of all these islands is generally covered with cocoanuts, which prefer such a situation. The intermediate vegetation consists of Pandani, Calophyllum Inophyllum, Hernandia peltata, and Hibiscus tiliaceus, all useful economic products.

Mahagudu and Landu are particularly noted for their great variety of economic plants; in the latter, in addition to the above, the areca palm, betel, sugarcane, maize, soursop, water melons, limes, lemons, chillies, Sonneratia acida, and bamboos being all grown in some numbers.

A few plants were collected on Landu and Mafaro islands, but only such as had apparently not been seen, or rarely been seen, elsewhere.

Tiladummati Atoll.

From the information I collected this seems to resemble Miladumadulu, but the atoll is famous for its plantains, which are exported even as far as Malé. Pandanus is much grown for sails, and Hibiscus tiliaceus for ropes. The people of this atoll formerly paid annual visits to the Malabar and South-West Indian coast. They are a very enterprising set, and have probably introduced a large number of the cultivated plants of the northern part of the group. Even now they regularly bring fresh strains of plantains from Ceylon and Southern India, as they say that their own deteriorate. One of my boys, too, from Nolewangfaro, collected quite a large number of seeds in Addu and Malé, which he intended to try when he got home.

IV.—THE MALDIVIAN NAMES OF PLANTS.

In the following table are set out in alphabetical order all the names known or supposed to be applied to plants by the Maldivians, with the plants to which they refer. Many of the names are no doubt wrongly applied, especially those given by other writers than Ibrahim Didi and J. S. Gardiner. It is remarkable how nearly all the plants of the flora have received names ; this is partly to be accounted for, no doubt, by the smallness of the flora, but suggests invention on the part of the inhabitants when questioned about the plants, such as is so troublesome to the botanical collector in Ceylon or India. The spelling of the names is given as originally written by the collector. Under the individual species above only recognized names and spellings adopted by

Mr. Gardiner or Ibrahim Didi are mentioned. In this list other names and spellings are also included.

Ahi, Morinda citrifolia
Ala, Colocasia Antiquorum
Amanaka, Ricinus communis
Anana, Ananas sativus
Annaru, Punica Granatum
Anona, Anona muricata
Asaruma, Mirabilis Jalapa
Asuraffole rai (ma), ditto
re, ditto
hudu (ma), ditto
Ata, Anona squamosa, muricata

Babukeyo, Artocarpus incisa
Bai, Eleusine Corocana
Bambakeyo, Artocarpus incisa
Bambara, unknown
Bambukea, Artocarpus incisa
Banke, ditto
Bari, Solanum Melongena
Barubo, Cucurbita Pepo
Beem magu, Oldenlandia biflora
Beembi, Eleusine Coracana
Berebedi, Erythrina indica
Bes gobili, Acacia Farnesiana, Parkia ?
Bilehhui, Ischæmum ciliare
Bilei, Piper Betle
Bilekkattala, Dioscorea, spp.
Bilimagu, Averrhoa Bilimbi
Bilinhui (Bell), unknown grass
Billaton, Piper Betle (leaf)
Billi, Piper Betle
Billikatella, Dioscorea alata
Bimbi, Eleusine Coracana
Bissagu, Acalypha fallax
Bo, Cocos nucifera
Bodu faru, Bryophyllum calycinum
Bodukafa, Gossypium barbadense
Bodu limbo, Citrus Medica
Bodu mirihi, Tithonia diversifolia
Boi, Ficus religiosa*
Bokeo, Pandanus, sp.
Borhi, Tournefortia argentea
Bulukiya, Corchorus capsularis
Burandagondi, Boerhaavia diffusa
Burubo, Cucurbita

Cadapie, Launæa pinnatifida
Cave, Acalypha fallax
Chunpápool, Artabotrys odoratissimus

Dagundi kandi, Acalypha paniculata
Dai kurandu, Barleria Prionitis
Dakada, unknown.
Dandu filia, Launæa pinnatifida
Dhadukuradi, Pemphis acidula
Dhumburi, Ochrosia borbonica
Diga, Hibiscus tiliaceus
Digga, ditto
Digutiyana, Cassia Sophera
Dikkunfati, Commelina, sp. ?
Divihe keeva, Pandanus, sp.
Diyamudoli, Commelina benghalensis
Dom (or Don) Moosa (or Moussa), Allophylus Cobbe
Dom velam buli, Cassytha filiformis
Dommadu, Terminalis Catappa
Donala, Zea Mais
Donera, ditto
Dongkeo, Musa Sapientum
Duburi (Bell), Calophyllum Inophyllum
Dugajde, Clerodendron inerme
Dugeti, ditto
Dumbu, Ficus infectoria
Dumburi, Ochrosia borbonica
Dumpai, Nicotiana Tabacum
Dunnika, Vitex Negundo

*Always called Boi-gas (gas = tree).

Emboo, Glochidion littorale
Emmuli, Oldenlandia umbellata
Eyaganawatura, Oldenlandia biflora

Faga, Momordica Charantia
Falo, Carica Papaya
Fatangu, Cæsalpinia pulcherrima
Fatunfaifila, Bryophyllum calycinum
Femfora, Areca catechu
Feru, Psidium Guyava
Fesko, Tephrosia tenuis
Fili, Ficus, sp. ?
Fini fen ma, Rosa, sp.
Fo, Areca Catechu (nut)
Foh, Adansonia digitata
Foni loli, Adenostemma viscosum
Foni tula, Ocimum gratissimum
Fuakon, Araca Catechu (nut)
Fufu, Benincasa cerifera ?
Funa, Calophyllum Inophyllum

Gadacolie, Ocimum basilicum
Gai kehabuli, Ocimum sanctum
Gakehebuli, Fleurya interrupta
Gandakoli, Ocimum basilicum
Garada, Abroma augusta
Gelavalie, Premna integrifolia
Gethawcoley, Corchorus acutangulus
Gitakoli, Pouzolzia indica
Giteyokoli, ditto
Gobili, Phyllanthus distichus
Gobu, Terminalia Catappa
Gokkuladuru, Cyperus, sp.
Gulhajaru, Pancratium, sp. ?
Gulu Sampa, Plumeria acutifolia

Hai kurudo, Barleria Prionitis
Hala veli, Suriana maritima
Halia veli, ditto
Hande riemo, Cyanotis, sp. ?
Handu, Oryza sativa
Hau (Bell) = Kuna ?
Heena, Lawsonia inermis
Heith thala, Tacca pinnatifida
Hekoopie, Desmodium triflorum
Helebeli, Tamarindus indica
Hikundi, Murraya exotica
Himeri, Phaseolus lunatus, and next
Himerri, Dolichos Lablab, and last:
Hinbatu, Thevetia neriifolia ?
Hiridigga, Corchorus acutangulus
Hirikulla, Emilia sonchifolia
Hirundu, Thespesia populnea
Hitala, Tacca pinnatifida
Hittala, ditto (Trimen, Dioscorea)
Hiti, Azadirachta indica
Hondikunavoo, Nephrolepis tuberosa
Huanduma, Jasminum grandiflorum
Hudufipila, Aerua lanata
Hudufupila, ditto
Hudu ruva, Calotropis gigantea
Hui, grasses generally
Hui ru, Mariscus Dregeanus
Hunigundifila, Lippia nodiflora
Hunigunditila, ditto
Huvaduka, Plectranthus ?
Huvadukotun, Plectranthus ?
Huvaduma, Jasminum grandiflorum
Huvago, Acorus Calamus
Huwanduma, Jasminum grandiflorum

Innapa (Pyrard), Lawsonia inermis
Irudema, Jasminum Sambac
Iroudemaus (Pyrard), ditto

Jamburool, Eugenia, sp.
Jumbu, Eugenia, sp.
Junapa (Trimen), misprint for Innapa

Kadapie, Launæa pinnatifida
Kadu, Hernandia peltata
Kadu, Cucurbita, sp. ?
Kaduru, Corchorus acutangulus
Kafa, Gossypium, spp.
Kairi, Cocos nucifera
Kala kiru, Pedilanthus tithymaloides
Kalandurugundi, Mariscus Dregeanus
Kalukadili, Eclipta alba
Kamaraga, Averrhoa Carambola
Kambulichi, Vernonia cinerea
Kanditoli, Poinciana regia
Kando, Hernandia peltata
Kandu, a Mangrove, see Rhizophora, Bruguiera, Lumnitzera
Kandufa, a mangrove swamp.
Kani, Cordia subcordata
Kara, Solanum Melongena, Citrullus Colocynthis ?
Kandolu, Rhœo discolor
Karhi, Cocos nucifera
Karhi leibu, Achyranthes aspera
Karhikeo, Pandanus, sp.
Karikeo, ditto
Karikuburu, Cæsalpinia Bonducella
Kasinji, Andropogon Nardus
Katella, Dioscorea, spp.
Kattala, Dioscorea and Ipomœa, spp.
Kave, Acalypha fallax
Keembi, Barringtonia speciosa
Kees fila, Nephrolepis exaltata
Keeva, Pandanus, sp.
Kekuri, Cucumis sativus
Keo, Musa sapientum
Kerutina, Euphorbia hypericifolia
Khari, Cocos nucifera
Kimbi, Barringtonia speciosa
Kirutina, Euphorbia, spp.
Kochchefai, Ageratum conyzoides
Konara, Zizyphus Jujuba
Kuda falo, Carica Papaya
Kuda limbo (lubo), Triphasia trifoliata
Kude, Premna integrifolia
Kudehi, Ficus, sp. ?
Kudibai, Panicum miliaceum
Kudima, Jasminum auriculatum
Kudingaybelamaw, Oldenlandia biflora
Kudingke, Phyllanthus maderaspatensis
Kudiraimaveyo, Ipomœa Quamoclit
Kudiruvali, Dodonæa viscosa
Kuhada, Cassia occidentalis
Kukulufaifila, Hibiscus Solandra
Kulitula, Ocimum sanctum
Kullafila, Launæa pinnatifida
Kullava, Sonneratia acida
Kulowa, do.
Kuna, Pycreus polystachyus
Kunnaru, Zizyphus Jujuba
Kuredi, Pemphis acidula
Kuradu do.
Kurifila, Ipomœa Turpethum
Kurra, Citrullus, sp.
Kurukuru, Dioscorea fasciculata
Kurumba, Cocos nucifera

Ladu, Mimosa pudica
Lagundi, Commelina, Gloriosa
Lami, Eugenia Jambolana
Lancimo, Andropogon squarrosus
Limbo, Citrus Medica
Los, Pisonia morindæfolia
Lunsimoo, Andropogon squarrosus

Ma ala, Alocasia indica
Mabori, Tournefortia argentea
Mabula, Abutilon indicum
Mabulan, Sida humilis
Abutilon indicum

Magu, Scævola Koenigii
Makahikeyo, Pandanus, sp. ?
Makumburuvani, unknown
Makunu hungal, Nephrolepis exaltata
Makunu fila, Portulaca quadrifida
Mala embu, Stachytarpheta indica
Ma lebu, Trichodesma zeylanicum
Maliku ruva, Vinca rosea
Manifa, Canavalia lineata
Mapijja, Sesuvium Portulacastrum
Maskando, Hernandia peltata
Maskota, Anisomeles ovata
Massagu, Amarantus viridis
Mathewa, Dioscorea, sp.?
Mativa, Dioscorea, sp. ?
Ma tumba, Barleria Prionitis
Medili, Terminalia Catappa
Medukeo, Pandanus, sp.
Medu mokaneo, Pandanus, sp. ?
Meia limbo, Evolvulus, Phyllanthus
Meia sagu, Acalypha paniculata
Midili, Terminalia Catappa
Mirajje sai, Sida carpinifolia
kochchefai, Artemisia vulgaris
Mirihi, Wedelia biflora, and see bodu-, veo-, walu-, mirihi
Mirus, Capsicum minimum
Mita bodi, Ruellia ringens
Moli, Citrus Aurantium
Munima, Mimusops Elengi
Muraga, Moringa pterygosperma
Muraki, Physalis minima
Muranga, Moringa pterygosperma
Muskotan, Anisomeles ovata
Muskundu, Hernandia peltata

Nagukandi, Hibiscus Solandra
Nanubeddi, Corchorus, Boerhaavia
Nargis, Pancratium, sp.?
Nika, Ficus, sp. ?
Nita bodi, Ruellia ringens
Nitu badi, ditto
Niyaduru, Citrus Decumana
Nunnay, Stachytarpheta indica

Okkafa, Gossypium herbaceum
Oludukattala, Ipomœa Batatas
Ona hui, Oplismenus, Apluda, sp.
Orhani, Datura fastuosa

Prumo, Psilotum triquetrum

Rábeburi, Cleome viscosa
Raidadi sagu, Amarantus caudatus
Ragundi, Cordia, sp. ?
Raigeda, Portulaca oleracea
Ranarua, Cassia, sp.
Ranaura, ditto
Ranawia, ditto
Ra rohi, Colubrina asiatica
Ra ruhi, ditto
Re asaruma, Mirabilis Jalapa
Re irudema, Jasminum Sambac
Re kandolu, Rhœo discolor
Revi, Brassica juncea
Ribu fila, Portulaca tuberosa
Riindu filia, ditto
Rua, Calotropis gigantea
Ruva, ditto

Sabudeli, Chrysophyllum, sp.?
Sagu, Amarantus, Acalypha
Sakkeyo, Artocarpus integrifolia
Sannipoo, Eragrostis plumosa
Satavaru, Asparagus racemosus
Sembu nerinchi, Tribulus terrestris
Semper Beddha, Plumeria acutifolia

Taburu, Ipomœa biloba
Talafuri, Canavalia ensiformis
Tavakarhi, Lodoicea Sechellarum
Thaburu, Ipomœa biloba

Tilo lagundi, Commelina Kurzii
Timbi, Barringtonia speciosa
Tinfaikattala, Dioscorea pentaphylla
Tora, Luffa ægyptiaca ?
Tubuli hui, Eragrostis plumosa

Udandi, Saccharum officinarum
Uni, Guettarda speciosa
 Bambusa, sp. ?
Ura, Setaria italica

Vaffufuli, Acalypha indica
Vakkunfati, Commelina, sp. ?
Varukundu, Trewia nudiflora
Vele buli, Cassytha filiformis
Veo falo, Carica Papaya
 magu, Evolvulus alsinoides
 mirihi, Convolvulus, Leucas
Veppila, Herpestis Monniera
Veyodigga, Sida humilis
Vihafilia, Indigofera tinctoria ?
Vihagiguni, Crotalaria retusa
Vihalagondi, Gloriosa superba
Viyula tari, ditto
Vihatoli, Pachyrhizus angulatus

Walu kafa, Vernonia cinerea
 mirihi, Convolvulus parviflorus
Wang, Piper Betle
Wihelia gundi, Gloriosa superba

Zaggumu, Argemone mexicana
Zoowari, Andropogon Sorghum

The meanings of some of the commoner words above are given in the following list :—

Ali, ash gray
Bodu, big
Buli, fish-hook
Dambu, dark
Digu, long
Dom, light or white
Fai, ankle, leg
Faro, a ring-shaped reef awash
Feli, cloth
Filia, thread (cotton)
Fehi, green
Fune, deep
Gas, tree
Gundi, stool
Hini, cold
Hudu, white
Huni, hot
Iru, sun
Kafa, a cloth colour
Kalu, black
Kandi, deep sea, deep passage
Kuda, small
Kuding, child
Ma (suffix), very ; flower ?
Magu, path
Noo, blue
Re, red
Riindu, yellow
Tilia, dirty
Tiri, low
Veli, sand
Walu, a well

V.—THE ECONOMIC PRODUCTS OF THE MALDIVES.

Under this head must be considered not only those plants which have certainly been introduced for purposes of cultivation, but also those which are known, though wild, to yield useful products. All the plants of the former class are printed in capitals in the list of the flora. Some plants, such as the cocoanut, though now cultivated, have probably been introduced by natural agencies. Many of the cultivated plants in the list have without doubt been introduced quite recently by Ibrahim Didi and others, and are as yet hardly to be found in the outlying islands. There has been a marked increase in the successful acclimatization of food and other plants in the last twenty years. This is largely due to Ibrahim Didi, Dorimenokiligefanu, late Chief Vizier, to whom the people owe a very great debt in this respect. The Sultans, too, have taken more interest in the matter, and the nobles at Malé at present vie with one another in the rare (*i.e.*, with regard to the Maldives) plants and shrubs growing in their compounds.

The effect of the eruption of Krakatoa in 1883 has not been sufficiently emphasized. Before then the islands had no pumice, and it was not possible to grow a large number of the food plants in many of the islands. Now plantains, &c., grow almost anywhere, a basket of pumice being placed around the roots of each.

The certainly introduced and cultivated plants of the Maldives in the list above given number (including doubtful identifications) 98, belonging to 73 genera and 33 families. Sixty-one genera and 12 families are represented by cultivated plants only.

We may classify the economic products into groups as follows, using the classification of the "Indian Agricultural Ledger" :—

Group I.—Gums, Resins, &c.

There are several trees in the flora which are elsewhere used for the source of gums and resins, but we have no record of any being used by the Maldivians. Such are Azadirachta, Acacia Farnesiana, Bread-fruit, Mango, Moringa. The saps of bread-fruit, mangrove, and Barringtonia are used for caulking boats with coir or native cotton, the whole mixed with soot of cocoanut husks or preferably of Barringtonia fruits.

Group II.—Oils, Perfumes, &c.

The chief oil used in the islands is of course that of the cocoanut. Castor oil is sometimes used as a purgative. Calophyllum Inophyllum oil is used as an ointment. The Margosa has lately been introduced.

Perfumes are obtained from the flowers of the Jasmine, Plumeria, rose, basil, and probably others, such as Guettarda, &c., and also from the Khus-khus and Citronella grasses.

Group III.—Dyes and Tanning Stuffs.

The principal source of dye seems to be the root of the Ahi, Morinda citrifolia, from which they prepare the red dye used for mats, &c., by mixing a decoction with lime. A black dye, sometimes used in the mats, is made by boiling gallnuts and rusty iron together in cocoanut water (Bell), but the deepest black is made from plantain sap. A deep black is made from Mangrove mud, and lighter shades to brown from Mangrove sap. Black is also obtained by mixing cocoanut shell charcoal with oil. Lacquer work is carried on only in Turadu (S. Mahlos); the lac and colours used are obtained from Calcutta. The flora also includes Indigo and the Chay root (Oldenlandia umbellata), but these are not now used as dyes. Henna is not uncommon. Of tanning substances there appear to be none in use, fish skins, &c., being simply stretched and dried; there are several possible sources, such as Mangroves, Cassias, &c. [The only mammals are a bat, a rat, and a mouse, with a few semi-wild white rabbits.]

Group IV.—Fibres.

The chief fibre in use is of course coir. Like the Laccadives, the islands produce a very fine quality of this fibre, light in colour, fine, and strong, which brings a high price in the market, and is exported in large quantity. The best quality is made in Addu Atoll, where the fibre made is longer.* The fibre of Hibiscus tiliaceus, the Diga, and of Hernandia peltata, also bread-fruit sometimes, is used for ropes and lines and for sails. Cotton is cultivated to a slight extent, and a certain amount of cloth is made in Mahlos and Addu, and perhaps elsewhere. Several other fibre-yielding plants, such as Corchorus, Calotropis, &c., exist in the flora, but we have no information as to their actual use, if any. In the southern atolls a great industry is carried on in the making of the fine Maldivian mats, of their kind about the finest in the world, beautifully woven, in tasteful patterns, and dyed with very fast colours, black, white, and brown-yellow. The chief source of material is the kuna, Pycreus polystachyus, a common sedge in Ceylon, where however it does not appear to be utilized. Fimbristylis spathacea is also used. These mats were formerly used for sarongs. The weaving of cloth in the Maldives may have been derived from that of these mats.

The leaves of Pandanus (*q.v.*) are used for mat- and sail-making.

Group V.—Drugs.

The only known plants of the flora from which drugs are recorded as used in the above list are Calotropis, Ricinus, Calophyllum, and Rhœo, but probably many others, *e.g.*, Croton, Azadirachta, Vitex, are used. "Internal medicines are very little used, being regarded as contrary to the Koran. (Allah willed the sickness, perhaps as a punishment for sin, and it is useless to strive against it.) There has always been a small class of witch doctors (men), who prepare draughts, but these are mere decoctions over which a charm has been wrought, and not medicines. More definite ideas prevail in the southern atolls, particularly Suvadiva, where I have no doubt that all the above and many more are used."—J. S. G.

* I understood that an especially long nut was grown in Addu for this purpose ; I saw some which appeared to be merely selected examples of the Khari, but my information would lead me to believe that there is an especial variety which gives little oil but excellent coir.—J. S. G.

Group VI.—Foods and Edible Products.

Taking first the cereals and other staples, we find that the bulk of the rice used is imported from Bengal. Bimbi, Eleusine Coracana, is a good deal cultivated, and occasionally some of the millets, Panicum miliaceum and Setaria italica, and a little maize. The cocoanut, as in other tropical countries, provides many of the necessaries of life. Of root crops, half a dozen kinds of true yams (Dioscorea) are grown, as well as the sweet potato, the cassava or tapioca, and Colocasia and Alocasia. The root of Tacca furnishes food in times of scarcity. Of pulses, there are Dolichos Lablab, Pachyrhizus angulatus, Phaseolus lunatus, and Canavalia ensiformis, all common beans of Ceylon and Indian cultivation. Mangrove rootlets are often eaten.

Of spices, arecanut is both cultivated and imported, betel, pepper, and chillies are grown, and a little black pepper. Murraya and Brassica are recent introductions.

Sugar cane is cultivated to a slight extent, and some of the Amaranti are perhaps used as potherbs. Tobacco is occasionally cultivated.

Of fruits, eaten raw or in curries, there is a fairly long list. The most important are in order : the papaw, bread-fruit, pumpkin, plantain, pomegranate, lime. Orange, lemon, shaddock, watermelon, soursop, guava, cucumber, pineapple, &c., are also frequent, and custard apple, carambola, blimbing, jambu, jak, brinjal, mango, &c., have been introduced. The wild or semi-cultivated fruits of Triphasia, Zizyphus, Allophylus ? Tamarind, Terminalia, Sonneratia, Physalis, Pandanus are also eaten. The cocoanut has already been mentioned.

Murraya (rare) and Moringa are cultivated as curry stuffs, and Premna is perhaps also used. Coffee and sugar are imported, but sugar is principally made from cocoanut sap (ra). No alcoholic drinks are known. Coffee is used by everyone who can afford it, tea by only a select few who have learnt the habit in India or Ceylon.

Group VII.—Timbers.

Timber is not plentiful in the islands, and some is at times imported. Practically every possible tree is used for timber. Kuredi (Pemphis) is used principally for firing. Good houses, boats, and other things are constructed from the cocoanut wood. Pandanus is used in a temporary house. Flooring is made of any light wood. Among the list of plants in the islands given above there occur the following which have more or less useful timber: Gyrocarpus, Barringtonia, Scævola, Chrysophyllum ? Mimusops, Cordia, Premna, Vitex, Pisonia, Hernandia, Ficus spp., Artocarpus spp., Bamboo.

Ornamental Plants.

Pyrard de Laval records the islanders as very fond of bright and sweet-smelling flowers,* but the number upon the list above is very small, and there are many which one would expect to have found which are absent from the list. To enumerate them in systematic order, there are : (i.) common everywhere, Cassia Sophera (possibly not cult.), rose, Guettarda speciosa (wild), Jasmines, Vinca rosea, Plumeria acutifolia, Ocimum spp., Mirabilis Jalapa, &c. ; (ii.) occasionally cultivated, Artabotrys ? Gynandropsis (wild), Hibiscus Rosa-sinensis, H. Abelmoschus ? Abroma augusta, Clitoria, Cæsalpinia pulcherrima, Poinciana, Acacia Farnesiana, Passiflora cœrulea, Panax, sp. ? Aralia Guilfoylei, Tithonia diversifolia, Thevetia, Ipomœa Quamoclit, Datura suaveolens, Clerodendron fragrans, Antigonon Leptopus, Bougainvillæa spectabilis, Celosia, Amarantus caudatus, and others. Many are quite recent introductions and found only in Malé Atoll.

For a people fond of flowers, the list, even considering the unfavourableness of the soil and climate to gardening, is a small one.

* They certainly care for the scent, not the prettiness, now. I doubt Pyrard here, and think he must have got confused with his later experiences in India. There is nothing to show that the people ever attained this pitch of civilization.—J. S. G.

Comparing the list of cultivated plants in the Maldives with that of the Laccadives and Minikoi,* we find that it is much larger, as might be expected from the greater size, wealth, &c., of the group, containing at least 46 species that do not occur in the northern islands. It contains about 98 species, as against about 58. Among the 12 species found in the northern group not cultivated in the Maldives are Annatto, Ægle Marmelos, Ground-nut, Cowpea, Physalis peruviana, Phyllanthus Emblica, Agave vivipara, and a yam. Among the Maldivian plants not cultivated in the Laccadives or Minikoi are Custard apple, Carambola, Blimbing, Zizyphus, Jujuba ? Roses ? Plumeria, Brinjal, Tobacco, Cassava, Ficus religiosa, Pineapple, some yams, &c. Some of these, *e.g.*, Zizyphus, probably were introduced from the West, whence much of the native stock came to the islands, others, *e.g.*, Plumeria and Ficus religiosa, probably owe their introduction to pre-Islamic times, prior to the arrival of Arab, Malay, and possibly Persian settlers.†

VI.—THE ORIGIN OF THE FLORA.

The flora of the islands is undoubtedly recent and derived from abroad. We must now proceed to deal with the question of the sources from which it was derived, and the manner in which it reached the islands.

Plants introduced unintentionally by Human Agency.

The paths of human migration and trade, all over the world, are marked by weeds that have accompanied the wanderers or been carried in the articles of trade, unintentionally, but none the less certainly. Going over the above list of the flora there can be little doubt that at any rate the

* This may be partly due to the hurricanes which at times sweep the latter islands, destroying and washing away many plants.

† There is no evidence (*sensu stricto*) of Buddhism, though there is of Hinduism, in the Maldives. *Cf.* Gardiner : The Natives of the Maldives, Proc. Camb. Phil. Soc., XI., 1900, p. 17.

species mentioned in the following list have reached the Maldives in this manner. Many probably have come in the bags of imported rice, others attached to articles of clothing or to packages, others in the earth attached to the roots of imported plantains and other useful plants, and in similar ways dependent on man. Species in brackets occur in the Laccadives, Minikoi, or Diego Garcia, but not in the Maldives :—

Argemone mexicana
Cleome viscosa
Gynandropsis pentaphylla
Polygala erioptera
Sida humilis
Abutilon indicum
Hibiscus Solandra
Corchorus acutangulus
Tribulus terrestris
Crotalaria retusa
(verrucosa)
(Indigofera cordifolia)
Cassia occidentalis
Tora
glauca
auriculata
Mimosa pudica
(Passiflora suberosa)
Spermacoce ocymoides
Hewittia bicolor
Evolvulus alsinoides
(Linaria ramosissima)
Ruellia ringens
Justicia procumbens
Rungia parviflora
(linifolia)
(Peristrophe bicalyculata)
Anisomeles ovata
Leucas biflora
zeylanica
(aspera)
Amarantus spinosus
Euphorbia hypericifolia
Phyllanthus maderaspatensis
Urinaria
Niruri
(rotundifolius)
(Claoxylon Mercurialis)
Acalypha paniculata
indica
fallax
Fleurya interrupta
Pouzolzia indica
(Aneilema ovalifolium)
Commelina benghalensis
Kurzii
Cyanotis cristata
(Oplismenus Burmanni)
compositus
(Setaria verticillata)
Ischæmum ciliare
Apluda varia
(Cynodon Dactylon)
(Andropogon contortus)
Eleusine ægyptiaca
(indica)

A total of 56 species, of which 41 occur in the Maldives proper. They represent 41 genera and 18 families, of which 28 genera and 4 families are represented in this list alone, taking all the islands, or 23 genera and 4 families of the Maldive flora only.

Now let us examine into the local distribution of these species, as given in detail above. Dividing the islands into the following groups : The Chagos, Southern Maldives (Addu and Suvadiva Atolls), Central Maldives (Haddumati to Malé Atolls, south of the Kardiva Channel), Northern Maldives (north of the Kardiva Channel), Minikoi, Western Laccadives (the chain including Akati and Bitrapar), Central Laccadives (Kiltan, Kadamum, Ameni, &c.), and Eastern Laccadives (Anderut, Kalpeni, &c.)—we have—

	Chagos.	S. M.	C. M.	N. M.	Mkoi.	W. L.	C. L.	E. L.
Species cert.	2	12	38	26	21	21	30	9
prob.	—	14	2	7	—	—	—	—
Total ...	2	26	40	33	21	21	30	9

In the first line are given only those species of which we have a certified record of occurrence ; in the second are given, for the Maldives only, those species which are so common elsewhere in the group that their occurrence is probable, *e.g.*, Abutilon indicum, Cassia Tora, Evolvulus alsinoides, Fleurya interrupta, Ischæmum ciliare, for the Southern Maldives. The figures for the Chagos are certainly incomplete, owing to Mr. Hemsley having excluded this class of plants as far as possible. If we examine the remainder, we arrive at the following conclusions :—The greatest number of weeds of this class is to be found at the centres of maximum traffic and commerce, *i.e.*, the central islands of each group. Many of the 40 species recorded for the Central Maldives are found in Malé or Malé and Hulule (close by) only, and the number decreases as we pass to the outlying islands. In the Eastern Laccadives, though so near to the Indian coast, we find only a few species. Malé is not the only point to which traffic comes : the northern and southern atolls (see above, Tiladummati, &c.) have a certain amount of direct communication with India, which has caused introduction of some weeds not known in Malé. Leaving Diego Garcia out of consideration, in which the weeds are of Seychelles or cosmopolitan types, we find that the weeds are, as a rule, the commonest weeds of India and Ceylon. Poygala erioptera is the only Maldivian weed not known in Ceylon, but is common in India. There is a considerable direct trade between Malé and Calcutta, to which is probably due the introduction of many Indian weeds.

Taking Maldives and Laccadives together, the commonest and most widely distributed of these weeds are probably Sida humilis, Abutilon indicum, Anisomeles ovata, Phyllanthus maderaspatensis, P. Niruri, Acalypha indica, A. fallax, and Oplismenus compositus, each of which occurs in at least six of the seven divisions made above.

The number of these weeds is greater on the more cultivated islands; their presence is largely dependent on cultivation. There are only a few of them on the wilder islands where there is less traffic, less cultivated ground, and greater competition with other plants. Most of the species occur in more than one of the divisions, and are often distributed in such a way as to indicate having spread from one spot in each archipelago or group. All the Maldivian weeds occur in Malé or Goifurfehendu Atolls, with the exception of Hewittia bicolor, recorded only from Mahlos. The following islands have fairly complete floras, and show the following numbers of introduced weeds of this list: Malé 27 at least, Hulule 13, Hedufuri (S. Mahlos) 16, Goifurfehendu Atoll 17, Veimandu (Kolumadulu) 13.

Species probably introduced by Birds.

All previous investigations tend to show that the agency of birds in providing distant islands with plants is a comparatively unimportant one, so far as number of species is concerned. In the case of plants with fleshy fruits, whose seeds are afterwards dropped, it is evident that in general only islands lying at comparatively short distances can be reached, but in the case of fruits or seeds sticking by means of hooks or gum, or enclosed in mud pellets attached to the feet, greater distances may be traversed. Let us take the fleshy-fruited plants first. Of these we have the following :—

(Flacourtia Sepiaria)	(Solanum torvum)
(Pleurostylia Wightii)	Physalis minima
Zizyphus Jujuba	Datura fastuosa
Colubrina asiatica	Lantana mixta
Vitis Linnæi	Premna integrifolia
(quadrangularis)	Vitex Negundo
(carnosa)	Cassytha filiformis
Allophylus Cobbe)	Ficus benghalensis
Sonneratia acida	infectoria
(Cephalandra indica)	Retusa
(Pavetta indica)	sp.
Morinda citrifolia	Asparagus racemosus
Ardisia humilis	

Of these 25, it is all but certain, as we have seen above, that Zizyphus, Allophylus, Physalis have been intentionally introduced for cultivation. The occurrence of Vitis Linnæi is very doubtful. Colubrina, Sonneratia, Morinda, Cassytha, Premna, and Ardisia are littorals which may be introduced by sea currents, though when once introduced they may be further spread by birds. Datura fastuosa and Solanum torvum are common cultivation weeds. The Asparagus is almost certainly intentionally introduced, as it only occurs in Malé, and has the same name as in India and Ceylon, and there are doubts about Vitex and the Fici. We can thus only accept as almost certainly introduced by means of seed-dropping by birds the following species :—Flacourtia, Pleurostylia, Vitis two spp., Cephalandra, Pavetta, Lantana, seven in all, belonging to six genera and six families. Of these, five occur only in the Eastern and Central Laccadives near to the mainland of India, one occurs only in the Western Laccadives, one only in the Northern Maldives. We may therefore reasonably conclude (i.) that there is a fair amount of evidence that plants may be carried by birds in their intestinal canals from India to the nearer Laccadives, a distance of 100–150 miles, and possibly from Ceylon to the Maldives, a distance of 350–400 miles ; if this occurred, it must have been in the north-east monsoon, when the wind may travel in the necessary direction 250 or more miles in the day ; (ii.) that there is no evidence to show that this method of transport has certainly carried plants over wider distances than 400 miles and probably even 350 ; (iii.) that when once introduced by any means, plants with fleshy fruits may very probably be largely distributed among the islands by birds, many of the fleshy-fruited species above mentioned being very widely scattered among the islands.

Pass on now to the carriage of seeds attached by claws or hooks to the feathers of birds. The evidence that this carriage ever takes place in nature is small, but there are a few known probable cases. In the flora above enumerated, the following are possibilities :—

Sida carpinifolia	(Plumbago zeylanica)
(Urena sinuata)	Boerhaavia diffusa
Desmodium triflorum	Pisonia aculeata
Adenostemma viscosum	morindæfolia
(Bidens pilosa)	Achyranthes aspera

Any or all of these may obviously just as likely have been introduced by man, attached to clothing or other articles. Taking the list for what it is worth, we find that Sida and the Pisoniæ occur in the Maldives only, Bidens, Urena, and Plumbago in the nearer Laccadives, and the others through both groups. Boerhaavia and Pisonia are very probably sea-borne. So far as this evidence goes, therefore, it shows the same results as that of the dropped seeds.

Now, take the case of the plants with seeds or fruits so small that they may be carried in mud pellets attached to the feet of birds. This evidently applies mainly to the plants of wet places with muddy ground, not so much to sandy soil. We thus get the following list :—

Portulaca oleraceaa	Wedelia calendulacea
quadrifida	Herpestis Monniera
tuberosa	(Striga lutea)
(Ammannia baccifera)	Lippia nodiflora
Sesuvium Portulacastrum	(Polygonum barbatum)
Eclipta alba	Euphorbia pilulifera

as well as the following possible grasses and sedges :—

Pycreus polystachyus	(Oplismenus Burmanni)
(Fimbristylis diphylla)	compositus
(glomerata)	Apluda varia
Cladium Mariscus	Eleusine ægyptiaca

Of these 20, other observers have shown that there is a probability of sea carriage in the case of the Portulacas, Lippia, and possibly some of the others. Leaving out those mentioned, we find Ammannia baccifera, Polygonum barbatum, and Fimbristylis diphylla confined to the Eastern Laccadives, F. glomerata to Diego Garcia, while the rest are mostly widely spread among the archipelagos, except Cladium, which is confined to the extreme south. Cladium occurs in the African islands to the west, and is not found in India proper or in Ceylon. We cannot therefore say that we have any evidence for carriage of seeds by attachment to feet of birds which is unimpeachable, but we may say that there is a slight amount of evidence in favour of the possibility, and that if this evidence be ever proved true, it supports, as does that of the dropped seeds and the hooked fruits or seeds, the view that the transport is of few species, and over comparatively short distances, usually not exceeding 200 miles. The poverty of the islands in land shells is another argument against extensive transport by birds. The birds of the group are not such as to lead one to believe that they ever had any marked influence in bringing plants to the Maldives. The hooded crow is found in every inhabited island, and every shore has at times sand-snipe, curlew, and plover. A rail is found in the densest bush, and seabirds—terns, boatswains, &c.—are found everywhere. Of migrants, a few of the swallow family winter in the Maldives, together with several species of kite and owl, and a roller in considerable numbers ; green parrots, too, the only truly graminivorous forms, are occasionally seen.

The flying-fox, Pteropus medius, hangs in enormous numbers during the day from nearly every banyan in the group, and must be of importance in distributing these, and probably other species, among the islands.

Transport of Seeds, &c., by Wind Agency.

On land and for short distances,* this is one of the most important of transport agencies, but very little evidence has as yet been collected to show that it is the means of carrying many seeds or plants across wide stretches of sea. Looking through the lists of plants above, the only fairly certain cases of wind transport are those of the spores of the ferns and Psilotum, including the following species :—

(Asplenium æquabile)	Thamnopteris Nidus
(longissimum)	Nephrodium molle
(falcatum)	(unitum)
Nephrolepis exaltata	(Pteris marginata)
(tuberosa)	Psilotum triquetrum
(cordifolia)	

Of these, five, one of which is an endemic species, are confined to Diego Garcia, one to Minikoi, one to the Eastern Laccadives, and the others are fairly widely scattered among the islands. We may thus conclude that there is no distance by which any of these islands are separated from one another or from the mainland or other islands, which is too great for the transport of cryptogamic spores by wind. It must be remembered that the soil and climate of most of the islands are not highly favourable to cryptogams. Treub, in his interesting paper on the new flora of Krakatoa, has shown how the ferns are about the first vegetation to appear, and has drawn from his observations the conclusion that in the colonization of distant oceanic islands, other than mere banks or small reefs, with plants, the ferns must take a great part, and form a large part of the vegetation, conclusions borne out by the actual composition of the floras of Juan Fernandez and Ascension. Passing on to the more problematic cases of wind transport, we have the case of the two

* *Cf.* Willis and Burkill : The Flora of the Pollard Willows near Cambridge, Proc. Camb. Phil. Soc., 1893.

Asclepiads, Tylophora asthmatica and Leptadenia reticulata, found in the Laccadives, and a third, Asclepias curassavica, in Diego Garcia. The presence of the first, which is widely spread in the islands, may be due to intentional introduction, as its root is a valued medicine, used as ipecacuanha, but there is a chance that the second may have been introduced by wind, and thus have been carried about 150 miles. Asclepias curassavica may have been carried to Diego Garcia by wind, but is a cosmopolitan tropical weed wherever cultivation occurs.

Lastly, there are the pappose Compositæ, but with regard to all these, which, as a glance at the list will show, are the commonest of Indian weeds, there is at least as much likelihood of accidental introduction through the agency of man, and no deductions as to wind transport can be based on their presence, though their commonness in the islands is no doubt partly due to their easy local transport by wind.

Another argument against any great transport by wind is the poverty of the insect fauna of the islands. The north-east monsoon brings a few butterflies and other insects from India, so that it is possible that some of the parachute seeds or fruits, *e.g.*, those of Asclepiads or Compositæ, may be carried over also.

Introduction of Plants by Ocean Currents.

Of all the agencies in the stocking of oceanic islands, this is the most important, and it has been fully described by Schimper,* Hemsley,† and others. Many, especially the most widely distributed, of the littoral plants of the tropics are provided with admirable adaptations for the floating of their seeds or fruits over long stretches of sea. There is no need to go into details here with regard to these mechanisms. We shall merely extract from the lists of plants of the Laccadives, Minikoi, Maldives, and Chagos the species about

* Die Indomalayische Strandflora. Jena, 1891.

† Botany of the Challenger Expedition, Vol. I., 1885.

which there can be practically no doubt that they have been introduced in this way. These are :—

Calophyllum Inophyllum
Hibiscus tiliaceus
Thespesia populnea
Suriana maritima
Dodonæa viscosa
Canavalia lineata (obtusifolia)
(turgida)
Vigna lutea
Sophora tomentosa
Cæsalpinia Bonducella
(Afzelia bijuga)
Acacia Farnesiana
Rhizophora mucronata
Bruguiera caryophylloides
Terminalia Catappa
Lumnitzera racemosa
Barringtonia speciosa
Pemphis acidula
Guettarda speciosa
Wedelia biflora
Launæa pinnatifida
Scævola Koenigii
Ochrosia borbonica
Cordia subcordata
Tournefortia argentea
Ipomœa grandiflora
denticulata
biloba
Clerodendron inerme
Aerua lanata
Hernandia peltata
(ovigera)
Euphorbia Atoto
Agyneia bacciformis
Crinum asiaticum
Pancratium zeylanicum
Gloriosa superba
Pandanus odoratissimus ?
Mariscus Dregeanus
Spinifex squarrosus
Thuarea sarmentosa
Eragrostis tenella
(Lepturus repens)

A total of 43 species, representing 39 genera and 24 families, of which 39 species, 37 genera, and 24 families are Maldivian.

Of these 43 species, only 36 occur in Ceylon, and only 30 and 29 on the Malabar and Coromandel coasts of Southern India respectively (or 39 in Ceylon and Southern India together), so that it is evident that the sea-borne flora of the islands at any rate is derived in part from other countries than those nearest to them. We may best consider the origin of this flora by dealing first with the effects likely to follow from the directions of the currents and winds at different seasons. Reference to any atlas of physical geography will show these ; a good current map forms Plate I. in Schimper's work, and the map at the end of this paper gives the currents for the western half of the Indian Ocean.

Consider first the wind. South of latitude 10° S. the south-east trade blows throughout the year. North of this is the monsoon region, in which from April to September there blows the south-west monsoon of India and Ceylon, and from October to March the north-east monsoon. South of the equator the wind is south-east, at the equator about south, and north of the equator it is south-west to west. In the other monsoon the wind is north-east over Ceylon, northerly nearer to the equator, and north-west to the south of it.

Now consider the currents. The great equatorial current flows all the year round in a westerly direction, passing through the Malay Archipelago (especially between Java and New Guinea and Australia), and crossing the Indian Ocean south of the equator. It splits south of the Chagos Archipelago, the northern half going round the Seychelles and returning along the equator to Sumatra. Part of the southern stream reaches and rejoins this *viâ* the Mascarene Islands and Madagascar. North of this constant stream in the trade-wind region are the variable currents of the northern Indian Ocean, which change with the monsoons. In the south-west monsoon the currents run in general to the east, in the north-east monsoon to the west, round the Arabian Sea and the Gulf of Bengal, as shown on the maps.

Now consider the probable results to be expected in a long period of time during which these causes work together. The equatorial westerly current, aided by the south-east trade-wind, will carry to the Seychelles all or nearly all those littoral species of the southern parts of the Malay Archipelago and North Australia which have adaptations good enough to carry them safely over the long distance. On the way a few species may be left in the Chagos Archipelago, but these islands do not lie in the main course of the current, nor offer any great intercepting area. The return current will carry the littoral flora of the Seychelles to some extent to the Chagos, and also to Sumatra, whence it may spread a little into the Malay Archipelago. During the south-west monsoon the water north of this is also moving eastwards, and aided by the wind may carry the Seychelles plants to the Maldives and even to the south of Ceylon, whence the current flows round the Bay of Bengal to the Malay Peninsula and the Andamans. Other currents during this monsoon may carry the plants of the Seychelles by longer routes to the Laccadives and the Malabar Coast, and bring with them a few from the coasts of Africa and Arabia. On the change of the monsoon and the currents, the plants of the Malay Peninsula may be carried to the Coromandel Coast, Ceylon, and the Maldives and Laccadives, more reaching the more southerly islands through which the main stream goes. The same streams and winds may carry a few Ceylon and Indian and African forms to the Seychelles.

We may therefore expect, on the whole, to find the following results after the lapse of a long period of time. The littoral sea-borne flora of the Seychelles will consist of a large number of the more southern Malayan forms, with a sprinkling of species from East Africa, Madagascar, Arabia, and India. Many of these will also reach Diego Garcia and the other islands of the Chagos group, whilst owing to the much greater intercepting area of the Maldives most of the Seychelles littoral flora will in all probability reach those islands during the south-west monsoon, which may also bring a few African or Arabian forms, and during the north-east monsoon many of the northern Malayan forms will reach the east and south of Ceylon and the Maldives, while a few Ceylon and south-west Indian forms may also be carried to the latter. The Maldives lying much more in the track of the currents and nearer to the sources of supply will have a richer flora than the Laccadives, so far as the littoral sea-borne plants are concerned, and also, when we consider the currents and the greater strength of the south-west monsoon, a richer flora than Ceylon in the Seychellan (*i.e.*, chiefly South Malayan) and even perhaps in the North Malayan types. If we examine the actual statistics of the distribution of the flora of the islands, we shall find them in pretty fair general accordance with these views. It would lead too far to go into the details of the littoral sea-borne flora of the Seychelles in this paper, but in general it is of the Malayan type, especially the southern type, with a sprinkling of other forms.*

Of the 43 species enumerated above, Afzelia bijuga and Hernandia ovigera are found only in Diego Garcia; both of these are Seychellen plants, and the former at any rate also Malayan. Of the whole number, 20 are Polynesian, 34 or more occur in the Malay Archipelago, 36 in the Malay Peninsula; of the last-named, 25 also reach the coasts of Burmah; 30 occur on the Malabar, 29 on the Coromandel Coasts of the Indian Peninsula, while 36 occur in Ceylon, many of them only on the southern coasts; the Maldives have 39, Minikoi 29, the Laccadives 22; 32 or perhaps 34 occur in the Seychelles, Madagascar, and Mascarene Islands, 14 in Diego Garcia.

All the Diego Garcia species occur in the African Islands, and all, except perhaps Hernandia ovigera, are Malayan; there is no difficulty in accounting for the origin of the flora on the views given above as to the distribution of plants by the currents and winds. Turning to the Maldives, and dividing the group as before into South, Central, and North Maldives, we have in each of these about 37 species, and in the whole Archipelago 39. The species peculiar to the South Maldives are Agyneia bacciformis, Pancratium zeylanicum, and perhaps Lumnitzera racemosa, the first occurring in the African Islands, Malay Peninsula, and Ceylon,

* I find in my notes that I saw three Ceylon or Malay outrigger boats cast up, one buoy, and one Malay pran. I also passed a catamaran when going down in October, about 30 miles east of Fadiffolu Atoll.—J. S. G.

The well known double cocoanut or Coco-de-mer of the Seychelles was formerly called Cocos maldivica, its fruits being so frequently cast ashore in the Maldives.

so that its actual immediate source can hardly be determined; the second occurring in the Malayan region and Ceylon, but not in the African Islands, and turning up also in Minikoi; while the third occurs in the Malay Peninsula, Ceylon, and East Africa, though not in the African Islands. In the Central and Northern Maldives, though apparently not in the Southern, we find Canavalia lineata (Malaya, African Islands, Ceylon) and Gloriosa superba (Malaya, Eastern Africa, Ceylon). The whole group of Maldives contains four species, or including the Chagos, Laccadives, and Minikoi, seven species not found in Ceylon, but all of which occur in the African Islands and the Malayan region, viz., Canavalia turgida, Vigna lutea, Cæsalpinia Bonducella, Afzelia bijuga, Acacia Farnesiana (planted in Ceylon), Terminalia Catappa (ditto), and Hernandia ovigera (? Malayan).

We shall therefore probably not be far wrong if we assume that the littoral sea-borne flora of the Chagos-Maldive-Laccadive Archipelago is chiefly Malayan in composition, partly derived directly by the currents in the north-east monsoon, partly indirectly by the currents in the same monsoon (aided by the wind) from Ceylon or Southern India, and partly by the currents and wind in the south-west monsoon from the Seychelles, from which or from other parts of the Arabian Sea the few non-Malayan forms, such as Launæa pinnatifida, have been obtained. The main track of the transporting agencies leads through the Southern Maldives, which have in consequence the richest flora, while the flora of the Laccadives is comparatively poor, in fact poorer in these widespread forms than that of the Malabar Coast. As this point may be raised as an objection, let us briefly consider the Malabar flora. Thirty of the 43 enumerated species occur in it, against 22 in the Laccadives and 29 on the Coromandel Coast. The two Malabar plants not known to occur on the latter are Ipomœa grandiflora and Euphorbia Atoto, both found in the Laccadives and Ceylon, and possibly carried from the former to the Indian Coast rather than in the reverse direction or from Ceylon. Of the 12 species not known from the Laccadives, 11 occur all round the Indian and Malayan Coasts, and may have travelled by land, while the remaining one, Pemphis acidula, has probably been derived from Malaya by the currents of the north-east monsoon bringing it to the Coromandel Coast. The Laccadives, on the other hand, have Tournefortia argentea, Hernandia peltata, Thuarea sæmentosa, Lepturus repens, which do not occur on the Malabar Coast, nor indeed in India at all.

Many of the Malayan and Seychellan forms are abundant in the Maldive Islands, but rare in Ceylon, showing that the main track of distribution passes south of Ceylon. Such are Suriana, Guettarda, Ochrosia, Cordia, Tournefortia, Ipomœa denticulata, Lepturus repens.

Forms whose Mode of Introduction is uncertain.

There still remain upon the list the following forms whose presence has to be accounted for. After each name are placed letters indicating in order of probability the agencies by which means it may have reached the islands. Species probably introduced for cultivation are marked C, those unintentionally introduced by man M, those probably brought by sea currents S, those by birds B, those by wind W :—

Tinospora cordifolia, M, C
Brassica juncea, C, M
Portulaca tuberosa, B, S
 oleracea, B, S, M
 quadrifida, M, B
Sida carpinifolia, B, M
(diffusa), B, S, M
(Urena sinuata), B, M
Hibiscus Abelmoschus, C, M
Adansonia digitata, C, S
Corchorus capsularis, C, M
(Triumfetta procumbens), M, B, S
Triphasia trifoliata, C, M, B
Zizyphus Jujuba, C, M, B
 sp. ? M, C
Colubrina asiatica, B, S
Vitis Linnæi, B, C, M
Cardiospermum Helicacabum, S, M
Allophylus Cobbe, C, B
Indigofera tinctoria, C, M
Tephrosia tenuis, M, S
 purpurea, M, S
(Sesbania aculeata), M, S
Desmodium umbellatum, M, S
 gangeticum, M, S
 triflorum, M, S, B

Erythrina indica, C, S
(Phaseolus calcaratus), C, M
Cæsalpinia Bonduc ? S
Cassia Sophera, S, M
Adenanthera pavonina, C, M, S
Bryophyllum calycinum, M, C
Lumnitzera coccinea ? S
Gyrocarpus Jacquini, S, C
(Ammannia baccifera), B, M
Sonneratia acida C, S, B
Sesuvium Portulacastrum, S, B
(Dentella repens), M, B,
Oldenlandia corymbosa, M, B, S
(diffusa), M, B, S
umbellata, M, B, S
biflora, M, B, S
Morinda citrifolia, S, B
Vernonia cinerea, M, W
Adenostemma viscosum, M, B, S
Ageratum conyzoides, M, W
(Blumea laciniata), M, W
membranacea, M, W
Eclipta alba, M, B
(Wedelia calendulacea), M, B
(Bidens pilosa), M, B
(Crepis acaulis), M, W
Tithonia diversifolia, C, M
Artemisia vulgaris, C, M
Emilia sonchifolia, M, W
Lactuca sp ? M, W
(Plumbago zeylanica), M, B
Ardisia humilis, S, B
Chrysophyllum ? S, B
Mimusops Elengi, C, B
Vinca rosea, M, C
Calotropis gigantea, C, M
(Tylophora asthmatica), W, C
(Asclepias curassavica), M, W
(Leptadenia reticulata), W, M
Trichodesma zeylanicum, M, S
Ipomœa Turpethum, C, M. S
(sinuata), C, M
Convolvulus parviflorus, S, M
(Solanum torvum), M, B
Physalis minima, B, C, M
Datura fastuosa, M, C, B
Herpestis Monniera, B, M
(Striga lutea), B, M
Barleria Prionitis, C, M
Lippia nodiflora, S, B
Stachytarpheta indica, M, C
Premna integrifolia, B, S
Vitex Negundo, B, C, S
Ocimum basilicum, C, M
gratissimum, M, C
sanctum, C, M
Plectranthus zeylanicus ? M, C
Boerhaavia diffusa, B, S
(repens), M, B
Mirabilis Jalapa, C, M
Pisonia aculeata, B, S
morindæfolia, S, B
Celosia argentea, M, C
Amarantus gangeticus, C, M
viridis, C, M
Nothosærua brachiata, S, M
Achyranthes aspera, M, B, S
(Polygonum barbatum), B, M
Cassytha filiformis, S, B
Euphorbia pilulifera, M, B
thymifolia, M, B
Glochidion littorale ? S, M
Trewia nudiflora ? C, M
Ficus benghalensis, B, C
infectoria, B, C
retusa, B, C
sp. ? B, C
(Casuarina equisetifolia), S, C
Tacca pinnatifida, S, C
(Dioscorea bulbifera), C, M
Pancratium, sp. ? S, C
Asparagus racemosus, C, B, M
Commelina, sp. ? M, C
Rhœo discolor, C, S
Cocos nucifera, S, C
Pandanus, sp. ? S, C
sp. ? S, C
Pycreus pumilus, M, S
polystachyus, S, M, B
(Cyperus compressus), M, S
(pachyrhizus), M, S
(ligularis), M, S
sp., M, S
Mariscus albescens, S, M

(Kyllinga brevifolia), M, S
(monocephala), M, S
Fimbristylis spathacea, S, M, B
(diphylla), S, B
(glomerata), S, B
Cladium jamaicense, B, S, M
Paspalum sanguinale, S, M
(Panicum trigonum), M, S
Stenotaphrum complanatum, S, M
Zoysia pungens, S, M
Ischæmum muticum, S, M
Cycas circinalis, S, C

These represent a total of 132 species, belonging to 103 genera and 45 families, of which 101 species, 82 genera, and 41 families are Maldivian. If we group them according to the first-mentioned means of distribution in each case, we get—

	Whole List.	Maldives only.
Cultivated ?	29	26
Introduced by man ?	50	32
Introduced by sea ?	30	27
Introduced by wind ?	2	—
Introduced by birds ?	21	16
	32	101

Owing to the doubtfulness in these cases as to the precise mechanism of introduction of each species, it would be idle to discuss the distribution as has been done above with the species whose transport could be pretty certainly decided, but a consideration of these species gives the same general results as the others, and supports the general conclusions as to distribution arrived at above, or at least does not contradict them. Those attributed to birds and wind have been mainly carried over short distances only, those supposed sea-borne are mainly Seychellen and Malayan, the weeds are mostly in frequented islands.

Summing up now the floras of all the groups of islands—Chagos, Maldives, Minikoi, Laccadives—and employing the same criteria throughout, we get the following table :—

Mode of Transport.	Chagos.	Maldives.	Minikoi.	Laccadives.	Whole Flora.	
Sea currents	14	39	29	22	43	73
Sea, probably	7	27	10	11	30	
Birds	—	1	—	6	7	28
Birds, probably	5	16	7	10	21	
Wind	7	4	2	2	11	13
Wind, probably	—	—	—	2	2	

Mode of Transport.	Chagos.	Maldives.	Minikoi.	Laccadives.	Whole Flora.	
Total independent of man ...	33	... 87	... 48	... 53	... 114	
Man, unintentional ...	2	... 41	... 21	... 35	... 56	} 106
Man, probably	9	... 32	... 16	... 26	... 50	
Total wild flora	44	160	85	114	220	
Cultivated ...	4	... 98	... 40	... 32	... 110	} 139
Cultivated, probably ...	1	... 26	... 9	... 4	... 29	
Grand Total ...	49	284	134	150	359	

Leaving out the cultivated plants, and calculating the rest in percentages, crosswise, we get the following table :—

	Chagos.	Maldives.	Minikoi.	Laccadives.
Sea ...	... 28·76	... 90·41	... 53·42	... 45·20
Birds ...	... 17·85	... 60·71	... 25·00	... 57·14
Wind ...	... 53·84	... 30·77	... 15·38	... 30·77
Total independent of man ...	... 28·95	... 76·31	... 42·10	... 46·49
Man ...	... 10·37	... 68·86	... 34·90	... 57·54
Total wild	... 20·00	... 72·72	... 38·63	... 51·81

(Thus sea-borne plants on the Chagos are 28·76 per cent. of the whole sea-borne flora, not of the flora of the Chagos themselves. The total wild flora of the Maldives is 72·72 per cent. of the total wild flora of all the groups.) We may now proceed to use these figures in the same way as in calculating insect preferences to flowers,* subtracting the total percentage from the particular in each case. Thus, of species unintentionally introduced by man, the Chagos, which are furthest from the stream of traffic, have a decided deficiency (10·37–20 per cent.). The Laccadives have, on the other hand, a decided preponderance of these plants (57·54–51·81 per cent.). Dealing now with the total independent

* *Cf.* Willis : Manual and Dictionary of the Flowering Plants and Ferns, I., p. 102.

of man, we find in the Chagos a great proportion of wind-borne species (53·84–28·95),* a deficiency of bird-carried species (17·85–28·95), and an average of sea-borne. The Maldives have a large preponderance of sea-borne species, a deficiency of the others. Minikoi has a considerable excess of sea-borne, a deficiency of otherwise carried forms. The Laccadives show a slight deficiency in sea transport, and a preponderance in bird. The total evidence thus shows as before that the sea is the chief agent, after the unintentional action of man, in stocking outlying oceanic islands, and the more so the farther out they lie, or the more (as in the case of the Maldives) they lie in the track of the great equatorial current systems. Bird carriage is chiefly important in islands nearest to the mainland, while wind is operative everywhere, but especially nearer to mainlands and in the carriage of cryptogams. Unintentional introductions by man are more numerous the nearer to the ports of commerce.

VII.—THE ORDER OF APPEARANCE AND THE COMPETITION OF PLANTS ON NEW ISLANDS.

Very little has been described as to the first plants to people a new island beyond the noting of certain species actually observed growing on newly formed beaches, *e.g.*, by Darwin, Guppy, and others (see Hemsley, *l.c.*). Darwin notes that Pemphis is very often among the first to appear. Guppy notes that on the windward or growing side of a reef there is a scanty vegetation with few trees, Casuarina, Pandanus, &c. On the leeward, older side, where there is a richer soil with more humus, there is a denser vegetation, the trees forming a thick belt overhanging the rising tide ; common among them are Barringtonia speciosa, Calophyllum Inophyllum, Thespesia populnea, Hibiscus tiliaceus, &c. Just within the line of trees bordering the beach

* It must, however, be remembered that the equatorial climate of the Chagos is especially favourable to ferns, which form the majority of the plants under this head.

are Cycas, Pandanus spp., Heritiera littoralis, Terminalia Catappa, Cerbera Odollam, &c. Further inland are large banyans, and other trees introduced by birds.

Under the descriptions of the various islands and atolls above given many interesting details are recorded as to the composition of the floras, and the appearance of plants on newly formed reefs or the flora of those which are washing away. The main general features only are summarized below. The flora differs considerably according to whether the island in question is rocky or sandy. In each case the more strictly littoral flora may be perhaps subdivided into the beach jungle and the shore herbs.

When a new bank forms, the vegetation brought to it is at first all sea-borne, but after a few shrubs appear the islet is visited also by birds, bringing other species with them. The order of appearance of plants was studied in Mahlos (*q.v.*) on a number of islets, and confirmatory observations were made elsewhere. The first arrivals are in general Launæa, Spinifex, Mariscus Dregeanus, Eragrostis plumosa, Aerua lanata, Tournefortia argentea, Suriana, and Scævola. The last-named is often late in coming, but spreads with great rapidity when once established, and largely at the expense of the Tournefortia, which, at first numerous, is often only represented after some time by a few clumps or isolated trees. On the first shrubs Cassytha filiformis is nearly always to be seen, presumably brought by birds. The islets are visited by waders, terns, herons, &c. Thus on a young sandy islet, both a shore herb formation and a beach jungle are soon formed. The former lies further out than the latter, and corresponds very much to the Ipomœa Pes-capræ formation of Schimper (*l.c.* 77). Ipomœa biloba (I. Pes-capræ) itself is rather rare in the Maldives. The beach jungle of the sandy island is not so complex as that described by Schimper as his Barringtonia formation, but resembles it in general. Ochrosia borbonica, Terminalia catappa, Morinda citrifolia, and the small species of Pandanus soon appear as the islet grows, and when there is a large drier central part Guettarda speciosa and Hernandia peltata are usually to be found. Pemphis also occurs, but is only common in rocky islands. In the southern atoll of Suvadiva the beach jungle includes much Pandanus at the expense of the Scævola and Tournefortia. On rocky islands the beach jungle is much loftier in growth, and includes the large species of Pandanus, Allophylus Cobbe, Hernandia peltata, Acalypha fallax, Premna integrifolia, Barringtonia speciosa, Banyans, Calophyllum Inophyllum, &c.

The contrast between the marginal jungle of forming beaches and those which are washing away (only when latter are rocky) is very remarkable. The former have Scævola and Tournefortia, with the shore herbs outside them, the latter only Pemphis acidula, which may often be found with its roots washed by the water. The presence of this species in a continuous belt near the water regularly indicates a washing away of a rocky beach. In the case of a sandy islet washing away, the process is generally very much more rapid, so fast indeed that there can be no definite flora. Should a period of rest or of very slow erosion set in—a period which is characterized by the formation of large masses of sandstone in the beach—Pemphis begins to assume the same dominance, and forms with the sandstone an important barrier against the further encroachment of the sea. The near approach of the sea does not, except very slowly, kill hard-wooded trees except banyans. Softer shrubs sicken, die, and are replaced by Pemphis. Pemphis is rarely found until the island is washing away. Tournefortia remains until the water begins to actually wash its roots with every high tide, and then it dies. Pemphis flourishes best where its roots are regularly washed by the tide, and will stand thus for many years. It has a remarkably hard red wood which resists decay and all destructive organisms. Its biological position compares with that of willows and withes grown by the banks of rivers to preserve them. At last when its roots are completely submerged, as off Turadu, it too dies, but even here it must have been in this condition for some three or four years, so that the process is slow.

Of other trees the cocoanut lives with the waves washing all round it at each tide until it falls. Some considerable portion of its root mass must always be above the water. When grown in a rocky soil it bears about three times as well as in a sandy one, and has larger nuts. On new rocky islands it flourishes at once, and bears in eight years, but on sandy ones its growth is very slow and it takes about twenty years to come into bearing. The best place for it is the junction of the two sub-strata. Sea-borne cocoanuts are usually bored into and destroyed by the shore and other crabs. Pandanus does not appear readily on any rocky or sandy bank. It is almost certainly sea-borne, and its segments may very probably be dragged out of the reach of the waves by the crabs. On an eroding coast as the sea approaches root after root is killed until the whole goes. In general it flourishes best on sand rather than rock. It very quickly appears in clumps on old grain land, and in places this is a perfect jungle of its stems and roots. This again may be attributed to rats and crabs. Of large trees the banyans do not like salt water, and as with Pandanus root after root dies and the whole tree goes when the centre root is reached. Bread-fruit goes still more quickly, but Calophyllum and Barringtonia will continue to flourish until absolutely washed by the waves. Even then their dead trunks continue to be conspicuous features of the beach, as for instance on Mamaduwari, S. Mahlos.

Mangroves are not well represented as a formation in the islands. On new sandbanks or on true outer beaches they are never found. They flourish at the heads of deep bays, or on the inner shores of crescent-shaped islands. Where, as in Ehasdu, Landu, and Fendikolu, Miladumadulu, they are found round pools and lakes, it seems probable that they owe their position to the lakes having been at some time in direct communication with the sea. This is probable also on geological grounds, while the lake at Huludu, Addu Atoll, which has no mangrove, was apparently due to other causes.

VIII.—THE FLORAS OF OCEANIC ISLANDS.

There now remain to be discussed, very briefly, some features of the more general bearing of the above facts on questions of geographical distribution in general. Firstly, as to the much discussed question of the origin of the floras of oceanic islands. It is evident that in a tropical island, man's interference being supposed absent, we shall get, on the beach, and in the case of an island with a loftier centre also to some extent inland, the littoral sea-borne species of the ocean in which the island lies. If not too far removed from the mainland, bird-introduced littoral species will also appear, and also probably some other inland species which will become established if the island be big enough and raised enough to permit them to grow independently of the littorals. Wind will bring species of ferns and other cryptogams, and possibly a few Compositæ or other flowering plants. Now, suppose the island to have been in the first place quite free of any vegetation, and consider what may happen in the course of a long period of time. The further history of the littorals and of the inland species will almost certainly be quite different. The former will come in large numbers, depending on the currents passing the island, but the available area for their growth will be small, and the competition greater. Continual crossing with new arrivals will probably help to keep the type constant, and we shall not expect to find many endemic forms developing from the littoral flora. If any such should form and remain littoral in their habitat, they will probably spread about the ocean like the other species that first came to the island, and their place of origin may be finally undiscoverable. With the inland forms introduced by wind and birds the case will be quite different. Few individuals arrive, and probably only at long intervals of time apart, and there is no special reason why further arrivals should necessarily be others of the same species. Finding a large vacant area, these forms may spread in great abundance over the interior of the island, and ultimately give rise to endemic species, whose chance of further distribution is small, and depends on the nearness of other islands. It has been elsewhere shown that wind distribution tends to carry more species, but fewer individuals than animal distribution, and we may therefore expect perhaps to find more wind-carried species than bird-carried giving rise to endemics. Treub, in his work on the new flora of Krakatoa,* has shown that we may expect to find many ferns in oceanic islands, due to their carriage by wind, and supported by the actual state of the floras of Juan Fernandez, Ascension, &c. We shall expect to find ferns and other cryptogams specially well represented, but may also look to find Compositæ (wind), Rubiaceæ (birds), Palms (birds), small seeded plants (birds' feet), and others carried in similar ways. Examination of the actual floras of oceanic islands will show that a large number of their endemic species belong to orders in which means of carriage are well marked, but, on the other hand, there are many in which it is difficult to assume such ancestry. Thus, in the Admiralty Islands the few endemic species belong to the genera Medinilla, Hydnophytum, Dendrobium, Cyathea, Hymenophyllum, Polypodium, Acrostichum. In Diego Garcia occurs an endemic Asplenium, the only endemic species in the Laccadive-Chagos chain among the higher plants, with which alone we are at present dealing. In Rodriguez we have a small island isolated by a considerable distance from its nearest neighbours, the Seychelles and the Chagos. In former times it may have formed part of a large island lying east of the Seychelles-Mascarene Island, indicated on the map by the 2,000-fathom line, but any land connection with that region must have been at a vast distance of time,

* Ann. Buitenz., VII.

and would perhaps be indicated by a greater generic endemism in the flora than is actually the case. The endemics of Rodriguez, as we might expect from what has been said, consist in great part of Rubiaceæ, Compositæ, Asclepiadaceæ, Verbenaceæ, Palms, Selaginellas, &c. Some of them show Asiatic affinities, but if we suppose land to have formerly occupied parts of the present sites of the Maldive and Chagos Archipelagos, there is no difficulty in accounting for their passage. It is evident from the facts above given that if there were but an inland part, where the wind and bird-borne species could be free from the competition of the littorals, and from the unfavourable soil and climate of the shore, species with any reasonably good distribution mechanism suited to birds or wind could get across from Ceylon to Africa or *vice versâ*. Taking now the case of the Seychelles, we find in them 60 endemics, which include 14 Rubiaceæ, 6 Vascular Cryptogams, 6 Palms, 3 Pandani, 2 Compositæ, 2 Orchids, and others. Here, again, the facts fit in well with the views expressed above. There is probably no need to assume complete land connections across the Indian Ocean to explain the floras of its islands, or perhaps even the affinities of the African and Indian floras, but we must almost certainly assume that formerly there were larger islands in the present places occupied by the Maldives, Chagos, and Rodriguez (see map). There are, as is well known, other oceanic islands, in which, for the full explanation of the flora, it is necessary, so far as our present state of knowledge goes, to assume former continental connection or great land extension, but for the islands of the tropical Indian Ocean this is perhaps unnecessary. The present paper, however, is hardly the place for a full discussion of the question. Let us, in conclusion, briefly consider the bearings of the facts of the Laccadive-Maldive-Chagos flora on the question of the former greater land area of these groups. If we suppose that in former times there was a large area of land, whether insular or continental, in place of these groups, let us consider what would happen as it became submerged. Its flora would inevitably get smaller and smaller as the available area and choice of suitable habitats decreased, and presently a condition like that now seen in Rodriguez would be attained. Let us now imagine Rodriguez to sink to submergence; it is all but certain that its peculiar flora would be exterminated, being unable to live on the coral reef. If any species developed into a littoral form, it would probably become spread about the Indian Ocean, and cease to be confined to Rodriguez or to the island in which it first appeared. Ochrosia borbonica is probably such a case. It is therefore evident that the flora of the Laccadives and Maldives, as we now find it, may be equally regarded as due to the submergence of the former land areas, or to the appearance of new plants on an area appearing for the first time above the waves, or in other words, it is valueless as evidence one way or the other, so far as our present means of interpreting the evidence go. Other evidence seems to render necessary the supposition that where the coral reefs now are there was formerly a great extension of land, but there is no evidence from the present state of the flora for or against this view, nor any certain evidence even of the continual presence of land in the places occupied by the archipelagos. If these were now to be submerged and to rise again above the waves, they would probably acquire in time a flora almost identical with that which they now possess. Other evidence seems to indicate that the former land masses were completely submerged, leaving only banks covered with at least a few fathoms of water; the present islands subsequently rose above the sea, to be peopled by waves, birds, wind, and finally man, with their present flora.

IX.—GENERAL SUMMARY.

The Maldive Islands have a flora of about 284 spp. of flowering plants and ferns (or with the Chagos and Laccadives 359), of which the cultivated plants and weeds number about 197 (245), while of the remainder about 66 (73) are probably due to introduction by sea, 17 (28) by birds, 4 (13) by wind.

The flora is enumerated in detail, and the local and general distribution of its members mentioned, as well as the Maldivian names of the plants. It contains but few plants of special interest. Cladium jamaicense and Ardisia humilis in the southern atolls are worthy of note.

The cultivated species in the Maldives number 100 or more, much exceeding those in the other archipelagos. The chief locally cultivated grain is kurakkan (Eleusine Coracana), rice being imported. The most important cultivation is that of cocoanuts. A classified description of the economic products of the islands is given. The most generally interesting is perhaps the mat industry, in which Pycreus polystachyus is employed. The weeds number about 79, mostly the common weeds of cultivation of India and Ceylon.

Sea-borne species are especially numerous in the Maldives, including many not found in India or Ceylon, or in the Laccadives or Chagos. The main stream of the currents passes through the group, and the flora is thus derived partly from the Malay Archipelago, partly from the Seychelles, Africa, India, and Ceylon. A full discussion of the effects of currents and wind on the dispersal of these plants is given.

Bird-carried species are mostly found in the Laccadives, nearest to the mainland, but there is slight evidence to indicate that any part of the combined archipelagos can be reached by bird transport.

Wind is responsible for the introduction of many cryptogams, but there is little reliable evidence for the carriage of other plants.

Interesting details are given of the order of appearance of new plants on newly formed islands, and other points of this nature.

The bearing of the facts on general questions of the distribution of plants and the flora of oceanic islands is briefly touched upon, and evidence given to show the probability that there were formerly land masses where the coral archipelagos of the Indian Ocean now lie, though the present composition of the floras of these archipelagos will fit in equally well with any theory of the origin of these reefs, which allows for the complete submergence of the former land.

Peradeniya, October 19, 1901.

Explanation of Plate II.

Fig. 1.—Map of Western Indian Ocean, showing archipelagos, currents, &c. Arrows indicate the direction of currents : when two occur together facing in opposite directions, the longer indicates the current in the south-west, the shorter that in the north-east, monsoon. The 2,000-fathom line is marked, and indicates what may once have been the configuration of the land masses in the Indian Ocean.

Fig. 2.—Map of the Maldive Islands. Scale, 1 inch to 60 miles.

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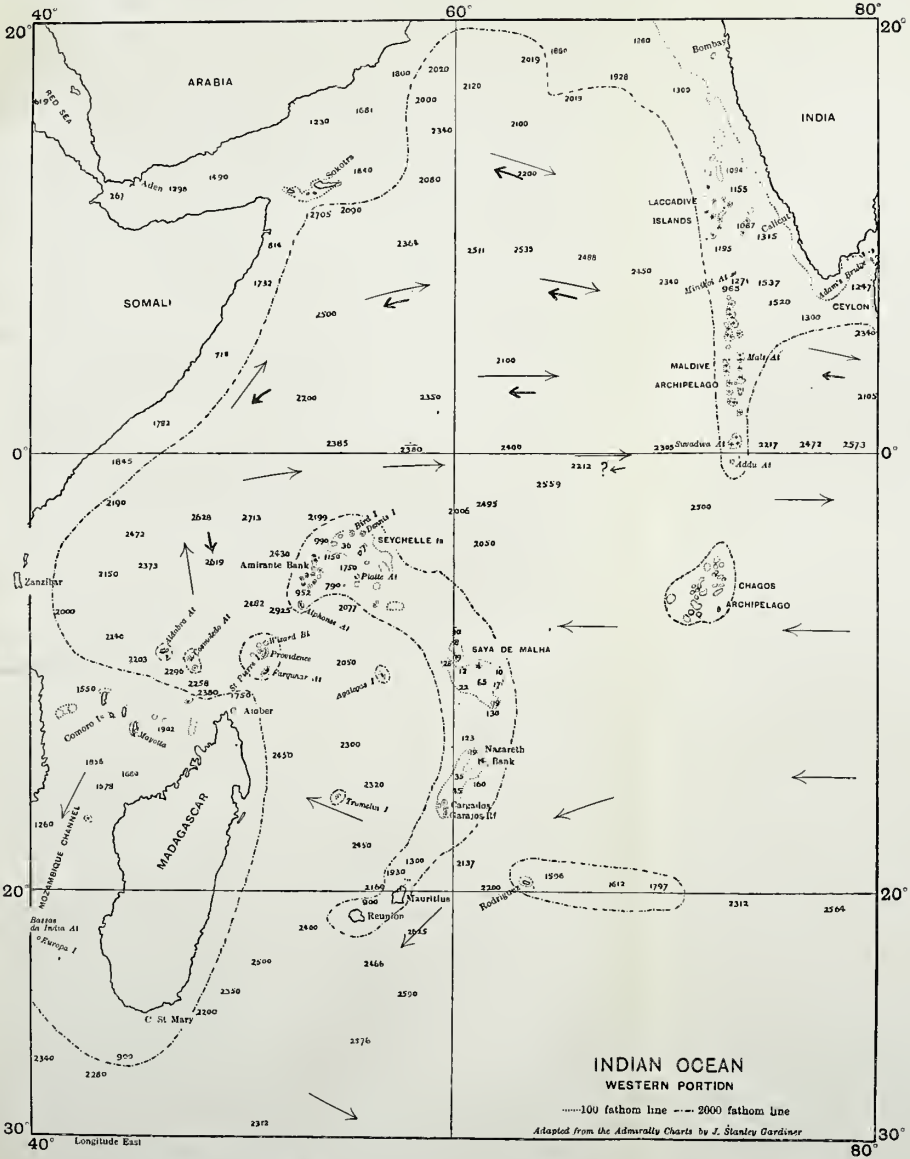

Fig. 1. *The arrows represent direction of currents: where two are shown facing in different directions, the longer represents the direction in the S.W., the shorter that in the N.E. monsoon.*

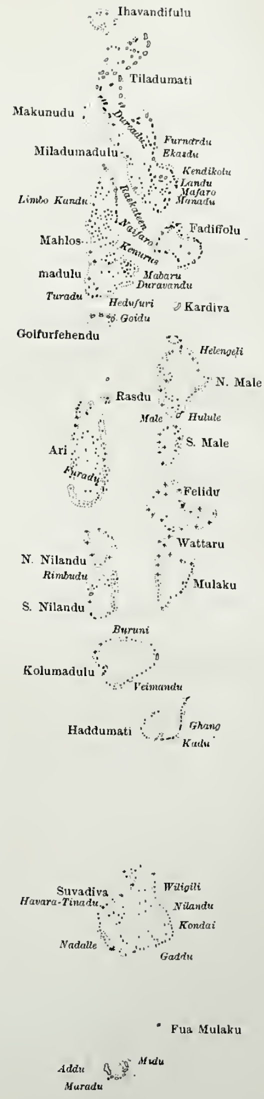

Fig. 2. Maldive Islands.
Scale 60 miles to 1 inch.

Observations on Dracæna reflexa, *Lam.*

BY

HERBERT WRIGHT.

(With Plate III.)

THE absence of cauline branching in the vegetative system among the commoner monocotyledonous plants and its prevalence among dicotyledons is a familiar fact. In several monocotyledons, however, a definite system of branching occurs, *e.g.*, in the Pandanaceæ,* Palmæ,† and some tribes of Liliaceæ.

In the last-named order the occasional branching and often bushy habit of species of Yucca and Asparagus, the more marked semblance to an arborescent type exemplified in species of Cordyline, and the magnificent tree-like form of species of Dracæna are examples which may be mentioned.

The genus Dracæna has long been known as containing species which assume an arborescent type approximating to that of dicotyledonous trees. *D. Draco*, L., even when growing under a condition of open canopy, possesses a well-defined leader, which when old branches considerably, each ultimate twig being terminated by a tuft of crowded linear-lanceolate leaves. The famous specimen of Teneriffe was one of the most gigantic, and, according to Humboldt, the

* Schumann, Die Verzweigung der Pandanaceen. Engl. Jahrb. XXIII., 1897, p. 559.

† Drude, in Engler and Prantl, Die Nat. Pflanzenfamilien, Palmæ, p. 9. Morris, The Phenomena concerned in the production of Forked and Branched Palms. Journ. Linn. Soc. XXIX., 1893, p. 281.

[Annals of the Royal Botanic Gardens, Peradeniya, Vol I., Pt. II., December, 1901.]

plant measured 70 feet in height and the stem 45 feet in circumference. The dimensions of this unique specimen are not to be wondered at, if we accept the opinion of Meyen, and regard the antiquity of the tree as being greater than that of the Pyramids. The size reached in fifty years by the tree dealt with in this paper, however, perhaps throws some doubt on this supposed immense age of the Teneriffe specimen.

Dracæna reflexa, Lam.

Habit.—The specimen of *D. reflexa* figured at the end of these notes was introduced into the Peradeniya Botanic Gardens in 1847, and is therefore only some fifty-four years old. It is a native of Madagascar, the Mascarene Islands, and Tropical Africa, and, as far as my information goes, always assumes an arborescent character. It is the very pronounced branching habit of the tree which gives it its interest and makes it worth a description and figure. No one casually seeing the tree at Peradeniya would suppose it to be a monocotyledon.

At Peradeniya it is unique among the monocotyledons in the complex nature of its branching system, and this, together with its large proportions, renders it a conspicuous object. It consists of a short main stem, irregular in outline, and measuring nearly three metres in circumference. The stout branches given off reach a height of several metres from the ground, and after repeated divisions th thin twigs are terminated by crowded small leaves, usually enclosing an inflorescence. The total height of the tree is about ten metres, and the branches cover a total diameter of nine metres. It has therefore the appearance of a low branching dicotyledon, and compares in habit with such trees as *Garcinia spicata*, Hk. f., *Gardenia latifolia*, Ait., *Jacquinia aristata*, Jacq., and *Cynometra cauliflora*, L. The resemblance to the last-named is very striking, particularly if grown under open canopy.

The other plants of *D. reflexa* now growing at Peradeniya are too young to give rise to such a form, though in nearly every case the cauline branching is observable at varying levels along the thin leader. As will be seen later, branching of the stem may occur in seedlings only a few months old.

Development.—The seeds when fresh are green, circular, and hard. If sown immediately after plucking, they germinate within a period of two months, and if dried for some time in the open before sowing, an earlier vitality is manifest. The seedling is of the hypogeal type, and the cotyledon, together with the greater part of the reserve food enclosed by the hard testa, becomes detached at an early period. The primary root is white and fleshy, and tapers strongly towards the apex. It is followed at an early stage by a pair of secondary roots, which arise from near the hypogeal cotyledonary node, ànd, though usually remaining thin and thread like, attain a considerable length.

Subsequent to the dropping of the cotyledon, stout white roots arise from the root stock area, and the primary root changes to a faint red colour and gives off numerous branches. The roots formed during the first twelve months invariably strongly assert their positive geotropism, and, with the exception of one specimen exhibiting congenital concrescense, no abnormal developmental features were presented.

The aerial shoot has in twelve months' time attained a height of 15 to 20cm., and borne upwards of thirty leaves. Usually it remains undivided during the first twelve months, but a few examples were seen in which lateral shoots developed from the lower part of the stem. This was the earliest indication of the branching, which in older plants gives rise to the arborescent type just referred to. It may be worth while to mention that seeds were sown in different parts of the Island, and the dry climate of Anuradhapura proved unsuitable for continued development. Even established plants when forwarded to the branch garden in this district failed to develop.

The Vascular Tissues.—The genus Dracæna has been the classic ground among monocotyledons for the study of sliding growth and vascular cambial activity.

Respecting the cambial activity and the nature of the vascular bundles produced in the roots and stems of species of Dracæna and Yucca nothing need be said, since figures are so frequent in almost every text book of botany. A few points of general interest have been worked out, and may be of supplementary value to our knowledge of this group of plants. It will be remembered that Strasburger* worked mainly with the stems and roots of *D. reflexa*, and Scott and Brebner† with the same structures in *D. fragrans*, Gawl., and *D. angustifolia*, Roxb., together with the roots of *D. Draco.*

The first point of interest lay in determining the period in the life of the plant and the particular area at which the vascular cambium made its first appearance. The first indications of a vascular cambium were obtained in a seedling nearly seven weeks old, and which consisted of an aerial shoot bearing eight comparatively small leaves, and having a basal diameter of 2 mm. ; the root system comprised a strongly branched primary root about 70 mm. in length, together with two young stout white roots arising from the root stock area. The cambium appeared in the pericycle of the very short hypocotyl immediately below the cotyledonary node, and from this area spread upwards into the stem and downwards into the primary root, where the thickenings of the endodermis helped to elucidate the origin layer of the cambial tissue. In the subsequent development the vascular cambium spreads more rapidly in the stem structures than in those of the root. This continues at such a rate that in seedlings seven months old the cambium has spread to a height of 6 cm. in the stem and only just over 1 cm. in the primary root.

The products in the basal part of the stem have assumed considerable proportions,—radial rows of three or four vascular bundles,—whereas in the root a continuous ring of cambium

* Botanisches Praktikum, 2nd ed. ; Histologische Beiträge, III., 1891.

† The Tissues of certain Monocotyledons ; Ann. Bot. VII., 1893.

does not exist, even near the root stock. The cambial activity in the small part of the primary root is very irregular, and develops apparently in response to local irritation in the cortex, the cells of which had also begun to divide.

Starting from this stage I was able by means of repeated peripheral measurements and microscopical examination of the tissues, to determine the rate at which the vascular bundles were added. In the plants examined, the cambium once started in the stem produced a radial row of four vascular bundles, together with the intervening parenchyma, in six months' time. During twelve months' cambial activity a radial row of eleven bundles had been formed. It must be remembered that since the periphery of the stem increases with age, the same number of vascular bundles per radial row represents an increased total activity in each successive month.

The next point of interest was in determining the part of the root in which vascular cambium originated.

Scott and Brebner state that in *D. Draco* and *D. fragrans* a definite relation was found between the secondary thickening and the insertion of the branch roots. They found stages in which there was pericyclic thickening only, limited to the immediate neighbourhood of the rootlet insertion. One case is noted in *D. Draco*, where "no sooner had the secondary tissues begun to thin out in receding from a lateral root than they began to widen again as the next lateral root was approached." It is further stated that "the chief formation of secondary tissues begins at the bases of the rootlets and thence extends both up and down the root and also peripherally." It is therefore clear that for these two species the cambium commences at the insertion of the rootlets, and the maximum thickness of the secondary zone is attained in this area and not at the base of the main adventitious root itself.

This is quoted as being contrary to what is described for *D. reflexa*, where, according to Strasburger, the cambium starts and attains maximum thickness at the base of the adventitious root, and tapers off regularly towards the root apex. It is further suggested that this difference may be a character of the species.

The almost unlimited supply of material of *D. reflexa* allowed an investigation into this point. In the first place, an examination of the roots of young plants showed that cambial activity occurred at the base of the primary root and existed in no other part of the root system, though a considerable number of branches were given off. Examination of another specimen consisting of a main root 3·5 mm. in diameter and giving off a rootlet 2·0 mm. diameter revealed a pericyclic cambium in the older part of the main root, but which disappeared 1 cm. before rootlet insertion was reached. From this area to the root insertion, at and below the root insertion, no vascular cambium either pericyclic or cortical was present. Other specimens showing active cambium in all parts did not present any bulky secondary products at the root insertion. Even if the secondary products are present in maximum quantities at the root insertion, does it necessarily indicate the point of origin of the cambium from this area? In studying the origin of the cambium it should be remembered that there is often a radial disposition of the cortical parenchyma, which in the presence of cambium might give rise to misleading notions.

Nevertheless, when one reflects over the fact that each rootlet subsequently becomes the main root of another system, there seems every reason to expect that the differentiation of a cambium will start as in the primary and main roots from the base, *i.e.*, point of insertion. The cases mentioned above can be explained on the grounds that the cambial activity, commencing at the base of the primary or main root, had spread so quickly that the areas of insertion of several rootlets were affected prior to the appearance of their own cambia. Whenever the differentiation of cambium in a rootlet is on any account delayed, it is obvious that that of the main root might easily overtake it. Further, the formation of the rootlet may itself be delayed until cambial activity has spread from the base of the main root to the area from which the rootlet subsequently emerges. It would therefore seem most likely that in order to obtain specimens showing the commencement of cambium at the insertion of the rootlets material should be examined in which the primary root is relatively young, and which, nevertheless, bears rootlets in a comparatively advanced condition of development.

These conditions obtained in one specimen consisting of an adventitious young root 3·2 mm. diameter, bearing a rootlet 50 mm. from its apex. The rootlet was comparatively well developed, being 60 mm. long, and therefore extending beyond the apex of the main root on which it was inserted. An examination of the area of insertion showed the commencement of a pericyclic cambium on the side of the insertion which extended to less than 1 millimetre above the insertion and to a *greater* distance below the insertion. Here, then, was a case in which cambium appeared independently at the insertion of the rootlet, first being purely pericyclic, and subsequently, after a scattering of the lignified endodermis, continued by the inner cells of the cortex.

It would therefore appear that either of the contentions held by Strasburger and Scott and Brebner may be valid according to the vitality of the cambium in the main roots, or the delayed or enhanced development of lateral rootlets in the particular system dealt with. Though many specimens were examined, the details observed were not such as to allow one to conclude that the area of insertion of a branch root was the centre from which the differentiation of the cambium for the main roots proceeded. The development of the cambium at the insertion point was more the starting point for the rootlet itself and not for the mother root, and in this respect would seem to differ from what prevails in *D. Draco* and *D. fragrans.*

One more point remains to be dealt with. According to Strasburger the roots of *D. reflexa* are epinastic, the secondary thickening beginning on the upper side and continuing to be more vigorous there. Certainly the pericyclic cambium is highly eccentric, and several areas of activity can only be explained in terms of the idiosyncrasies of the particular pericyclic cells. In the primary root, which has a fairly regular and downward course, the pericycle develops a cambium on one side only; similarly, in secondary roots and in lateral branches exhibiting positive geotropism. The only relation that could possibly be established was that the cambium was active on the side from which a rootlet emerged, but as this occurred on any part of the mother root no "epinastic" development could be said to exist. A similar arrangement has been described by Scott and Brebner for *D. Draco* and *D. fragrans*, and the eccentric development correlated with the proximity of the lateral root.

The stele of the roots, though of the usual polyarch exarch type, seems to be liable to variation. A cortical injury often caused a breaking of the endodermis on one side, and this layer then curved inwards at each end and produced an arc similar in outline to that which monostelic systems often assume in their transition to other forms. In cases of congenital concrescence a transverse section reveals two separate monosteles, which when traced upwards into the older portion fuse in a regular manner producing a single polyarch stele.

Explanation of Plate III.

"DRACÆNA REFLEXA, LAM."

(Illustration reproduced from a photograph by L. Maddock, Esq., the Studio, Kandy.)

The tree is fifty-four years old; circumference of stem = nearly 3 metres; height of tree = 10 metres; total spread of foliage = 9 metres. Scale, $\frac{1}{75}$ nat. size.

Apothecaries C° phot. *Sadag Sc. — Genève*

DRACÆNA REFLEXA Lam.

REVIEWS.*

Disease in Plants.

By H. MARSHALL WARD.

(Macmillan & Co., London, 7*s.* 6*d.*)

Though the title of this book is comprehensive enough for a much more bulky volume, yet its contents would perhaps be more correctly summed up as "plants in health and disease."

Professor Ward has done much in England to advance the science of plant pathology and to encourage others in the pursuit, and his work in this field is of special interest in Ceylon, because his first scientific investigation of a disease and its causations was at Peradeniya.

To the lay reader some of the book may be not easily understandable, but if read carefully and intelligently by agriculturists and horticulturists, whether in temperate climates or the tropics, a great gain must result. They will be led to a clearer understanding of the complex problems which those who tend plants have to consider, if they would keep their charges in as productive a state as possible.

To workers in the domain of plant pathology and therapeutics the book will be welcome as much for the suggestions as to lines of attack as for the record of positions already secured. It is to be hoped that this volume, summing up as it does in a brief form the main facts about plants in the abnormal states called disease, will be the precursor of a work dealing with therapeutic methods and results.

There is a mass of knowledge on therapeutic points gradually being acquired in Germany, America, and other countries, which requires to be put through the mill of inductive reasoning and reduced to a series of general laws. Even in the present work a chapter might most usefully have been devoted to some methods of investigation, and a brief account given of one or more cases of the working out of the life history of disease-producing organisms, by De Bary, Hartig, or Tubeuf. Such examples of accurate tracing of causation by

* The articles which appear under this head are written primarily for the Ceylon constituency of this Journal, and deal chiefly with advances in Science which are of immediate local interest.

observation and exact experiment go a long way to discourage perfunctory explanations, which so often do duty for careful investigation, and lead to the employment of empirical remedies.

Each page in many chapters touches on so many points on which our knowledge is yet insufficient that we might suggest that an interleaved copy, in which the observer either in the field or laboratory could note down pertinent facts, should in many cases lead to the record of many minor observations, which would otherwise be lost.

Professor Ward objects to the division of plant diseases into "physiological" and "parasitic," since all disease is physiological in so far as it consists in disturbance of normal physiological functions.

The separation into two groups, those induced primarily by physical causes and those due to the effects of a parasitic organism, is sound both systematically and for practical purposes, but "environmental" is perhaps a more accurate name than physiological.

The whole question of grouping of diseases in plants is one of great difficulty, and even the sub-grouping of the diseases due to specific parasitic organisms is not easy. The method of arranging the diseases by the natural order of the organisms causing them is plain sailing in the case of diseases attributable to one chief and primary cause, but does not help where one or more factors are correlated. There is a chaos at present, and a system would be welcome, even if somewhat arbitrary, which would aid the collection of data and pave the way to a rational arrangement. In the book before us such grouping as "artificial wounds," "natural wounds," "excrescences," "exudations," "monstrosities," is open to various objections.

In the chapter on the spreading of disease nearly all agencies which have been suspected or proved to directly distribute spores are mentioned, and here we have a field of investigation possessing attractive interest and of direct economic importance. If we take the question of wind agency alone, we have a number of phenomena, which, if properly understood, would lead us far on the road of preventive sanitation.

Observation of meteorological conditions will bring much information of value in forming a clear conception as to the means of distribution of various parasitic fungi. The study of wind currents, succeeded by moist atmospheres, flights of insects, itineraries of animals with regard to their porterage of spores, will give results which enable us to determine the best way of dealing with protective wind belts of trees and selection of safe places for the cultivation of plants specially liable to attacks of parasitic organisms.

It is not to be expected that in such a small book on so large a subject everything can be included; some mention, however, of the factors in nature which make for the success of the host plant in its fight against the parasite would have added to the completeness and interest of the book.

The effect of direct sunlight—a subject on which Professor Ward has already added to knowledge—on tissue containing bacteria or the mycelium of fungi, the feeding of animals and insects on diseased tissues, the production of roots from tissues not previously root forming in cases of diseased roots, all have an important bearing on the plant in its pathological aspect. In fact, all agencies, organic or physical, which tend to restore the plant to the normal, are of the greatest interest, both from a biological standpoint and that of the therapeutist.

At a time when attention is specially directed to the application of exact knowledge to all human activities, this book will do much to further this principle in a sphere the importance of which it is hard to undervalue.

J. B. CARRUTHERS.

Tropical Agricultural Journals.

Journal d'Agriculture Tropicale. Paris. Monthly. 20 francs per annum.

Revue des Cultures Coloniales, Paris. Fortnightly. 20 francs per annum.

Bulletin du Jardin Colonial, Paris. Bi-monthly. 20 francs per annum.

Der Tropenpflanzer, Berlin. Monthly. 10 marks per annum.

Mededeelingen uit's Lands Plantentuin. Buitenzorg, Java. Appearing at irregular intervals and prices.

Bulletin Economique de l'Indo-Chine, Saigon. Monthly.

With the exception of Holland, the nations of Continental Europe have hitherto been backward in developing tropical agricultural colonies. This, however, is no longer the case, and the energetic efforts that are now being put forth by France, Germany, and other nations to found prosperous tropical colonies, and which are already meeting with a large measure of success, deserve the careful attention of all interested in the agriculture or the politics of this Island. Not merely are these foreign colonies commencing to compete with Ceylon in the continental markets, but other countries, favoured with richer soils or better climates, yet under the English flag, are rapidly coming into prominence as producers of what have hitherto been, or might be, Ceylon staples. This is not the place in which to enter upon a discussion of this topic ; all that is here intended is to call attention to some of the chief journals in which may be found much that is of interest to the Ceylon planter, but whose contents have as yet remained almost unknown to him. The numerous English journals published in many different tropical lands contain much that is of value and copy freely from one another, so that any information appearing in English is soon spread over the colonies. To judge from internal evidence, however, their editors rarely read any article written in a foreign language, and yet a perusal of the journals above mentioned would furnish much information that should be at the service of English planters and others in the tropical colonies. The economic history of the past century in Ceylon shows an alternation of periods of great prosperity with periods of great depression, due to the rise and fall of successive agricultural industries. It can scarcely be doubted that this phase of enormous fluctuations is nearly over, and that for the future we must devote our attention to industries in which severe competition will have to be faced, and in which the victory, as in Europe, will be to those who most intelligently apply to their work all the resources of industry, ability, science, and politics. This has long been recognized in the Dutch colony of Java, in which there has been a wonderfully steady prosperity for many years, attended by less fluctuation than in Ceylon, and in which the history of agricultural progress is not so marked by the ruins of extinct industries and by enormous areas of waste and almost valueless land. The finest scientific institution in the tropics for the aid of agriculture is without doubt that of Buitenzorg in Java, which it may be remarked is largely paid for directly by the planters concerned, a proof that they believe the results of scientific methods and investigations to be of direct practical value to their industries. The results of much of the work carried on in this institution are of value to Ceylon planters, if intelligently applied to the different local conditions. Unfortunately the fact of their being in the Dutch language renders them unavailable to most English people, but the attention of the editors of English tropical journals should be called to this mine of information. Among recent articles in the "Mededeelingen" may be mentioned a detailed illustrated account of Butin Schaap's method of grafting coffee, which has proved of such value in the Java industry, accounts of the common diseases of tomatoes, coffee, &c., with methods of treatment, and many others.

The French and German colonies are endeavouring from the beginning to work on scientific lines, and their journals contain much that is of interest to us. Several excellent critical articles have appeared dealing with the English tropical industries and calling attention to their faults, with the view of enabling their rivals to start competition on lines likely to be successful in the end. In the present period of decreased profits in tea innumerable inquiries are made for "new products." In the strict sense such things are now hardly to be found; in some place or other everything has been or is being tried or is regularly exploited. Detailed information about many such products is to be found in the journals quoted above. All may be seen in the library of the Peradeniya Gardens, in which almost every journal of importance dealing with tropical agriculture is received. Each of the journals mentioned above has its own particular line of work or speciality. The Journal d'Agriculture Tropicale is new, and aims at giving crisp practical information, including the latest results of scientific investigations at various institutions in all parts of the world. The two numbers which have already appeared contain interesting papers on Sisal Hemp and the machines used in its preparation, on the various kinds of Castilloa (of this more hereafter), and on Camphor, with many other things. The "Revue des Cultures Coloniales" is an older paper, and frequently contains useful articles, especially with reference to the many plants which are staples in the older French colonies, such as vanilla, nutmegs, &c. The "Bulletin du Jardin Coloniale" (a new institution, somewhat on the lines of Kew) contains in its first number articles on the ploughs used by natives in the different countries of the tropics, on Manila hemp, and other topics. The German journal, "Der Tropenflanzer," contains many useful papers; among recent articles of interest may be mentioned a long paper by Koschny on Castilloa in its native countries, dealing with the various kinds of Castilloa, their yield, treatment, and commercial exploitation; a detailed and critical account of the tea industry of India by Schulte im Hofe; an interesting paper (the result largely of investigations carried on at Peradeniya) by Preyer on Fermentation of Cacao, and others. In the "Bulletin de l'Indo-Chine" there are often papers with an application to Ceylon, the climates and soils of the two countries being not dissimilar.

Let it suffice to have indicated that the English journals and official publications do not exhaust the available information of value, and that in the severe competition in tropical industries, which is approaching, no source of information may safely be neglected.

J. C. WILLIS.

NOTES.

Material for Demonstration of developing Embryos (Klugia).

BETTER material for class demonstrations of the stages in development of a dicotyledonous embryo than the Ceylon species of Klugia—Notoniana and zeylanica—it would be difficult to find. By taking seeds from capsules of all ages from those where the corolla has just fallen to those that are all but ripe, and mounting in eau de Javelle, the whole series of stages is easily demonstrated much more clearly than in most of the plants used for class work. The embryo can be seen in all stages from eight cells onwards, with its suspensor, gradually filling the embryo sac and seed. The embryo sac, tapetum, nucellus, and integument show with extraordinary clearness, and the gradual destruction of the nucellus and endosperm can be easily seen. The plant is well worth cultivation in Europe, where K. Notoniana should succeed in wet soil, well drained, with a fairly steady temperature of about 60° F.

J. C. WILLIS.

The New Laboratory at Hakgala Garden.

THIS building has been completed, and is now ready for work. It lies in an open site on the patana south of the cultivated part of the garden at an elevation of 5,580 feet above sea level. There is a laboratory room facing north measuring 21 feet by 13 feet, with two large working places, a herbarium of the hill flora, a small collection of books, and simple essentials for botanical work. Opening from it is a somewhat smaller living room, and beside this are two single bedrooms, with a kitchen and room for a servant. The building is of wood, with stone pillars raising it above the ground, and with fireplaces. It is being furnished with all necessaries, except linen and cutlery. Visitors must take their own servant to do the cooking and general attendance. There is a charge of one rupee a night for the use of the building to visitors not belonging to the Scientific Staff of the Department, who must obtain the permission of the Director to reside there. Hakgala occupies so admirably central a site for the study of the various types of mountain flora of Ceylon that we may well hope to see much good work done in this laboratory in the future. It has already been occupied by Mr. Coomaraswamy, the Geologist, and by the Director.

Personal Notes.

THE Barclay Medal of the Royal Asiatic Society of Bengal, given annually for the best work in Biology in India or Ceylon, has this year been awarded to Mr. E. E. Green, Entomologist of the Department. This is the first award.

As in 1900, a large number of officials of similar departments in other countries have officially visited Peradeniya during the year to study the organization and working of the Department. They include Dr. Stuhlmann, Director of Agriculture and Acting Governor of German East Africa; Dr. Van Romburgh, Director of the Java Experiment Gardens; Mr. I. H. Burkill, Assistant Reporter on Economic Products to the Government of India; Dr. E. J. Butler, Cryptogamist at the Calcutta Botanic Gardens; and Mr. R. H. Proudlock, Curator of Gardens and Parks, Ootacamund, Madras Presidency.

ANNALS

OF THE

ROYAL BOTANIC GARDENS,

PERADENIYA.

FIRST SUPPLEMENT.

A HANDBOOK OF THE VEGETABLE ECONOMIC PRODUCTS OF CEYLON, NATIVE, CULTIVATED, OR IMPORTED.

BY

J. C. WILLIS AND HERBERT WRIGHT.

Colombo:

H. C. COTTLE, ACTING GOVERNMENT PRINTER, CEYLON.

1901 *et seq.*

Prefatory Note with regard to the Supplements of the Annals of the Royal Botanic Gardens, Peradeniya.

It is proposed to publish in the form of Supplements to the Annals certain pieces of useful work more of the nature of compilations than of original scientific work : for example, the present Handbook of Economic Products, a revised List of the Flora of Ceylon, &c. The Supplements will be included in the subscription to the Journal, and portions of them will appear as ready. They should be detached from the rest before binding, as they are separately paged with a view to being separately bound when complete. A few extra copies of each portion are printed, and when complete will be sold as separate works at a considerably enhanced price. Fragments will not, as a rule, be sold separately, but may be obtained by purchasing the whole number in which they appear.

It is not intended that the number of Supplements shall exceed the number of volumes, though it is probable that the publication of a second supplement may commence before the first is complete.

A Revision of the Podostemaceæ of India and Ceylon.

BY

J. C. WILLIS.

NO family of Indian flowering plants is so imperfectly known as the Podostemaceæ. This is somewhat surprising when we remember how interesting these plants are on account of their peculiar habitat and mode of life in the swiftest waters of rushing mountain streams, their very extraordinary morphological construction, resembling in external and internal features that of Algæ or Bryophyta, and their great variability, to say nothing of the great difficulty of placing the order in its proper position in a natural system of classification.

Living for the last six years near to the best known locality for Podostemaceæ—Hakinda rapids on the Mahaweli-ganga, a mile below the Peradeniya Gardens—where six species occur in profusion, I have devoted much attention to these plants. The interesting morphological and ecological observations which I have made will be described separately; in the present paper I propose to describe the important changes in the nomenclature and classification of the Indian species, which I have found necessary in the course of my work. New species have been found, old ones proved to be identical with forms described under other names, new genera established, and other changes made.

[Annals of the Royal Botanic Gardens, Peradeniya, Vol I. Pt. III., May, 1902.]

Having by the end of 1898 brought my observations on the Ceylon species to a state of comparative completeness, I found it necessary for their complete understanding, as well as for the sake of a full account of the order, to study the Indian forms also in detail. With this in view, I visited in 1899 the great herbaria of Kew and Paris to examine the type specimens there preserved. This, however, proved to be largely time thrown away. The herbarium specimens are almost all mere fragments gathered from the centres of dead and shrivelled plants in the dry season of the year, and give very erroneous ideas of the morphology of the mature living plants. The descriptions of the species, even in the best monographs and floras, based upon these fragments, are marked by serious, even glaring, errors, confusions, and omissions. It was evident that the only useful course was to collect again for myself fresh material of the Indian species from the rivers where they had been previously found. I am therefore very much indebted to the Committee of the British Association for the Advancement of Science, and to the Government Grant Committee of the Royal Society, for grants of £20 and £35, respectively, made to me in 1900 and in 1901 for this purpose. In December, 1900, and January, 1901, I visited the hills of South-Western India, from the Bombay Ghats to Travancore, and in December, 1901, the Khasia Hills of Assam and the Sikkim Himalaya. As it is eminently desirable that the Indian species should be studied upon the spots where they grow at various times of year, I have given under each an exact description of the places in which I found it, for the guidance of future workers.

I have to thank many friends who have helped me in my work by collecting or supplying material. In particular Mr. C. A. Barber, Government Botanist, Madras Presidency, has collected for me excellent dry and spirit material of many species, including three new to science, in South Kanara, Tinnevelli, and elsewhere. By the kind assistance of Prof. Gammie of Poona I have obtained some good material from

Atgaon, west of Poona, collected by Mr. R. K. Bhide. I have also received dry and spirit material from Sir W. T. Thiselton-Dyer, Director of the Royal Botanic Gardens, Kew ; from Dr. D. Prain, Superintendent of the Calcutta Gardens ; from Mr. T. F. Bourdillon, Conservator of Forests in Travancore ; from Prof. Goebel of Munich ; from Miss Gulielma Lister ; and others. To all these friends, and to Mr. R. D. Fenton of Monica (Anamalais), Capt. D. Herbert, Deputy Commissioner of the Khasia and Jaintia Hills, the Rev. P. Decoly, Mr. F. Lewis, Mr. J. Parkin, Mr. H. F. Macmillan, and others, I am very greatly indebted.

Type sets of material—herbarium specimens, and in some cases also specimens dried on the rocks on which they grew, or preserved in alcohol—are being distributed to the following great herbaria and museums:—Kew, British Museum, Cambridge, Edinburgh, Paris, Berlin, Munich, Vienna, Copenhagen, St. Petersburg, Rome, Washington, Harvard, Rio de Janeiro, Calcutta, Saharanpur, Poona, Ootacamund, Singapore, Buitenzorg, Tokio, Durban, Sydney. A complete illustrative set of type specimens and material (much more complete than any of the distributed sets) is preserved at Peradeniya.

It will be convenient to sum up here the work that has already been published upon the Indian and Ceylon Podostemaceæ. The first species was discovered by Gomez in the mountains of Sylhet (probably the Khasias), and enumerated as No. 5,225 in Wallich's Catalogue (1828) as Podostemon Wallichii, R. Br. This species was again found near Cherra Punji in the Khasia mountains by Griffith in 1835, and he also discovered another species in a tributary of the Bogapani in the same district—P. Griffithii, Wall. MSS. Both these were described by him.* After an interval of ten years, my predecessor, Gardner, in company with Wight, collected several species in the Nilgiri mountains, to which Gardner

* Description of .... two species of Podostemon .... Asiatic Researches, XX., 103.

subsequently added several from Ceylon: his paper* contains descriptions of Tristicha ceylanica, the first of this genus to be discovered, and of Podostemon Griffithii, Wallichii, olivaceum, griseum, subulatum, dichotomum, Wightii, rigidum, and elongatum, together with an interesting account of the order, some species of which he had also studied in Brazil.

The next to occupy himself with this order was Law, who during his residence at Thana, near Bombay, made excursions into the Ghats lying to the eastward. Numerous little streams flow westward down these hills, uniting to flow out near Salset Island. In the floras, Law's localities are often given as "Salset River." I am indebted to the Collector of Thana for pointing out that no such river exists, and that probably "Salset Rivers" is meant, including all the little streams just mentioned. As much doubt has arisen over Law's specimens and their localities, I quote here all that I was able to find in his correspondence with Sir William Hooker (preserved at Kew) bearing upon this subject:—

No. 300. Tanna, 30th October, 1844: "The genus Hydrobryum founded by Endlicher† on some species of Podostemon described by Dr. Griffith in the Asiatic Researches is considered by the latter botanist to be untenable, in which Robert Brown agrees with him. The plant of which I sent you a specimen is however a new and very distinct species of Podostemon, which Dr. Griffith proposes to name P. ecostatum,‡ the fruit not being ribbed as in the other species. I enclose a few more specimens in fruit, and probably by next mail may be able to send you some in different stages. I have discovered another Podostemmea, which Dr. Griffith considers to be the type of a new genus, to be characterized in a paper on the Indian Podostemmeæ. At Dr. Wight's suggestion he proposes to do me the honour to name it after me. Of this also I enclose a few specimens."

* Observations on the Structure and Affinities of the Plants belonging to the Natural Order Podostemaceæ. Calc. Journ. Nat. Hist. VII., 1846.

† Endlicher, Genera Plantarum, p. 268.

‡ P. Hookerianus, Benth.

No. 301. Tanna, 30th December, 1844: "I enclose some pretty good specimens of Lawia, as well as of a second species which I have just discovered at a height of about 2,500 feet. There are also a few more specimens of Podostemon ecostatum. Of all these I propose to send you specimens hereafter preserved in spirits. These curious plants have no roots, and appear to grow in the manner of Algæ."

No. 288. Tanna, 27th August, 1847 (forwarding box of plants): ...... "are in it specimens of rocks covered with the lichen-like fronds of the two species of Podostemoneæ, of which poor Griffith proposed to constitute a new genus, but they evidently belong to Tristicha, and are allied to T. ceylanica of Gardner, described in the Calcutta Journal of Natural History."

In 1849 appeared Tulasne's preliminary list of the order;* in this he classifies the Podostemaceæ for the first time into their groups, and describes the following Indian species:—

Dicræa, Du Petit-Thouars
- Wallichii
- dichotoma
- Wightii
- rigida
- elongata

Podostemon, Michx.
- subulatus, Gardn.

Hydrobryum, Endl.
- olivaceum
- griseum
- Griffithii

Mniopsis, Mart.
- Hookeriana (Podostemon ecostatus Griff. mss.)

Lawia, Griff. mss.
- zeylanica (Tristicha ceylanica, Gardn.)
- pulchella
- longipes

All these have been mentioned above, mostly as species of Podostemon; the last two named are those collected by Law.

In his great monograph of the order,† published a few years later, Tulasne describes the above species in further

* Podostemacearum Synopsis Monographica, Ann. Sc. Nat., 3me Ser., t. XI., 1849, p. 87.

† Monographia Podostemacearum, Arch. du Museum d'Hist. Nat., VI., 1852.

detail, with many good figures. No change is made in the nomenclature, except the substitution of the genus Terniola Tul. for Lawia, which had already been used as the name of a group of Rubiaceæ, now reduced to Adenosachme.

We now come to Wight's work,* some of which has already been mentioned. In his Icones he figures and describes most of the known Indian species, of which the following are new:—

Dicræa longifolia, Malabar, Rev. E. Johnson.
stylosa, mountain streams, Malabar, Rev. E. Johnson.
Mniopsis Johnsonii, rivers in Malabar, Rev. E. Johnson.
Dalzellia or Tulasnea (Terniola Tul.) foliosa, Lawii, pedunculosa, all from Salset rivers, Law.
D. or T. ramosissima, Malabar near Cochin, Rev. E. Johnson.

All these and the other Indian species are figured in the plates, but very inaccurately ; the relative sizes and shapes of the parts are very far from right.

Beddome, in his Anamalai Plants,† figures and describes two further species found in those mountains, Mniopsis selaginoides and Dicræa algæformis.

Thwaites, in his Ceylon Flora,‡ enumerates the Ceylon species already mentioned, and adds Podostemon Gardneri, Harv. MS., from waterfalls at Ramboda, with a note to the effect that this may possibly prove to be an early stage of Hydrobryum olivaceum, a supposition I have since found to be correct. In the addenda to Tulasne's monograph, a doubtful species, Dicræa apicata, from the Nilgiris, is described, and it is suggested that it may be the early stage of D. rigida ; I have, however, found it to be that of Hydrobryum griseum, and almost identical with P. Gardneri.

Kurz,§ from material collected in Martaban by Mr. Parish, makes a further new species, Hydrobryum lichenoides.

* Icones Plantarum Asiat., V., p. 31, t. 1916–1920, Jan., 1852.

† Anamallay Plants, Trans. Linn. Soc., XXV., p. 223, 1862, 1865.

‡ Enumeratio Plantarum Zeylaniæ, p. 222, 1864.

§ Journ. As. Soc. Beng., XII., pt. 2, p. 103, 1873 (read 5th March, published 28th May).

Weddell's* monograph has been the standard for subsequent lists and descriptions of the Indian species. He accepts nearly all the species mentioned above. In Terniola, therefore, he puts seven species. In Hydrobryum, re-defining the genus, he leaves H. Griffithii only, olivaceum and griseum being united and transferred to Podostemon. He puts Mniopsis selaginoides into Dicræa, makes D. rigida, Wightii, and longifolia into varieties of dichotoma, and establishes two new species, D. pterophylla and D. minor, from material collected by Hooker in the Khasia mountains. Mniopsis Hookerianus and M. Johnsonii he puts into Podostemon, and adds to this genus two new species, P. acuminatus from the Khasias and P. microcarpus (Hydrobryum lichenoides, Kurz) from Burma.

Bentham and Hooker† follow Weddell fairly closely, but unite Dicræa to Podostemon. Their grouping of the order rests, like Weddell's, on rather too variable characters, and often breaks down in practice.

Warming,‡ in the second of his beautiful series of monographs of the order, describes Dicræa elongata and D. algæformis in detail from Ceylon material. In subsequent papers he has described Podostemon subulatus, Hydrobryum olivaceum, P. acuminatum (this he places in a new genus, Polypleurum, to which he also refers a new Siamese species, P. Schmidtianum ; I do not regard this genus as tenable), Lawia zeylanica, and L. foliosa. In the final paper of the series he deals with the classification of the order. Podostemon Hookerianus he transfers to a new genus, Griffithella, and describes a new species, G. Willisiana, which I hardly think is really distinct from G. Hookeriana. Lawia he divides into three genera, Lawia (zeylanica type), Terniola (foliosa type), and Dalzellia (ramosissima type). The

* De Candolle, Prodr. Syst. Nat. Regni Veget., XVII., p. 39, 1873 (October).

† Genera Plantarum, vol. III., p. 105, 1880.

‡ Warming, Familien Podostemaceæ, I.–VI., Kgl. Dansk. Vid. Selsk. Skr., 6 Rk. II., 1881, II., 1882, IV., 1888, VII., 1891, IX., 1899, XI., 1901.

second of these, as we shall see, is not essentially different from the first, but the third is a very distinct form. He erects the very remarkable species Podostemon selaginoides, Benth., into a new genus Willisia, re-instates Dicræa, and retains Hydrobryum.

Goebel* has described Lawia foliosa from material collected at Khandala.

Hooker,† in his Indian Flora, accepts the following Podostemaceæ :—

Terniola zeylanica, Tul.	...	Ceylon
pulchella, Tul.	...	Konkan
Lawii, Wedd.	...	Konkan
longipes, Tul.	...	Konkan
pedunculosa, Wedd.	...	Konkan, N. Kanara
foliosa, Wedd.	...	Konkan
ramosissima, Wedd.	...	Malabar
Hydrobryum Griffithii, Tul.	...	Khasias
Podostemon dichotomus, Gardn.		Nilgiris, &c.
stylosus, Benth.	...	Malabar, Anamalais
elongatus, Gardn.	...	Ceylon
algæformis, Benth.	...	Anamalais, Ceylon
subulatus, Gardn.	...	Ceylon
Hookerianus, Wedd.	...	Konkan, N. Kanara
Johnsonii, Wedd.	...	Malabar
olivaceus, Gardn.	...	Ceylon, Nilgiris
acuminatus, Wedd.	...	Khasias
microcarpus, Wedd.	...	Tenasserim
Wallichii, R. Br.	...	Khasias, Burma
pterophyllus, Benth.	...	Khasias
minor, Benth.	...	Khasias
selaginoides, Benth.	...	Anamalais

and a doubtful species, Dicræa apicata, Tul., Nilgiris.

Trimen‡ accepts the following in Ceylon, the last-named being new to the Indian list:—

Lawia zeylanica, Tul.	Podostemon subulatus, Gardn.
Podostemon elongatus, Gardn.	olivaceus, Gardn.
algæformis, Benth. (Trim.)§	metzgerioides, Trim.

* Pflanzenbiologische Schilderungen, I., 166., II., p. 331, 374.
† Flora of British India, V., p. 61, 1886.
‡ Trimen, Flora of Ceylon, III., p. 415, 1895.
§ Trimen. Journal of Botany, XXIII., 1885, p. 173.

P. metzgerioides on examination turned out to be a very distinct form, which I have raised to generic rank under the name Farmeria,* in recognition of the fact that it was first discovered by Prof. J. B. Farmer, who also in the most generous way withdrew his intended publication of an account of it on finding that I was monographing the family.

Further new species have since been discovered by Mr. C. A. Barber, viz., Podostemon Barberi, Hydrobryum sessile, and Farmeria indica. In spite of this, however, the total result of my work is to decrease the number of species, no less than eight of Hooker's list proving to be duplicates.

On some of the Characters used in the Classification of Podostemaceæ.

The detailed investigations of the morphology and life-history of the Indian species, on which these remarks are based, will be given in a separate paper. It will, however, be convenient here to deal with the characters of these plants in order, pointing out some of the many pitfalls into which it is so easy to fall in dealing with these very variable and polymorphic organisms. Many of the characters used in floras and monographs are nearly or quite valueless for purposes of distinguishing the forms. Instances are given elsewhere. It is in the highest degree essential to investigate the entire life-history and morphology of these plants before any safe deductions as to their grouping can be drawn. My observations suffer from this defect with respect to many of the species, but are perhaps more complete than those of my predecessors.

The General Life-history.—This is fully described in a subsequent paper, and, if clearly understood, will explain much of the difficulty that necessarily accompanies any attempt to use the dry material for classification of this order. The seeds germinate at the beginning of the rains, and the plant

* Notes to Trimen's Flora of Ceylon, V., p. 386, 1900.

is submerged and purely vegetative till almost the end of the wet season. The primary axis is commonly insignificant, and from its base there buds out, horizontally, an organ which may be, phylogenetically, either of "shoot" or "root" nature, the *thallus*, from which arise, endogenously and usually acropetally, secondary shoots, which are at first only vegetative, but ultimately bear the flowers in those cases where the thallus is of root nature. The morphology of the thallus is very interesting. The secondary shoots (or branches, in the case of "shoot" thalli) develop the flowers late in the season, often changing their structure and appearance in so doing, and when the dry weather commences the flowers open, in some cases emerging through the water, in others remaining closed till exposed to the air by the fall of the water. The thallus when exposed usually becomes much altered by withering and soon dies; the seeds are shed on the rocks to await the next rise of water, and the life-history begins anew. It is thus easy to see that without study of these plants upon the spot where they grow, and at different times of year, the student is liable to fall into great errors and difficulties in dealing with them.

The Primary Axis.—Except for the few species described below, this is unknown in the Asiatic species and most others of the order, the usual axes preserved in herbaria being the secondaries. The characters of the primary axis are often very interesting, and are probably of considerable value in settling the affinities of the different forms, but as yet we know too little of them to use them with much effect. It is very remarkable that in the Asiatic forms at any rate the primary axis hardly ever bears flowers.

The Thallus.—Most of the Podostemaceæ possess some kind of thallus, using the term broadly to indicate the part of the plant that creeps on the rocks or lies near to them. There are two main types of this organ well illustrated in the Indian forms: the thallus of "shoot" nature, seen in Lawia,* and

* *Cf.* Plates X.–XII. of subsequent paper.

the thallus of "root" nature seen in the remaining genera; in some the root is a mere creeping thread, in others a creeping closely attached ribbon, or discoid body (Hydrobryum spp.), in others again a drifting thread or ribbon attached to the rock only or principally at the base, or a fucoid organ, or even a cup-like body, as in Griffithella.* Within the same species the form of the thallus is very variable in detail (the polymorphism reaches an extraordinary degree in Griffithella*), but examination shows that the main morphological features of it are very constant, and therefore of high classificatory value, *e.g.*, all the Dicræas† have a more or less free drifting root thallus, exogenously branched, with secondary shoots on the upper margins and in the angles; all the Farmerias ‡ have closely creeping endogenously branched thalli, with the secondary axes in the basiscopic angles, and so on. The degree of attachment to the rock is variable, as is well illustrated in Griffithella; so also is the degree of lobing or branching, as seen in species of Dicræa and Hydrobryum, and in the shoot thalli of Lawia. The size is also very variable. Many thalli alter very much in form as they approach the flowering season, and still more, as might be expected in water plants, after they have become exposed to the air in the dry season. The herbarium specimens of these plants are in very many cases merely examples of these exposed dead thalli, and owing to the great difficulty (practical impossibility in the case of such closely attached thalli as those of some Lawias and Hydrobryums) of detaching the thalli from the rocks are usually of the most fragmentary description. In the vegetative season the thallus is usually beset with secondary shoots almost to the extreme tips, but very often many of these do not form flowers, and when the flowers are ripening for anthesis the thallus often breaks away, except in the floriferous part. This is especially marked in the Dicræas, where in D. elongata the

* *Cf.* Plates XXV., XXVI. of subsequent paper.
† *Cf.* Plates XVIII.–XXIV. of subsequent paper.
‡ *Cf.* Plates XXXVIII.–XL. of subsequent paper.

long leafy tips of the thalli are not floriferous, do not become lignified, and drop as soon as exposed, leaving the short woody floriferous basal portion ;* in D. Wallichii,† on the other hand, the flowers are often more distal, but the marginal parts of the thallus are not lignified, and break away towards the flowering season, so that the thallus becomes linear, which was before broadly ribbon-shaped, and lobed, which was before entire. Only when the thallus is very closely attached to the rock does it retain its original form, and even here great changes usually occur when the plant is exposed, owing to the fall of the leaves. There is no Indian species which is well represented in herbaria by specimens which clearly illustrate the morphology of the thallus in its mature living condition.

Another complication is introduced by the great capacity for rejuvenescence exhibited by most thalli ; when broken or otherwise damaged, new growing points form behind the injury and grow out in various ways.

The Secondary Shoots.—In the root thalli these are endogenously formed close to the apex, in the shoot thalli of Lawia further back. In the latter they are mere rosettes of leaves, unless they happen to be at the extreme edge of the thallus, when they soon form growing points just like the original growing points of the thallus, and ultimately give rise to flowers. In root thalli we get two types of secondary shoot, the one illustrated by Podostemon, Willisia, and Tristicha, the other by the remaining Indian genera. In the first, the secondary axis grows on continuously and branches (except in Willisia), forming new leaves, and reaching a considerable length, finally forming several flowers (one in Willisia) in the usual way. In the second, the axis remains obsolescent during the vegetative period, being represented merely by a fascicle of leaves emerging from an opening in the thallus. Towards the flowering season the axis elongates so as to

* *Cf.* Plate XIX. of subsequent paper.
† *Cf.* Plate XXI. of subsequent paper.

come a short distance above the thallus, and ultimately bears one flower. At the base of the pedicel in these forms, and at first covering and protecting it, are several bracts, formed from the last vegetative leaves of the axis by the enlargement of their sheathing bases and the fall of the blades. The examination of herbarium specimens showing these bracts in many different stages of this process has led to many errors. Thus Podostemon acuminatus, Wedd., receives its characterization from having acuminate bracts, the specimen examined having been gathered before the tips of the leaves had fallen. Dicræa pterophylla, Wedd., is characterized from the keel at the back of the bract; the species is identical with D. Wallichii, but the specimens examined by Weddell had been taken from younger plants in which the keel had been less disintegrated. Trimen, in his Ceylon Flora, describes Hydrobryum olivaceum as leafless, as in fact it is in herbarium specimens; in reality it is densely leafy, but the leaves fall when exposed.

The Leaves.—These are usually of the simplest description. They are very delicate, and in herbarium specimens are usually missing, or have lost their tips. The interesting change to bracts of some of the vegetative leaves at the end of the wet season has already been mentioned. The hairiness of the leaves in many species is noteworthy, as it is unusual in water plants. The leaves of the Asiatic species are simple, but in some cases, where they have been pressed tightly together, have been mistaken for compound.

The Spathe.—The morphology of this organ is not yet quite understood; in all probability it represents two or more united leaves. From a taxonomic point of view the chief feature to note is the way in which it opens to allow the escape of the flower. In Hydrobryum and Farmeria it is usually prostrate or nearly so, and opens chiefly on the upper side, while in the other genera it is more or less erect, and splits at the apex into a number of teeth. These are often so uniform as to give the impression of a perianth, but examination of a number of specimens usually discloses the fact that hardly any two are alike in this respect. In Lawia the spathe is physiologically represented by the cupule, an organ of apparently axial nature bearing leaves, and often closed until exposed by the fall of the water. In Tristicha ramosissima the construction is still more primitive and the flowers emerge through the water like those of the water Ranunculi.

The Pedicel.—The young flower is enclosed within the spathe or cupule, and has practically no pedicel. When the spathe splits the pedicel elongates more or less, sometimes to as much as 5–6 mm., before the flower opens, but often only just enough to let the flower stand nearly erect in the spathe. After anthesis the pedicel usually lengthens while the fruit is ripening, and at the same time the outer pellucid cortical tissue falls away or shrivels, while the central tissue becomes woody, leaving the fruiting pedicel much thinner than the flowering one, only the central lignified tissue—the vascular tissue and the inner cortex—persisting. Sometimes part of the outer cortex remains on the lower part of the pedicel and has been mistaken for a spathe. The length of the ripe pedicel is variable, and the average of a large number of specimens should always be taken; it seems to be affected by the rate of fall of the water, the steepness of the rock, and other factors, and requires further investigation. The fruits ripen very rapidly, and even after gathering may ripen in pressing, so that the condition of the flower and length of pedicel in herbarium material is singularly untrustworthy. The leaves or bracts below the flower fall away with the cortex of the stalk in many species; this is especially well marked in Willisia selaginoides, whose fruits, really sessile, often appear to be provided with long pedicels.

The Flower.—The parts of the flower are, as a rule, very constant in number and arrangement, but some features vary greatly, and it so happens that considerable taxonomic stress has been laid on some of these variable characters. The Tristicheæ, to which Lawia and Tristicha belong, have a trimerous regular flower with perianth; the depth of the segmentation of the latter is variable. The Eupodostemeæ, including the rest of the Asiatic forms, have a very zygomorphic flower, dimerous, without perianth. At the sides of the stalk of the monadelphous andrœceum there are two small thread-like organs, variously regarded as staminodes or as perianth; these organs vary much in size and length. The length of the stamens also varies, and the number may be either one or two in the same species in several cases. The ovary characters are fairly constant, but the shape and size of the stigmas are very variable, especially in Hydrobryum. In many forms the cortex of the ovary is deciduous with that of the pedicel of the flower.

The Fruit.—The characters of the fruit are of great importance for classification in the order. The chief distinguishing points are the presence or absence of ribs, and the equality or inequality of the two lobes in the fruit of the Eupodostemeæ. When the lobes are equal, the ribs on each run down into the pedicel, and the fruit splits evenly down the central ribs into two lobes, both of which remain on the pedicel; when the lobes are unequal, the ribs of one only are decurrent into the pedicel, and the other lobe falls off altogether after dehiscence. In the genera Hydrobryum and Farmeria, the characters of the fruit, which are usually generic, seem to be only of specific value.

The fruits ripen after gathering, so that the length of pedicel, as already mentioned, is variable, and so also is the size of the fruit. The ovary being usually smooth the ribs are formed by the fall of the outer tissues of the wall and the lignification of the vascular bundles and tissue near them, and frequently (especially in specimens gathered unripe) these tissues do not fall away properly, so that the fruit is not so ribbed as usual, or may even be mistaken for a smooth fruit (*cf.* description of Mniopsis Johnsonii in Wight, *l. c.*).

The seeds are usually very numerous, but in Farmeria we have a genus with a very small number (two or four) of larger seeds.

The Grouping of the Podostemaceæ.

Not merely is it extremely hard to place the order in its proper position in a natural system of classification, but it is almost equally difficult, in the present state of our knowledge, to divide it satisfactorily into sub-orders, genera, and species. The whole physiognomy of these plants is so different from that of most Phanerogams, the morphology is so peculiar, the organs are so variable, the plants are so exposed to injury by water currents, and the condition of the vegetative plant below water is so different from that of the dry fruiting specimen above, that all authors who have worked only with herbarium specimens or with small quantities of material have fallen into errors in dealing with them. The study of these plants is beset with innumerable pitfalls for the unwary, and in no group is it so absolutely necessary to base distinguishing characters upon the examination and comparison of large quantities of material, and to study the entire life-history and morphology before diagnosing the groups. In numerous instances separate species and even genera have been founded upon different phases in the life-history of one plant, upon different parts of the same plant, or upon material taken from different levels upon the rocks, *e.g.*, the genera Lawia and Terniola above-mentioned are separated upon the morphology of their thalli, one being interpreted as of root, the other as of shoot, nature. In reality the plants examined are only varieties of one species, agreeing in all essential details, but in the one case the centre, in the other the growing apex, of the thallus was examined. The cases of Dicræa pterophylla (= Wallichii) and Podostemon acuminatum have been already mentioned. The genus Hydrobryum as re-defined by Weddell is based on the fan-like stigma of the species H. Griffithii, the only species left in the genus by that author; but if a number of specimens of this plant be examined, it will be found that all kinds of stigmas occur, down to the almost subulate ones that occur in other species, such as H. lichenoides. Hydrobryum olivaceum, Tul., has a flat lichen-like thallus when mature, but when young has an erect primary axis; the latter has been described as Podostemon Gardneri, Harv., and again as Dicræa apicata, Tul. Other instances could be quoted, but these will suffice. The primary division of the order into sub-orders and tribes is the easiest. Omitting the Hydrostachyaceæ as forming a separate order, the family separates naturally into two main groups, the Chlamydeæ and Achlamydeæ of Tulasne, distinguished mainly by the presence or absence of perianth. The former may be again separated into two small groups, the trimerous Tristicheæ and the pentamerous Weddellineæ. The latter may be arranged in a series of groups of increasing zygomorphism of flowers. Tulasne simply divides them according to the fruits into Isolobeæ or Eulacideæ and Anisolobeæ or Podostemoneæ. Weddell divides them into Mourereæ (stamen whorl complete) and Neolacideæ (incomplete whorl), and Bentham and Hooker adopt practically the same grouping, adding Weddellina to the Mourereæ. Warming in the "Naturl. Pflanzenfamilien" makes three groups, Marathreæ, Mourereæ, Eupodostemeæ, the last being the most zygomorphic in the flowers, but including isolobous and anisolobous fruits, and being further divided on this character into two smaller groups. In his recent paper already quoted, he divides the group into Apinagieæ, Mourereæ, Marathreæ, and Eupodostemeæ or Podostemeæ, sections of gradually increasing zygomorphism. We may, I think, regard this as the nearest approach at present possible to a natural grouping, but we must acquire a much more detailed knowledge of the order before we can draw up a good classification.

All the Asiatic species known belong to the Tristicheæ and Eupodostemeæ, and thus split into two widely separated groups.

The Asiatic Tristicheæ.—All the Asiatic species are referred by Weddell and Hooker to the genus Lawia (Terniola), but the morphology of the peculiar South Indian species L. ramosissima, Wmg., is so essentially different from that of the Lawias of the L. zeylanica type, that I prefer to place it in a separate genus, following Warming; I do not, however, think that it needs a genus to itself as suggested by him. It may very well form a sub-section of the almost cosmopolitan tropical genus Tristicha, and probably represents a more primitive form with relationships on one side to the other species of Tristicha and on another to Lawia. In many ways this plant may be looked upon as perhaps the most primitive in organization of all the Podostemaceæ, and in habit and mode of life it comes more near to the common type of water plants than any of the rest of the order. Including this plant in Tristicha of course involves a slight revision of the generic characters, and it may perhaps be well also to split the genus into two sub-genera, Dalzellia and Eutristicha.

The Asiatic Eupodostemeæ (in Warming's sense).—All the other Asiatic species belong to this group. The group itself, as indicated above, is a fairly natural one, but its further division into genera and species is very difficult, and will only be practicable with any degree of accuracy when we shall have acquired a much more detailed knowledge of the structure and life-history of its members. Warming in 1890* divided it according to the fruit into Isolobæ (*Dicræa*, Du Pet. Th., *Hydrobryum*, Endl., *Ceratolacis*, Wedd., *Angolæa*, Wedd.) and Heterolobæ (*Mniopsis*, Mart. et Zucc., *Podostemon*, Michx., *Oserya*, Tul. et Wedd., *Castelnavia*, Tul. et Wedd., *Sphærothylax*, Bischoff, to which have since been added *Leiothylax*, Wmg., *Cladopus*, Hj. Moll., *Farmeria*, Willis, *Willisia*, Wmg., *Griffithella*, Wmg., *Polypleurum*, Wmg.). Before going on to the rest of the taxonomy, we must deal with these genera, and consider their right to autonomy. Angolæa is an apparently well-marked African

* Engler and Prantl, Die Natürlichen Pflanzenfamilien.

genus, without representatives in Asia and America. Sphærothylax is a characteristic Abyssinian genus, and Leiothylax is near to it. Cladopus, another very peculiar form in many respects, appears to be a good genus, confined, so far as we yet know, to Java. Castelnavia is probably a compound or polyphyletic genus, but at least has no representatives in Asia. We must consider the others in more detail.

All the American Podostemons, so far as we know them (chiefly from the beautiful work of Professor Warming) have long cylindrical or slightly flattened narrow creeping roots, bearing complexly-branched many-flowered secondary shoots, whose leaves are often compound, and which show no formation of scales or bracts in the way seen in most of the forms found in India. The capsule is ribbed, with one deciduous valve (see figures in Warming, *l.c.* I., III., V.). The American Mniopses have similar morphological construction, but smooth capsules and multifid stigmas with large papillæ (*l.c.* I., III., V.). It seems therefore that the latter is a genus of which there are no Asiatic representatives, unless Podostemon Hookerianus, Benth. (Mniopsis Hookeriana, Tul.), or P. selaginoides, Benth. (M. selaginoides, Bedd.), belong to it. Neither of these has the stigma of the American forms, nor the vegetative morphological construction, and both come as near to other genera as to Mniopsis proper. I think, therefore, that we may provisionally accept Mniopsis as a good genus, characterized especially by the capsules and stigmas, and confined to America. Oserya § Devillea, also American, comes near to it, but has not the same stigma, and has only one stamen. Probably it is distinct, but further study is needed, and it does not concern us here; Oserya § Euoserya is evidently a Podostemon, differing from the other species only in being monandrous. Turning to Podostemon, we soon find that the only Asiatic forms which approach the American in all the characters mentioned above are Podostemon subulatus, Gardn., in Ceylon, and P. Barberi, Willis, lately discovered in south-west

India. Later research may exclude these, but for the present they may best be regarded as species of Podostemon. They have simple leaves, but some of the American species have the same, and they show many points which, as compared with most of the Indian forms, seem primitive; perhaps their position in the extreme south-west also indicates their antiquity.

Under Podostemon, Warming and other authors include the curious flat lichen-like thalloid species, olivaceus, Johnsonii, lichenoides, and the new species sessile. I have shown below that these forms are perhaps better placed under Hydrobryum, along with the solitary species H. Griffithii, left in it by Weddell, Hooker, Warming, &c., as the stigmatic character of this species is not constant and cannot be used as generic; this genus will thus include species with smooth and ribbed fruits, and with iso- and heterolobous fruits. In most cases these differences are almost generic, but in this case they seem of less importance. A new genus, coming near to the thus extended Hydrobryum, is Farmeria, Willis, with one species in Ceylon (with a sessile, indehiscent smooth fruit) and one in South India (with a stalked, ten-ribbed, dehiscent, anisolobous fruit). This is well marked, so far as we yet know, by its thallus morphology and few seeds.

Now, take the genus Dicræa, merged in Podostemon by Bentham and Hooker; is it to stand, and if so, what is it to include? As defined by Tulasne, it has a ribbed isolobous fruit with both valves persistent, with one-flowered secondary shoots on a more or less dimorphic ribbon-like root thallus. Apart from the fruit, the flower resembles that of Podostemon. Under this definition comes a large group of nearly allied Indian species, fairly sharply marked off from any others: D. elongata, Wallichii, minor, dichotoma, stylosa. All these are very variable plants, but agree closely in many characters, possessing an exogenously branched ribbon-like thallus, partly floating freely in the water, with small one-flowered secondary shoots, leafy at first, afterwards with scaly bracts formed by a metamorphosis of the leaf-bases, and equal-valved 8- (or 9- to 12-) ribbed fruit, both of whose lobes persist. Taking all characters together, the Dicræas are a very distinct group, probably, from their isolobous fruit, as old at least as the Podostemons proper, and I am inclined to retain the genus, not to merge it in Podostemon. Possibly P. Barberi comes near to Dicræa, but it has an unequal-valved fruit and no bracts, so that the resemblance is not so close as at first thought appears. The South American genus Ceratolacis comes very near to Dicræa, and perhaps should be united with it, but detailed study of the former is required.

There remain now the two very peculiar species, selaginoides and Hookerianus, placed under Podostemon in Hooker's Flora, under Dicræa and Podostemon by Weddell. If either is to be placed in the former genus, its special characters require complete revision, because both have smooth fruits with one deciduous valve. Their characters differ in many other points from those of the Dicræas, and there seems to be no reason for placing them in that genus. Here, as so often in dealing with the Asiatic species, Weddell's work bears marks of haste and want of due consideration, so necessary in a puzzling group like this. Bentham and Hooker place both of these species in Podostemon, apparently simply because Weddell placed them in Dicræa and Podostemon, genera which they unite. They differ as much from the rest of the Podostemons as from the Dicræas. Warming gets over the difficulty by giving each a separate genus (Griffithella Hookeriana, Willisia selaginoides), and they are so distinct from most other forms of the family that this course is perhaps the best until we have a fuller knowledge of the group. They show relationships to Podostemon, Mniopsis, and perhaps other genera, and are probably ancient survivals.

The genus Polypleurum, Wmg., is, I think, untenable, resting on insufficient knowledge of the morphology of the species proposed to be included in it. The position of the

Siamese species P. Schmidtianum, Wmg., cannot be settled till we know its fruit : P. acuminatum, Wmg., is a Hydrobryum (lichenoides, Kurz), and P. Wallichii, Wmg., is a Dicræa.

We thus get the following as a preliminary grouping of the Eupodostemeæ :—

	Asiatic Species.
Dicræa, *Du Pet. Th.*	elongata, dichotoma, minor, Wallichii, stylosa.
Ceratolacis, *Wedd.*	
Podostemon, *Michx.*	subulatus, Barberi, (?) Schmidtianum.
Mniopsis, *Mart. et Zucc.*	
Oserya, *Tul. et Wedd.*	
Castelnavia, *Tul. et Wedd.*	
Griffithella, *Warming.*	Hookeriana.
Willisia, *Warming.*	selaginoides.
Sphærothylax, *Bischoff.*	
Leiothylax, *Warming.*	
Cladopus, *Hj. Möll.*	Nymani.
Hydrobryum, *Endl.*	Griffithii, sessile, olivaceum, Johnsonii, lichenoides.
Farmeria, *Willis.*	metzgerioides, indica.

The Generic and Specific Limits of the Asiatic Forms.

In an order of plants of such unusual features, such variability, and such polymorphism, it is of course impossible to draw the specific limits with any accuracy or certainty until the life-histories and the morphology of the various forms have been studied in detail. There is little doubt in my mind that the number of distinct forms will ultimately prove to be very great, and that there will be much dispute over their claims to specific rank, as with many other variable forms. Weddell* and Goebel† have already called attention to the fact that in the large rivers of South America the forms are different at each successive

* Sur les Podostemacées en général et leur distribution geographique en particulier. Bull. Soc. Bot. France, XIX., 1872, p. 50.

† Pflanzenbiologische Schilderungen, II., p. 333.

cataract, perhaps specifically. My own work on the Asiatic forms leads me to believe that this is generally true, and that when we shall ultimately have acquired a detailed knowledge of their morphology and life-history, we shall find that each river or group of rivers, if not each branch or section of each large river, has its own peculiar forms of each genus or species represented in it. Even from the comparatively small amount of material in my hands, a great number of species might easily be made by admitting as specific the well-defined differences between them. A vast amount of comparative work on the spot is required to thoroughly sift the question, and I therefore refrain from complicating the already tangled mass of taxonomic literature by making numerous new species. I have rather, probably, erred in the opposite direction by drawing my specific limits very widely indeed. Under each I have mentioned most of the well-marked forms observed by myself in the various localities visited.

With regard to the genera, I have adopted a somewhat different course, and have perhaps drawn my generic limits too narrowly, my object having been to indicate the groups into which the species naturally divide themselves. Probably further study and investigation of the doubtless numerous undiscovered species of South-east Asia and tropical Africa will bridge over many of the gaps, and clearly show which genera are to be finally retained as natural.

Podostemaceæ Indicæ.

Flowers hermaphrodite, regular 3-merous with perianth, or zygomorphic 2-merous without perianth, hypogynous, small, inconspicuous, anemophilous. Perianth when present (3), imbricate, sepaloid, equalling or exceeding ovary, marcescent. Achlamydeous flowers included before opening in a closed spathe, which opens irregularly at the tip or by a slit on the upper side. Stamens hypogynous, in regular flowers 3 alternate with perianth segments, in irregular flowers 1–3, usually 2, monadelphous on the lower side of the flower, the common stalk usually much exceeding the partial filaments. Staminodes or abortive perianth segments in zygomorphic flowers usually 2, filamentous, on either side of andrœceum, with sometimes a third between the partial filaments. Anthers introrse, 2-locular. Pollen grains didymous in zygomorphic flowers. Ovary superior, usually more or less ellipsoid, often oblique, 3- or 2-locular with thick central placenta and very delicate septa ; the outer wall usually smooth or only very faintly ribbed, often with deciduous cortex. Ovules anatropous, usually ∞, and very minute, few and larger in Farmeria. Stigmas as many as carpels, sessile, subulate, dentate, or cuneate, often lobed. Capsule usually pedicellate, the pedicel of the flower lengthening after fertilization and at the same time becoming woody and losing its deciduous pellucid cortical tissue, ribbed or smooth, septifragal (closed in one sp. of Farmeria), with equal or unequal lobes, in the former case both, in the latter the larger, persistent on the pedicel after dehiscence. Seeds usually ∞, small, with mucilaginous outer coat. Endosperm 0. Embryo straight, simple.

Herbs of rapids and waterfalls in mountains of India, Burma, and Ceylon, usually annual, submerged, and closely attached to the rocks, flowering when exposed in the dry season by the fall of the water level, with the habit and structure of algæ, lichens, mosses, and liverworts. Germination with the onset of the rains. Primary axis various, early giving rise to a thallus, in Lawia composed of flattened shoot, in the other genera of a root structure which assumes various forms, thread-like, ribbon-like, disc-like, cup-like, &c., attached to the rock at all points or only at the centre, or at the centre and two or three outer points, bearing the leafy endogenous secondary shoots on the margins or on the upper surfaces. Secondary shoots leafy only in the vegetative season ; leaves usually more or less distichous, except in the Chlamydatæ, simple, usually sheathing, often hairy on the upper surface; axis in most forms elongating only towards the flowering season, when the leaves usually enlarge at the bases to form bracts, whose leafy tips fall off. Flowers usually terminal, on the thallus apices in Lawia, on the secondary shoots in the other genera, enclosed in spathes in the achlamydeous forms, one or more on each shoot, sessile or pedicellate, usually not opening till exposed to the air.

Fl. regular. Perianth (3). Stamens 3. G (3) ... ... *CHLAMYDATÆ.*

zygomorphic, naked. Stamens (1–3). G (2) ... ... *ACHLAMYDATÆ.*

CHLAMYDATÆ—

Thallus a thread-like creeping root; secondary shoots long, complexly branched, freely floating, bearing ramuli or moss-like shoots of limited growth. Floral axis subtended by few leaves, sometimes slightly connate ... *Tristicha.*

Thallus frondose, foliiferous, creeping, closely attached to rocks; secondary shoots of small rosettes of leaves on upper side of thallus. Floral shoots arising from axial cupules ... *Lawia.*

ACHLAMYDATÆ (all belong to Eupodostemeæ)—

Fruit ribbed, iso- or aniso-lobous, dehiscent, with ∞ seeds. Spathe erect, more or less cylindrical, opening at apex by several teeth.

Thallus fucoid or dimorphic, usually freely floating; secondary shoots 1-flowered with scaly bracts; fruit isolobous ... ... *Dicræa.*

Thallus thread- or ribbon-like, creeping; secondary shoots erect, with several flowers; bracts dithecous, not scaly; fruit anisolobous ... *Podostemon.*

Fruit smooth, anisolobous, dehiscent, with ∞ seeds. Spathe erect, toothed or bifid.

Thallus fucoid or attached and closely creeping; secondary shoots small with distichous leaves ... ... *Griffithella*

Thallus crustaceous, attached to rock, secondary shoots large, erect, with 4-ranked leaves. Spathe bi-lobed at tip ... *Willisia.*

Fruit ribbed iso- or aniso-lobous dehiscent, or smooth anisolobous dehiscent or indehiscent, with ∞ or few seeds. Spathe more or less prostrate, splitting along the upper side. Thallus closely attached to rock.

Thallus crustaceous or ribbon-like, exogenously lobed or branched; secondary shoots usually prostrate when floriferous, 1-flowered with small scaly bracts. Seeds ∞, fruit dehiscent, iso- or aniso-lobous, ribbed, or smooth ... *Hydrobryum.*

Thallus ribbon-like, endogenously branched; secondary shoots as in Hydrobryum, but behind the branches of thallus. Seeds 2–4, fruit dehiscent or not, ribbed or not ... ... *Farmeria.*

TRISTICHEÆ.

TRISTICHA, Du Pet. Th. Nov. Gen. Madag., p. 2, No. 8, 1806; Endl., Gen. Plant., p. 270, No. 1835; Presl., Rel. Haenk., p. 86; Meisner, Vas. Gen., p. 122; Gardn., Calc. J. N. H., VII., p. 177 p.p.; Tul. in Ann. Sc. Nat., ser. 3, t. XI., 1849, p. 111, and Monographia Podostemacearum, 1852, p. 179; Dufour; *Dufourea*, Bory in Willd. Sp. Pl., pt. 5, p. 55, Willdenow, A. St. Hil., A. Rich., Spreng., Roem. et Sch., non H. B. K., nec Delise; *Philocrena*, Bong.; *Dalzellia*, Wight, p.p., Warming; *Terniola* (Tul.), Wedd., p.p.; *Lawia* (Tul.), Wmg., O. Kuntze, p.p.; *Tulasnea*, Wight, p.p.

Perianth (3). Stamens 1 or 3, alternating with perianth segments. Carpels (3), stigmas 3. Roots creeping; shoots not thalloid, much branched, many-flowered.

Perianth 3-partite hypogynous, imbricate, sepaloid, membranous, marcescent. Stamens 1 or 3, alternate with perianth segments; filaments slender; anther ovate, pollen globose. Ovary superior, free, ellipsoidal, 3-gonous, 3-locular, with thick placentæ and ∞ anatropous ovules; septa thin and fragile. Stigmas 3, linear or subulate, often with long papillæ or hairs, marcescent. Capsule triangular, 9-ribbed, 3-locular, septifragal, equi-valved. Seeds ∞.

Submerged herbs with the habit of Fontinalis and other aquatic mosses. Primary axis unknown? Roots creeping, filamentous, attached by feet or haptera. Secondary shoots ∞, endogenous in the roots, often more or less paired on opposite sides, floating freely in the water, when developed in their highest form often long, many-flowered, and frequently branched, but often quite short, unbranched or nearly so, and 1-flowered or vegetative only. Branches of two kinds, long branches repeating the structure of the main axis, and short branches or ramuli, consisting of a delicate axis with ∞ small leaves, often 3-stichous. Flowers terminal on pedicels subtended by 2–3 large or several ordinary leaves, in the latter case the upper ones more or less united. Pedicel and ovary with deciduous cortex, which shrivels after flowering. Flowers small, usually (?) emerging through the water at the beginning of dry season.

Cosmopolitan tropical. South America, Mexico, Africa, Madagascar, India.

§1. Dalzellia, (*Wight*) *Warming* (as genus). Stamens 3. Leaves of ramuli not tristichous. Flower subtended by several ordinary leaves, the upper united. India.

1. T. ramosissima, (*Wight*) *Willis*.

§2. Eutristicha, *Willis*. Stamen 1. Leaves of ramuli more or less tristichous. Flower subtended by two or three larger leaves. America, Africa.

2. T. hypnoides, *Spr.*
3. T. alternifolia, *Tul.*

TRISTICHA RAMOSISSIMA, (Wight) Willis; Lawia ramosissima, *Warming*, in Engl. Prtl. Nat. Pflanzenfam., *O. Kuntze;* Terniola ramosissima, *Wedd.*, in DC. Prodr. Dalzellia ramosissima, *Wight*, Ic. Pl. As., p. 35, 1852; Tulasnea ramosissima *Wight*, l. c., t. 1,920.

Stamens 3. Ramuli not tristichous. Upper leaves of floral shoot connate. Stigmas 3, long, filamentous, hairy.

Primary axis unknown (?). Roots cylindrical, filamentous, creeping, frequently branched, and attached to the rock by root hairs, haptera, or disc-like feet. Secondary shoots ∞, endogenous at the proximal ends of feet or haptera, floating freely in the water; when fully developed large—to 25 cm. long—and frequently branched, but often represented only by a ramulus or a tuft of ramuli, or by a short 1-flowered shoot. Leaves at apex of secondary axis small, narrow, simple, thin, in many ranks. Branches of two kinds, short branches or ramuli, developed first in the leaf axils, consisting of slender filiform axis of limited growth with ∞ entire simple thin linear or filamentous leaves irregularly arranged, and long branches, developed later above the ramuli and repeating the structure of the main axis. Flowers usually terminal on short shoots bearing a few leaves, the upper usually more or less connate, and two or more of the lower with ramuli in their axils, erect, emerging through the water, anemophilous. Pedicel 3–5 mm. lengthening to 5–15 mm. in fruit. Perianth sepaloid, marcescent. Stamens 3, much exserted, on flexible filaments. Anthers ovate-oblong, bilobed. Ovary superior, at first much shorter than perianth, but after fertilization elongating to the same length as the perianth, slightly trigonous. Stigmas 3, long, hairy, the tips usually deciduous. Capsule 9-ribbed.

In streams of the Western Ghats 300–4,000 feet, often in gently moving water, rather common. First discovered by the Rev. E. Johnson. S. Kanara, at Beltangadi, C. A. Barber, S. Ind. Flora, No. 2,517, 2,518 ! Malabar, in streams near Cochin, Rev. E. Johnson ! Anamalai Mountains, in the Sholai Aar, Monica Estate, at 4,000 feet, J. C. Willis ! Travancore, at Mundakayam, 300 feet, T. F. Bourdillon !

All these forms show slight differences in size and shape of leaves, number of leaves on the ramulus, and other features, but much further study of material from many localities is needed before the varietal rank of the different forms can be decided.

LAWIA (Griff. MS.), Tul. in Ann. Sc. Nat., 3me. ser., t. XI. p. 112; Warming, in Engl. Pr. Nat. Pflanzenfam. ; Trimen, Fl. Ceylon ; non Wight (=Adenosachme); *Terniola*, Tul., in Monogr. Pod., p. 189 ; Hooker, Fl. Br. Ind. ; Wedd. in DC. Prodr. ; *Tulasnea*, Wight in Ic. Pl. As., t. 1,919 ; *Dalzellia*, Wight, l. c., p. 34 ; Thwaites in Enum. Pl. Zeyl., p. 223 ; *Tristichæ sp.*, Gardner in Calc. J. N. H., VII., p. 177 ; *Mnianthus*, Walp. Ann. Bot. Syst. III., 443.

Species ramosissima excluded. Specific names unaltered under the various generic names.

Perianth (3). Stamens 3, alternating with the perianth segments. Carpels (3). Stigmas 3. No roots. Thallus frondose, branched, with rosettes of leaves endogenous on upper surface. Flowers ∞ at apices of lobes, emerging from axial cupules covered with small leaves. Fruit 9-ribbed.

Perianth 3-fid, regular, imbricate, membranous, brownish-coloured, marcescent. Stamens 3, hypogynous, alternating with the segments of the perianth; anthers 2-lobed, introrse, opening by longitudinal fissures; filaments oval in section. Pollen globose. Ovary of 3 carpels syncarpous, superior, ellipsoid, obtuse, more or less 3-angled, 3-locular, with ∞ anatropous ovules on a thick axile placenta; septa very thin. Stigmas 3, more or less linear, with large papillae, marcescent, simple. Capsule more or less enclosed in the persistent perianth, 1–3 mm. long, ellipsoid to obovoid, 9-ribbed, 3-locular, septifragal; valves 3, equal, opposite to the perianth, segments incurved after dehiscence, all ultimately deciduous. Seeds very numerous, minute, exalbuminous; outer layer of testa becoming sticky when wetted. Embryo straight, with crumpled cotyledons.

Herbs with frondose thalli, living on smooth rocks in rapids and waterfalls of the mountains of Western India and Ceylon, submerged in the period beginning with the onset of the south-west monsoon, and flowering in the dry season when exposed by the fall of the water Thallus closely attached to the rock, sub-orbicular or stellate, of shoot nature, rootless, attached by root hairs at all parts, usually much branched, with ribbon-like or flabelliform lobes; marginal growing points prostrate or slightly ascending. Leaves very numerous, simple, entire, usually acute, green or red with white-looking mesial line, very thin and delicate, and easily detached or broken in herbarium specimens: occurring in two positions, at or near the growing apices on the upper surface and edges of the thallus, and in closely packed endogenous rosettes on the upper surface of the older parts of the thallus. Leaves dimorphic at the growing points, the lateral ones broader and distichous, with the posterior margin uppermost, the upper ones linear and irregularly arranged; size variable, from 1–16 mm. long and to 3 mm. broad in the largest laterals. Older parts of the thallus leafless, except for the endogenous rosettes, but marked with scars of leaves. Flowers terminal on the growing points of the margins of the thallus, rarely on the upper surface, solitary, on pedicels emerging from terminal axial leafy cupules. Flowers radial in structure, but cupules thicker and shorter on the upper side, more or less ascending, bristly in herbarium specimens. Floral axis sometimes almost or completely foliose. Leaves on lower side of cupule larger, distichous, as at vegetative apices. Pedicel at anthesis about 3–6 mm. long, covered, as also is the ovary, with a pellucid cellular cortex, which falls off after flowering, the inner tissues becoming lignified and forming an elastic pedicel to the fruit, 5–25 mm. long, erect.

Seedling at first minute, tuberous by the swelling of the hypocotyl, with flat green membranous cotyledons, without erect primary axis, the growing point immediately growing out laterally to form the thallus by continual branching.

It is impossible to monograph this genus from the existing herbarium material ; the thallus is so closely attached to the rock that it cannot be removed entire, and the plants are very variable in their morphological features. Seven species are recognized by Weddell, and by Hooker, who follows him, but any one who has ever tried to identify a form from the descriptions must have suspected the genuineness of the species. I have transferred to Tristicha, above, the most aberrant form, *L. ramosissima*, placed under this genus by the authors mentioned, and by careful examination of living, alcohol, and herbarium material, have reduced the other six species to one. These six are :—

L. zeylanica, Tul.	L. Lawii (Wight), Wmg.
pulchella, Tul.	pedunculosa (Wight), Wmg.
longipes, Tul.	foliosa (Wight), Wmg.

L. zeylanica was discovered and described by Gardner in Ceylon. The other five are all based on Law's material, collected in the Ghats, east of Bombay, as mentioned above. In Law's letters, above quoted, we have seen that he himself only collected two forms, so far as the letters show. He evidently sent material of these to Wight, and also to Sir W. J. Hooker, from whom Tulasne obtained them for his monograph. Both Tulasne and Wight have left type packets, which I have examined at Kew and Paris. All of these contain labels in Law's handwriting, either "Lawia No. 1" or "Lawia No. 2." No other numbers occur. Tulasne named these L. longipes and L. pulchella respectively ; Wight, who in his Icones admits that he has not seen any of Tulasne's specimens, names the same plants Dalzellia or Tulasnea pedunculosa and D. Lawii respectively. I have confirmed this by actual examination of the specimens, which agree with one another in detail. Lawia pedunculosa thus is a mere synonym of L. longipes, and L. Lawii of L. pulchella.

We now have L. foliosa, another of Wight's species, to consider. Specimens from his herbarium, named in his own handwriting, are in the Kew herbarium; the packet is marked on the outside "Lawia No. 1, Law, Bombay," in Law's handwriting. The character on which Wight bases the species is the supposed absence of any union of the leaves at the base of the pedicel of the flower; in the other species the leaves are always united more or less into a cupular structure, or rather, the axis bearing the leaves is cupular. Examining Wight's material, I found the foliose character in a few of the flowers, but others had a distinct cupule, and in all other respects the material exactly resembled his L. pedunculosa, which is also Law's "Lawia No. 1." Wight, therefore, appears to have divided up Law's material into these two species on the chance observation of one or two flower axes (probably supposing each axis to represent a whole plant), and the fact that some axes were foliose, others not, showed the species to be untenable on his material. Warming, however, describes in detail a specimen collected at Khandalla by Goebel, which has the foliose character very well marked, at any rate in the bud stage, which is all that Warming (*l. c.* IV., 159) figures. By the kindness of Prof. Goebel, I have had the opportunity of examining his material, and find that it is usually cupular, but that in the bud stage it is occasionally foliose, and I have further verified this observation upon living material collected by myself at Khandalla and elsewhere in the Ghats, east of Bombay. Wight's L. foliosa, therefore, falls to the ground as an independent species, becoming a synonym of his pedunculosa, *i.e.*, of Tulasne's longipes.

We are thus reduced to Tulasne's three species, which, so far as herbarium material shows, are well separated, mainly by length of leaves and fruiting pedicels. I have, however, found by examination of large quantities of material that these characters are too variable to be relied upon, even in living material. Long and short leaves and pedicels may occur on the same plant, and it is by no means difficult to get from one plant in the Bombay Ghats pieces resembling the types of L. pulchella and L. longipes respectively. These two must therefore be united, and the only question left is whether the Indian forms are specifically distinct from the Ceylon forms. Enormous labour will be needed to fully settle this question, but for the present I have no hesitation in uniting them, though, as already mentioned, every locality seems to have its own peculiar form. The Indian forms agree fairly well among themselves in the following points of difference from those of Ceylon : they have a rather longer fruiting pedicel, a more obovoid and lighter coloured fruit, thinner fruit ribs, and usually rather longer leaves. The thallus type of the northern forms is more like that of the common Ceylon forms than that of the southern, so that it is possible that the two should be separated on geographical grounds, but for the present our knowledge is insufficient. Four groups of forms are found among the material at my disposal.

S. W. India and Ceylon. Only species L. zeylanica.

LAWIA ZEYLANICA, Tul. in Ann. Sc. Nat., ser. 3, t. XI., p. 112 ; Trimen, Fl. Ceyl., III., 416 ; Warming, &c. ; L. pulchella, *Tul.*, l. c. ; L. longipes, *Tul.*, l. c.; L. Lawii (*Wight*), *Warming*, *O. Kuntze ;* L. pedunculosa (*Wight*), *Warming*, *O. Kuntze ;* L. foliosa (*Wight*), *Warming*, *O. Kuntze ;* Terniola zeylanica, *Tul.*, Podo. Monogr., p. 190, t. 13 ; T. pulchella, *Tul.*, l. c. ; T. longipes, *Tul.*, l. c. ; Terniolæ spp. omn., ramosissima excepta, *Wedd.* in DC. Prodr., XVII., 46, *Hooker* in Fl. Br. Ind., V., 62 ; Tristicha ceylanica, *Gardn.* in Calc. Journ. Nat. Hist., VII., 177, 1846 ; Dalzelliæ spp. omn., ramosissima excepta, *Wight*, Ic. Pl. As., p. 34 ; *Thwaites*, Enum. Pl. Zeyl., 223, C. P., 3,809 ; Tulasneæ spp. omn., ramosissima excepta, *Wight*, l. c., tt. 1,919, 1,920 ; Mnianthus zeylanicus, pulchellus, longipes, *Walp.*, Ann. III., 443.

Thallus frondose, creeping, with ribbon-like or flabelliform tips ; flowers solitary, very numerous, terminal, emerging from leafy axial cupules of varying depth; leaves and pedicels varying in length, apical leaves dimorphic.

Thallus frondiform, rootless, closely attached to the rock by root hairs to the tips of the growing apices, often reaching 20–35 cm. in diameter, spreading in all directions, about 0·5 mm. thick, hard, and siliceous, deep crimson or green in colour when alive, much branched, with flabelliform or ribbon-like apical lobes; the branches to 10 mm. broad, diverging at a moderate angle from the main stem, closely crowded or scattered. Leaves very numerous, both at the growing points, where they are borne directly on the thallus, and on the older parts of the thallus, where they occur in endogenous rosettes, linear to linear-ovate, acute, very thin and delicate, 1–15 mm. long, with white mesial line in lower part, attached by broad base. Apical leaves dimorphic, the lateral ones distichous on the edges of the thallus, broader, the upper linear, more numerous, irregularly arranged on the upper surface. Flowers very numerous, closely crowded along the edges of the thallus, solitary, emerging from small terminal cupules, rarely on upper surface. Cupules ovate, about 0·5–2·0 mm. deep and 1·0–1·5 mm. broad at the mouth, axial, densely leafy above and on the edges, with thick upper and thin lower wall, free from thallus below, more or less ascending, bristly when dry. Peduncle from base of cupule about 2–6 mm. long when the flower opens, coated with pellucid cellular tissue which falls after flowering. Flower erect on the peduncle, often only emerging from the cupule when the water falls so as to expose the tip of the latter, which often remains closed so long as submerged. Perianth segments united for 2/3 of their height. Ovary ellipsoid subsessile, stigmas linear. Capsule about 2 mm. long, ellipsoid.

On smooth rocks in rapids, Ceylon, S.-W. India from Travancore to Bombay, to 2,500 feet, common.

This is an extremely variable plant, and specimens from many localities have been examined. Each locality seems to have its own form, but after close examination of all I incline to group them into four varieties, partly geographical.

L. zeylanica Gardneriana; Tristicha ceylanica, *Gardn.*—Thallus large, with flabelliform apices; leaves 1–3 mm. long; rosettes numerous. Cupules ovate, about 1·5–2·0 mm. deep, shortly bristly in dry specimens. Pedicel ultimately about 6 mm. long. Fruit ellipsoid, dark brown.

Ceylon only. First found by Gardner. Mahaweli-ganga at Hakinda near Peradeniya, Gardner! Thwaites (C. P. 3,809)! Willis! and at Haragama below Kandy, Thwaites! Laggala-oya (tributary of Mahaweli-ganga) in Matale east, Thwaites! Guru-oya at confluence with Hulu-ganga (tributary of Mahaweli-ganga) near Teldeniya, Willis! Kelani-ganga near Kitulgala, H. F. Macmillan!

L. zeylanica Parkiniana—

Thallus smaller than in last, more definitely branched, with long ribbon-like apical lobes, each terminated by one or few growing points; leaves usually 3–6 mm. long. Cupule with longer bristles. Fruit as in last.

Ceylon only. First found by Mr. J. Parkin at Hakinda in the Mahaweli-ganga! Guru-oya at confluence with Hulu-ganga, Willis! The latter specimens are rather smaller in all respects.

L. zeylanica malabarica; L. spp. indicæ, *Auctt.*—

Thallus to 6 inches or more in diameter, with frequent branching and ribbon-like lobes, tending to flabelliform lobing in some of the more northern forms. Leaves 3–9 mm. or more. Cupule usually short. Fruiting pedicel variable, averaging about 8 mm. long. Fruit obovoid-elliptical, 1–2 mm. long, light brown, with thin ribs and marked depressions between the carpels. Seeds light brown.

South India. Tinnevelli Ghats in the Tambraparni river, C. A. Barber, S. India Flora, No. 2,847! South Kanara, at Sullia, do. Nos. 2,150, 2,153, and at Beltangadi,* do. 2,516, 2,524, 2,525! Anamalais (?) Wight, spec. in hbb. N. Kanara, Talbot in the Kala Nuddi, No. 1,129, mixed with other Podostemaceæ. Wight and Talbot's specimens are too fragmentary for determination.

* In streams above the bridge near the Dâk bungalow.—C. A. B.

L. zeylanica konkanica; L. spp. indicæ, *Auctt.*—

Thallus to 6 or 10 inches, with flabelliform lobes and crowded growing points, occasionally tending to ribbon forms with single or few growing points. Leaves 6–15 mm. Cupule short or long, often foliose when young. Flowers often nodding in bud. Fruit pedicel very variable, averaging 8–9 mm. Fruit $1\frac{1}{2}$–$2\frac{1}{2}$ mm. long, obovoid, light brown, otherwise as in preceding.

Western India. Igatpuri in the Thul Ghat,* Willis, 1,800 feet! Kasara, Thul Ghat,† 800 feet, Willis! Khandalla and Lanauli,‡ in the Bhor Ghat, 1,500–2,500 feet, common, Willis! Sakarpathar, near Lanauli, Woodrow! Tiger Leap, near Khandalla, Woodrow! Khadshi river, near Bhorkus, west of Poona, R. K. Bhide! The Konkan, Dalzell, Law, Ritchie, &c., in herbaria; specimens too fragmentary for determination.

EUPODOSTEMEÆ.

DICRÆA (male Dicræia) (Du Pet. Th., Nov. Gen. Madag., p. 2, No. 4, 1806), Tul. in Ann. Sc. Nat., 3 ser., t. XI., 1849, p. 100, and Podo. Monogr., p. 114; Wedd. in DC. Prodr., XVII., p. 67; Wight, Warming, ll. cc.; *Podostemonis spp.*, Griffith in As. Res., XIX., 103; Gardner in Calc. J.N.H., VII., p. 179, and in Flora, 8, p. 40; Bentham and Hooker, Hooker in Fl. Brit. India; Trimen in Fl. Ceyl., &c.; *Polypleurum*, Tayl. MS. ex Tul., Warming, p.p.; *Lacis* (Lindl.), Steud., p.p.

Flower zygomorphic, naked. Stamens (2 or 1) with staminodes on either side of common axis. Ovary smooth, ripening to 8- (rarely 8–12-) ribbed isolobous fruit with ∞ seeds.

* In a stream below the Bombay road on the right-hand side going from Igatpuri, at about the 31st milestone.

† In streams crossing the road to Bombay below Kasara station, and especially in the large stream about one mile down the road, at a series of rapids about $\frac{1}{3}$ mile down stream from the bridge.

‡ Enormous quantities in the stream below the Hamilton Hotel on the left going from Khandalla to Lanauli; also in stream on the right after crossing the railway from the Hamilton Hotel, and in nearly all streams in the district and on far side of Sakarpathar.

Thallus various, usually freely floating from attached base exogenously branched, with marginal ultimately 1-flowered secondary shoots. Flowers enclosed in spathes, splitting irregularly at the tip, and subtended by 2–8 (usually 4) fleshy scaly bracts.

Flower zygomorphic, naked, enclosed before anthesis in a tubular, usually oblanceolate spathe, which opens irregularly at the tip, pedicellate, the pedicel lengthening as the fruit ripens and shedding its deciduous cortex. Stamens 2, rarely 1, monadelphous, with a filamentous staminode on either side of the common stalk. Pollen didymous. Ovary symmetrical, elliptical, 2-locular, with two equal or unequal subulate marcescent stigmas with small papillæ. Ovules ∞. Capsule isolobous, 8- or rarely 9–12-ribbed, the ribs on both valves decurrent into the pedicel, septifragal, both valves persistent. Seeds ∞.

Submerged herbs with the habit of Fucus and other seaweeds. Primary axis (? always) very short, non-flowering, giving rise laterally by endogenous development to a thallus of phylogenetic root nature, exogenously branched with root cap, ribbon-like, cup-like, filamentous, fucoid, often crisped or twisted, attached to the rock by a foot or by haptera, or by a creeping basal portion, or at all or most points, but usually with the distal parts drifting freely out in the water. Secondary axes ∞, endogenous on the upper sides of the thallus near the edge, or rarely in the central parts, consisting in the vegetative season each of a fascicle of small leaves with included evanescent axis, and all or some of them ultimately floriferous. Vascular bundles leading to floriferous shoots, and immediately adjacent parts of tissue of thallus becoming woody in flowering season, the rest of the tissue and the non-floriferous parts ultimately falling away (as, *e.g.*, in most herbarium specimens). Floriferous axes exserted, with 2–8 (usually about 4) distichous imbricated bracts, the upper larger, narrowly linear to broadly ovate or helmet-shaped, sheathing, thicker on the upper side, formed by the enlargement of the sheathing bases of the leaves and the fall or decay of the tips. Flower solitary, terminal, enclosed in spathe, opening when exposed to air.

The Indian and Ceylon species here included form a very natural group. There are also two species in Madagascar, about which more information is required. I use the genus in practically the same sense as defined by Tulasne. The latter's section Ceratolacis was made into an independent genus by Weddell, as mentioned above, but on further examination may probably be found to be best placed in Dicræa. Tulasne's other sections are based on insufficient knowledge of the forms, and the grouping of the Dicræas under Podostemon, as in Bentham and Hooker's Genera Plantarum and in the Flora of British India, is still more artificial, completely breaking up the genus and including in the section Dicræa the markedly different form Podostemon subulatus. Weddell spoiled the genus by admitting the smooth anisolobous-fruited Willisia selaginoides.

The Dicræas are very abundant in all the Podostemaceæ regions of India and Ceylon, and are extraordinarily variable and polymorphic. It is not yet possible to draw good specific limits, and unsafe to try to define varietal forms. I give below a tentative grouping of the forms studied by myself in fresh and preserved material, and have drawn the specific limits very widely.

Owing to the curious way in which the parts of the thallus not directly concerned in the production and nutrition of the flowers and fruit break away towards the end of the life of the plant, there is a great difference in the morphological structure, as already mentioned (p. 191), between the submerged plants and the dry fruiting specimens, in most cases. This will be more clear after the appearance of the figures illustrating the genus in the subsequent paper.

We have so little knowledge of the Madagascar species that it may easily prove to be the case that they are generically distinct, in which case our genus will have to be re-named.

Madagascar, Ceylon, Travancore, and Anamalai Mountains to Kanara, Khasia Mountains of Assam, Burma. Abundant in all districts mentioned, variable.

Dicrææ indicæ.

Thallus narrow, long, with creeping basal portion and free distal. Secondary shoots (floral buds) sessile on thallus by narrow base and tapering downwards, or stalked, often linear or narrow oblong.

Thallus cylindrical, filamentous, to 50 cm. long in free parts; pedicel of fruit about 8 mm. ...D. elongata, Tul.

Thallus narrow, ribbon-like, flattened, to 30 cm. in free parts; pedicel about 6 mm. ... ...D. dichotoma, Tul.

Thallus various, usually broad, rarely over 20 cm. long. Secondary shoots (floral buds) sessile on thallus by broad base, and often square, or broader than high ; bracts usually markedly helmet-shaped.

Pedicel of fruit under 5 mm. long. ...D. minor, Wedd.

Pedicel of fruit over 5 mm. long.

Thallus usually small, to 10 cm. long and 1 broad, algiform, branched, but becoming apparently much branched and narrow in dry specimens by breaking away of intermediate tissues. Pedicel 8–25 mm. N.E. India and Burma ... ...D. Wallichii, Tul.

Thallus usually large, algiform, often to 30 cm., usually much branched. Pedicel 6–40 mm. S.W. India and Ceylon ...D. stylosa, Wight.

DICRÆA ELONGATA, Tul. in Ann. Sc. Nat., 3 ser., t. XI., 1849, p. 102, and in Pod. Monogr., p. 124 ; *Wight*, *Thwaites*, *Wedd.*, *Warming*, ll. cc.; Podostemon elongatum, *Gardner*, in Calc. J. N. H., VII., 1846, p. 188; *Hooker*, *Trimen*, ll. cc.

Thallus long, narrow, cylindrical, tapering to filamentous, attached at base by creeping hapterous part, and with cæspitose freely floating parts to 50 cm. long. Secondary shoots distichous, the lower $\frac{1}{3}$ to $\frac{1}{2}$ ultimately floriferous, the rest deciduous with tips of thallus. Floral buds usually slightly stalked, narrow. Fruiting pedicel about 8 mm.

Thallus cylindrical, dimorphic, rarely over 3 mm. thick in any part; lower part frequently branched, creeping, attached by haptera and root hairs, and giving off cæspitose freely floating branches to 50–60 cm. long, sparingly branched and tapering to capillary ends. Secondary shoots distichous, chiefly on the floating thalli, usually about 5 mm. apart; the lower $\frac{1}{3}$ or $\frac{1}{2}$ or rarely more ultimately floriferous. Floriferous part of thallus woody, and the rest of the thallus, including the marginal parts of the floriferous portion, usually deciduous, at least on exposure to the air. Floral shoots in bud usually linear to oblong, widening upwards, not crowded together, the axis elongated above the surface of the thallus, with 2–5 (usually 4) distichous scales. Scales imbricate, often connate at base, most often with pointed tips after the fall of the leafy ends, but frequently more or less cowl-shaped. Spathe at first included, soon emergent, 2–5 mm. long when open. Pedicel about 4–5 mm. lengthening to about 5–9 mm. in ripe fruit. Stamens 2, equalling ovary with stigmas, staminodes shorter. Ovary smooth. Stigmas 2, sessile, shorter than ovary, stout, subulate, marcescent or deciduous. Capsule 1–2$\frac{1}{2}$ mm. oblong-elliptical, 8-ribbed. Fruiting thallus more or less erect on rocks.

Ceylon on rocks in rapids to 2,000 feet. Flowers January to March. First discovered by Gardner. Endemic.

Mahaweli-ganga in Ambegamuwa, Gardner, Mahaweli-ganga near Peradeniya, Gardner! Thwaites, C. P. 2,259! Trimen! Mahaweli-ganga at Hakinda rapids, Willis! Kelani-ganga at Kitulgala, Trimen! Bambarabotuwa-ganga, H. F. Macmillan!

A very distinct species, easily recognized by the long filamentous floating thalli, and by the comparatively widely separated and narrow floral shoots. The thallus tips are commonly missing in herbarium specimens. The Bambarabotuwa specimens have a rather smaller habit and more cowl-like bracts, but more material is required to decide whether they are specifically or even varietally distinct. Sometimes mixed in herbaria with D. stylosa laciniata. Good figures of this species are given by Tulasne (Monogr., t. IX.) and Warming (l. c. II., t. X.). See also Pl. XVIII., XIX., in subsequent paper.

DICRÆA DICHOTOMA, Tul. in Ann. Sc. Nat., l. c., 1849, and in Mon. Pod., p. 119; *Wight*, *Wedd.*, *Warming*, ll. cc.; D. Wightii, *Tul.*, *Wight*, ll. cc.; D. rigida, *Tul.*, *Wight*, ll. cc.; D. longifolia, *Wight*, l. c.; Podostemon dichotomum, Wightii, rigidum, *Gardn.* in Calc. J. N. H., VII., 1846; P. dichotomum, vars., *Benth.* in Hook. Fl. Br. Ind., &c.

Thallus long, narrow, thin, ribbon-like, oval in section, often zigzag, attached at base by creeping portion or foot, and with freely floating parts to 30 cm. long. Secondary shoots distichous, the lower $\frac{1}{3}$–$\frac{3}{4}$ ultimately floriferous, the rest deciduous with the tip of the thallus. Floral buds often slightly stalked, narrow. Pedicel of fruit about 6 mm.

Thallus flattened, oval in section, to 6 mm. wide, tapering ; lower portion usually sparingly branched, creeping, attached to rock at base and usually at several outer points, upper usually freely floating, to 10–30 cm. long, frequently branched, linear, often zigzag. Secondary shoots distichous on all parts of thallus, about 2–3 mm. apart, often on small lateral projections of the thallus, the lower or almost all ultimately floriferous, and then elongated above the thallus much as in the preceding species ; non-floriferous parts of thallus usually deciduous on exposure. Floral shoots in bud not closely crowded together, oblong or lanceolate to obovate, tapering downwards. Scales 4–5 or more, lower often connate, more or less helmet-shaped, at first with elongated leafy tips, which sometimes persist even after exposure (*D. Wightii* phase). Spathe much as in preceding species. Pedicel 3–6 mm. in flower, elongating to about 6–7 mm. in fruit. Stigmas ovate to subulate, marcescent or deciduous. Fruit 1–2 mm. long, 8-ribbed, the dehiscence ribs broader than in D. elongata. Fruiting thallus usually prostrate on rocks, with erect fruit stalks.

Nilgiris and Malabar Hills, on rocks in rapids, to 6,000 feet. Flowers November to March. First discovered by Gardner and Wight.

Paikara river, Nilgiris, near Paikara, Gardner ! Wight ! Proudlock ! Barber ! Gamble, 11,746 ! Willis !* River near Bangi Tappal,† Nilgiris, Gamble, 13,333 ! Malabar, Rev. E. Johnson !

A distinct species, fairly easily recognized by the thin ribbon-like thalli, short pedicels, and narrow floral shoots. It most nearly resembles D. stylosa, var. laciniata, or D. elongata.

Gardner, who originally discovered and described this species, divides it into three, to which Wight adds a fourth,

* Abundant at all rapids, commencing below the bridge near the Dâk bungalow at Paikara : especially good at Paikara Falls.

† About 22 miles south-west of Ootacamund, near Avalanche.

D. longifolia. Tulasne accepts these with hesitation, and Weddell, followed by Hooker, places them all under D. dichotoma as varieties. Without much further study, I am not prepared to admit even the varietal rank of these forms. The thallus varies much in stoutness and width, and in the degree of zigzagness, characters on which a good deal is based in the separation of the species mentioned. The form Wightii is mainly characterized by the apparently greater number and length of the bracts, but this depends merely on the specimens having been taken before the fall of the tips. The form longifolia is separated from dichotoma mainly on length of the leaves, a very variable character in most of the order. The species is figured by Tulasne, Monogr., t. IX.

DICRÆA MINOR, Wedd. in DC. Prodr., XVII., 1873, p. 71; Podostemon minor, *Benth. and Hk. f.; Hooker* in Fl. Br. Ind.

Thallus insufficiently known, apparently creeping, branched, ribbon-like, to 10 mm. wide and to 5 cm. long. Secondary shoots when floriferous sessile by broad base on thallus margins; bracts helmet-shaped. Fruiting pedicel very short, usually under 3 mm.

Thallus (*cf.* Griffith's rough sketch in Hb. Kew) stellately branched, algiform, ribbon-like, creeping, to 5 cm. long from centre and 3–10 mm. wide, hapterous at various points on the lower side. Secondary shoots marginal as in other species, some (all ?) ultimately floriferous. Bracts 2–5, more or less helmet-shaped, keeled, like those of D. Wallichii, or occasionally (?) like those of D. elongata, imbricate. Spathe very short, funnel-shaped. Pedicel of flower about 1 mm., lengthening to about 1½–4 mm. in fruit. Capsule 8-ribbed.

Assam, in the Khasia Mountains.

Borpani river, north of Nartiang, near Madan, Griffith, No. 2,437, ex. Hb. E. Ind. Co.; Khri river, below Nongkhlaw, Hooker (spirit material in Kew Museum, det. Weddell, fide Oliver).

This species is very imperfectly known, and may be only a phase of D. Wallichii. Griffith's specimens in the Kew

Herbarium are mere fragments. The spirit material collected by Hooker may be a different species or form ; I am not able to decide this question on account of insufficient supply of material. The main, or almost only, distinguishing mark of the species is the short pedicel of the fruit, but this may be due to its having been gathered unripe (*cf.* p. 194) or other cause. Fresh investigation is required on the spot where Griffith found it ; I much regret that I was unable to visit the place. The capsule is 8-ribbed, but Weddell describes it as having 10 ribs, probably having examined one in the early stages of opening. The idea of a sheath (*cf.* Weddell) at base of the flower stalk arises from the examination of bad herbarium specimens. The pedicel is so short that the bracts separate mainly on the top side to allow the escape of the flower.

DICRÆA WALLICHII, Tul. in Ann. Sc. Nat., l. c., p. 101, and Podo. Monogr., p. 118 ; *Wight*, *Wedd.*, ll. cc.; Podostemon Wallichii, *R. Br.* ex Wall., Cat. No. 5,225 (1828), *Griff.* in As. Res., XIX., 103 (descr. et ic.), *Gardn.*, *Benth.*, *Hooker*, ll. cc. ; Podostema Wallichii, *Royle*, Ill. Bot. Himal., I., 331 ; Dicræa pterophylla, *Wedd.* in DC. Prodr., XVII., 71 ; Podostemon pterophyllus, *Benth.*, *Hooker* in Fl. Br. Ind.; Lacis Wallichii, *Steud.;* Polypleurum orientale, *Tayl. MS. ex Tul.;* P. Wallichii, *Warming*, l. c. VI. ; Blandowia striata, *Lehm. MS. ex Tul.* (non Willd.).

Thallus algiform, ribbon-like, to 10 mm. wide and 10 cm. long, branched, more or less creeping, and attached at base and other points. Secondary shoots marginal or rarely central, some or all ultimately floriferous. Vascular bundles leading to flowers, and immediately surrounding tissue woody, the rest with the non-floriferous part of thallus deciduous. Floral buds sessile by a broad base, bracts helmet-shaped. Pedicel of fruit 8–25 mm. N.E. India and Burma.

Thallus Fucus-like when alive and submerged, attached at base by a foot and on outer parts by haptera, prostrate, branched, and lobed, to 10 cm. long or more and 1 cm. wide, ribbon-like, crisp, fleshy, with broad blunt apices; when gathered dry and in ripe fruit, small with cup-like base and fimbriate fruit-bearing outer ends. Secondary shoots on upper edges of margins, usually 2–3 mm. apart and hence rather crowded in flower, rarely on central parts of thallus, all or some ultimately floriferous, and then closely sessile on thallus and as broad as long before emergence of spathe. Bracts 2–7, usually 4, markedly cowl- or helmet-shaped, keeled, usually divaricate when open. Vascular bundles leading to flowers, with immediately adjacent tissue becoming woody, the rest of the thallus tissue deciduous, thus much altering the habit of the fruiting specimens. Spathe oblanceolate to 6 mm. long, splitting irregularly at the tip or occasionally on the under side. Pedicel of flower about 4–5 mm., elongating in fruit to 8–25 mm. Stamens equalling ovary and stigmas. Stigmas subulate, unequal, the lower larger. Capsule 8-ribbed, or with 2–4 extra ribs intercalated; ribs very narrow.

Assam and Burma on rocks in streams to 4,500 feet. Flowers October to February.

This species probably may be divided into two or more varieties or species. Wallich's original plant, found by Gomez in the Sylhet Hills, and all the Cherrapunji specimens of D. Wallichii and D. pterophylla, so far as I am aware, have short pedicels and eight ribs to the capsule. Some of Griffith's Assam specimens, locality unknown, have longer pedicels and more ribs than eight, and come near the specimens collected by Lehmann at Chepedong near Moulmein in Burma, and those collected in the same district by Parish in 1859. As mentioned above, D. pterophylla cannot be regarded as a separate species, being founded on material differing only from the typical D. Wallichii in having the keel of the bracts less disintegrated. I incline to think that there are two good varieties, geographically separated by the great valley of the Surma.

D. Wallichii Khasiana; D. Wallichii *(R. Br.), Tul.; Wedd.;* D. pterophylla, *Wedd.*

Pedicel of fruit 8–15 mm. Capsule 8-ribbed.

Khasia Mountains, plateau of Cherrapunji, 3,000–4,000 feet, on rocks in streams running towards Maosmai and

Maomloo, Griffith! Hooker! Clarke! Willis!* Sylhet rivers, Wallich! Sylhet Mountains, Gomez!

D. Wallichii striata; D. Wallichii (*R. Br.*), *Tul., p.p.: Wedd. p.p.;* Blandowia striata, *Lehm. MS. ex Tul.*

Pedicel usually 10–25 mm. Capsule usually with more than eight ribs.

Mountains of Burma (and Assam?), Chapedong near Moulmein, Lehmann, No. 3, 1827! Wallich, 33 in Hb. Kew! Moulmein, Parish 297, 1859!

DICRÆA STYLOSA, Wight in Ic. Pl. As., t. 1,917 (1852); *Wedd.* in DC. Prodr. XVII., p. 71; *Warming*, &c.; Podostemon stylosus, *Benth.* in Hk. Fl. Br. Ind.; Dicræa algæformis, *Bedd.* in Trans. Linn. Soc., XXV., p. 223, t. 24; D. algæoides, *Bedd. MS.;* Podostemon algæformis, *Benth.*, l. c.; *Trimen* in Fl. Ceyl.; P. fucoides, *Willis MS.* in herb. var.; P. laciniatus, *Willis MS.* in herb. var.

Thallus various in form and size, algiform, ribbon-like, to 1 cm. broad and 5–50 cm. long, freely branched, creeping, or floating from attached base, or partly creeping and partly floating. Secondary shoots marginal; the basal, rarely all or most, ultimately floriferous, 2–4 mm. apart, usually closely crowded when in flower. Flower buds usually sessile by broad base, bracts helmet-shaped. Pedicel of fruit in different varieties 6–40 mm. S.W. India and Ceylon.

Thallus Fucus-like or loriform, 2–10 mm. wide at base in different forms, tapering, of varying length from 5–50 cm., usually frequently branched, ribbon-like, oval in section, fleshy, often crisped or undulated, attached at the base by a stout foot, less often by a creeping portion, and frequently attached by haptera or hairs at other places or sometimes at all points. Secondary shoots ∞ on upper side, at the margins or very rarely in the central parts, 2–4 mm. apart, usually closely crowded when floriferous owing to the size of the buds. Lower $\frac{1}{5}$ to $\frac{1}{2}$, rarely more or all, ultimately floriferous, the non-floriferous

* Abundant at rocky places in river on left of path to Maomloo; also especially good in a tributary of the river crossed about half a mile from the Dâk bungalow on the road to Tharia Ghat; turn to the left just before reaching this stream and follow the path to the bridge over a rocky tributary, which is full of Dicræa.

ends and the margins of the flowering parts of the thallus usually deciduous. Floral buds closely sessile, usually as broad as long before the emergence of the spathe, often more or less prostrate on the thallus. Bracts usually 4–5, markedly helmet-shaped, in some forms with a tapering tip, keeled, thicker on upper side. Spathe tubular below, funnel-shaped above or altogether, opening irregularly at the tip. Pedicel about 2–5 mm. in flower, lengthening in fruit to 6–40 mm. in different varieties. Flowers much as in D. Wallichii. Stamens equalling or exceeding ovary. Stigmas two, varying in length, equalling ovary or shorter. Capsule 8-ribbed.

S.W. India and Ceylon.

Even more than the preceding, this species, as here defined, probably represents an aggregate of species which may ultimately be divided into at least three, if not many more. On the other hand, I do not think that Beddome's D. algæformis is separable from Wight's D. stylosa, since the length of the styles is an extremely variable character, even on the same plant. Fitch's drawing of Beddome's plant is copied from one made by Wight's native artist, and is inaccurate in certain points, notably in placing the spathe at the top instead of at the base of the pedicel. The material at my disposal seems to group itself, partly geographically, into four or five sets of forms. Until all have been collected in many localities, and good material either examined on the spot or carefully preserved in alcohol, it will be unsafe to define the species more nearly,

D. stylosa fucoides; Podostemon algæformis, *Trim.* in Journ. Bot., 1885, p. 173, and in Fl. Ceyl., III., p. 417; Dicræa algæformis, *Warming*, l. c., II.; Podostemon fucoides, *Willis MS.* in herb. var.

Thallus chocolate-coloured, Fucus-like, crisped or undulated, broad, branched, to 10 mm. wide and 10 cm. long, attached at base by a foot, and usually elsewhere by haptera or hairs. Stamens as long as ovary and stigmas. Stigmas shorter than ovary. Pedicel of fruit 6–8 mm. Ceylon, S.W. India (?).

Mahaweli-ganga at Hakinda rapids, Willis! Guru-oya at confluence with Hulu-ganga (tributary of Mahaweli), Willis! A plant from Kannikatti, S. India, C. A. Barber, S. Ind. Flora, 417, appears to be this form, but more flower material is required for certainty.

Very easily recognized in the vegetative condition by its crisped Fucus-like thalli, but in fruit almost indistinguishable from the next.

D. stylosa laciniata; synonymy as above, but Podostemon laciniatus, *Willis MS.* in herb. var.

Thallus with the habit of that of D. elongata, but flattened, narrow, to 5 mm. wide, with creeping basal part giving off freely floating branched laciniate thalli to 50 cm. long. Floral buds, &c., as in preceding variety. Ceylon.

Mahaweli-ganga at Hakinda, Thwaites! Trimen ! Willis! Guru-oya at confluence with Hulu-ganga, Willis!

Very easily recognized in the vegetative condition by the thalli, but when in fruit very similar to the preceding, owing to the falling away of the long laciniate ends. Occasionally mistaken for D. elongata, as, *e.g.*, in material distributed by Trimen, but distinguished by the flat thalli and square buds.

D. stylosa algæformis; D. algæformis, *Bedd.*, l. c. (non Trimen); D. algæoides, *Bedd. MS.;* Podostemon algæformis, *Benth.* (non Trimen).

Thallus algiform, much branched, to 25 cm. long and 1 cm. broad, branches tapering, laciniate or loriform. Edges of thallus thin, deciduous, often zigzag. Stamens equalling or slightly exceeding ovary and stigmas. Stigmas long, less than or equalling ovary. Pedicel of fruit 10–20 mm. S. India.

Anamalais, Beddome! Willis, in the Sholai Aar, Monica estate, 3,500 feet! C. A. Barber, S. Ind. Flora, 3,882! 3,702 (?). Scarcely distinguishable from the following, except by the shorter stamens, a character of rather doubtful value.

D. stylosa Bourdillonii ; D. stylosa, *Wight ;* Podostemon stylosus, *Benth.*

Thallus as in preceding form, but rather larger. Stamens much exceeding ovary. Stigmas usually equalling ovary, but variable. Fruit pedicel 10–20 mm. S. India.

Anamalais, Wight ! Malabar, Rev. E. Johnson ! Travancore, at Mundakayam, 300 feet, T. F. Bourdillon !

D. stylosa kanarensis.

Thallus to 6 cm. or more, with basal foot, spreading in all directions. Bracts usually with longer persistent tips than in other varieties, so that they appear more or less acuminate. Stamens variable in length. Stigmas equalling ovary. Pedicel of fruit 20–40 mm. S. India.

S. Kanara, at Sullia, C. A. Barber, S. Ind. Flora, 2,117 ! Also at Beltangadi, do. 2,521 ! N. Kanara, Taylor, 1,129, seems to be this, but may be a separate variety ; it requires further investigation.

This form is easily recognized by its long fruiting pedicels and the acuminate bracts, and is probably specifically distinct.

Species Exclusæ.

Dicræa apicata, *Tul.*, Monogr. Podost., p. 204 ; *Hooker*, Fl. Brit. India, V., p. 68 = Hydrobryum olivaceum, var. griseum. Dicræa selaginoides, *Wedd.* = Willisia selaginoides.

PODOSTEMON (Michx., Willd., Pers., Kunth., Lindl., Nutt., Griffith, Endl., Meisn., &c.), Tul. in Ann. Sc. Nat., 3 ser., t. XI., p. 102, and in Podo. Monogr., p. 128 ; Wedd. in DC. Prodr., p.p.; Hooker in Fl. Brit. Ind., p.p.; Warming, l.c., p.p.; *Lacis*, Bong., p.p.; *Polypleurum*, Warming (non Taylor), p.p. (?); excl. *Dicræa*, Tul.; *Hydrobryum*, Tul., and *Mniopsis*, Tul.

Fruit anisolobous, 8-ribbed, dehiscent, with ∞ seeds. Thallus thread- or ribbon-like ; secondary shoots ascending, several-flowered, with long subulate leaves and no scaly bracts. (This diagnosis requires slight modification if the American species be included.)

Flowers zygomorphic, naked, terminal, with tubular or funnel-shaped erect spathe which ruptures irregularly at the tip. Stamens 2 or 1, monadelphous, with staminode at each side of common axis and sometimes at the fork of the partial filaments. Pollen didymous Ovary ellipsoidal; stigmas 2, simple, subulate, with small papillæ. Capsule unequally lobed, 8-ribbed; one valve persistent, with 3 decurrent ribs, the other deciduous.

Primary axis, in the only known case, small and little developed, non-floriferous. Thallus phylogenetically of root nature, narrow cylindrical or flattened, rarely over 3 mm. wide, creeping over the rocks, attached by hairs and haptera, exogenously branched (always?). Secondary axes ∞, endogenous from sides and axils of thallus, erect or more or less prostrate, many-flowered, with usually distichous compound (American) or simple leaves, branched from the lower axils of dithecous leaves.

Herbs of eddies and rapids, in mountain streams. Many species, chiefly S. American; one in Mexico and S.E. United States; two in India and Ceylon.

The position of this genus and its relation to others has been discussed above in general terms. I have excluded from it the Tulasnean genera Hydrobryum, Dicræa, and Mniopsis, which I think were merged with it by Weddell and Bentham on insufficient evidence. But all these genera must to some extent be regarded as artificial until we have a more detailed knowledge of the various species included in them.

Stamens usually 2. Flower not cleistogamic. Ovary not winged P. subulatus, Gardn.

Stamen 1. Flower cleistogamic. Ovary with 6 broad wings ... P. Barberi, Willis.

PODOSTEMON SUBULATUS, Gardn. in Calc. J. N. H., VII., 1846, p. 184; *Tul., Wedd., Wight, Hooker, Warming*, &c., ll. cc.; P. dendroides, *Thw. MS.*

Stamens usually 2. Ovary not winged. Thallus thread-like.

Primary axis very short, non-floriferous, with a few small leaves. Thallus filamentous, exogenously branched alternately right and left, with no root cap. Secondary axes at forks of thallus, erect, to 2–4 cm. high, covered below when fully grown with the scars of fallen leaves, somewhat dorsiventral in structure. Leaves to 30 cm. long, distichous, subulate, sheathing, simple. Flowers in axils of dithecous leaves or otherwise terminal, erect. Spathe about 3–10 mm., splitting irregularly at the tip. Stamens usually 2, equalling ovary and stigmas. Ovary not winged. Capsule 2–3 mm. long, elliptical, 8-ribbed, anisolobous, on pedicel 3–20 mm. long, whose cortical tissues fall during the ripening of the fruit.

Ceylon and S. India; first discovered by Gardner.

P. subulatus Mavœliœ; Fruit pedicels 3–10 mm., erect.

Ceylon; in the Mahaweli-ganga and its tributaries, from 1,500 to 2,500 feet, rare. Holnicut in Ambagamuwa, Gardner! Raxawa in Dolosbage, Thwaites! Hakinda near Peradeniya, Trimen! Willis!

P. subulatus Sholaii; Fruit pedicels 10–20 mm., more or less prostrate.

S. India, in the Anamalai Mountains, in the Sholai Aar, Monica estate, at 3,500 feet, Willis! Barber, S. Ind. Flora, No. 3,884!

The Ceylon specimens from Hakinda show a tendency to group themselves into a large and a small form, and the specimens are also small at the higher localities.

PODOSTEMON BARBERI, Willis, sp. nov.

Stamen 1. Ovary with 6 broad wings. Thallus ribbon-like. Flowers cleistogamic.

Primary axis not known. Thallus broader than in preceding, rather like that of some Dicræas, to 3 mm. broad, sometimes tending to become crustaceous, closely attached to the rock. Secondary axes as in preceding, smaller, with leaves to 5 cm long. Spathe very long, enclosing the flower till after fertilization, connate below to the pedicel. Flower (? always) cleistogamic. Stamen 1, equal to or shorter than ovary. Ovary winged on 6 ribs; dehiscence ribs not winged. Fruit as in preceding; pedicel 6–20 mm.

S. India; first discovered by Barber. S. Kanara, at Beltangadi, C. A. Barber, S. Ind. Flora, No. 2,522, November, 1900!

Warming's Polypleurum Schmidtianum from Siam (l. c., VI., p. 1) seems to be related to Podostemon Barberi and to form a connecting link to Dicræa, but until we know the fruit its exact position cannot be determined.

Species Exclusæ.

P. dichotomus, Gardn. (incl. Wightii, rigidus, longifolius)	= Dicræa dichotoma.
stylosus, Benth. (incl. algæformis, Benth.)	= D. stylosa.
elongatus, Gardn.	= D. elongata.
Wallichii, R. Br. (incl. pterophyllus, Benth.)	= D. Wallichii.
minor, Benth.	= D. minor.
Hookerianus, Benth.	= Griffithella Hookeriana.
Johnsonii, Wedd.	= Hydrobryum Johnsonii.
olivaceus, Gardn. (incl. griseus, Gardn.)	= H. olivaceus.
Gardneri, Harv. MS. ex Thw.	= H. olivaceus.
acuminatus, Wedd.	= H. lichenoides.
microcarpus, Wedd.	= H. lichenoides.
selaginoides, Benth.	= Willisia selaginoides.

GRIFFITHELLA, Warming, Famil. Podost., VI., Kgl. Dansk. Vid. Selsk. Skr., 6e Raek., XI., p. 12 ; *Mniopsidis sp.*, Tul., Wight, ll. cc.; *Podostemonis sp.*, Wedd., Benth., Hooker, ll. cc.

Fruit anisolobous, smooth, dehiscent, with ∞ seeds. Thallus algiform, of great polymorphism; secondary shoots marginal or on central parts, small with included axis in vegetative condition, ultimately slightly exserted, with distichous leaves. Spathe erect or ascending, splitting at tip into irregular teeth.

Flower naked, zygomorphic, emerging from erect or ascending spathe ruptured irregularly at the tip. Stamens 2, monadelphous, with staminode at either side of common filament. Pollen didymous. Ovary very oblique ; stigmas 2, simple, subulate or more or less toothed or lobed, with small papillæ. Capsule perfectly smooth, usually nearly spherical, unequally lobed, splitting obliquely into a larger persistent and a smaller deciduous lobe.

Primary axis not known. Thallus phylogenetically of root nature, of the most various form, most commonly like the smaller Dicræas, but sometimes cup-like, or rotate on a stalk, or completely attached and creeping ribbon-like ; size usually small, but in the creeping forms to 20 cm. across. Secondary axes ∞, on the margins or less often on the central parts, endogenous, at first vegetative only with included axis and a few exserted leaves, later mostly 1-floriferous with distichous scaly bracts, 4–7 in number, formed by the expansion of the sheathing bases and the fall of the tips of the last leaves, more or less cowl- or helmet-shaped. Spathe tubular to broadly funnel-shaped, erect, splitting irregularly at the tip.

S.W. India, from the Bombay Ghats to S. Kanara.

Tulasne included the only known species in Mniopsis as a sub-genus Griffithella characterized by a frondiform thallus and simple stigmas. Weddell transferred it to Podostemon, § Griffithella, in which he also placed Hydrobryum Johnsonii, giving as the characters of the section "Caulis frondiformis incumbens. Spathella tubulosa, vel ovoidea, apice hians." Hydrobryum Johnsonii is in reality quite different from the plant under consideration, having a ribbed fruit, and a spathe splitting on the upper side. Tulasne's position is more nearly natural, it seems to me, than Weddell's. Hooker, in his Indian Flora, places Podostemon Hookerianus in his § Polypleurum, characterized as having "stems dilated frond-like ; flower buds scattered or submarginal with few scales," and again puts it near to the Hydrobryums. Undoubtedly it has relationships to the latter genus, as well as to Mniopsis, but for the present I am inclined to follow Warming, and give it an independent genus, though with some hesitation. Two species have been described, but without more material from many localities I am inclined to regard these as only varietally distinct at most.

GRIFFITHELLA HOOKERIANA, Warming in Fam. Podost., VI., l. c.; Mniopsis Hookeriana, *Tul.* in Ann. Sc. Nat. and Podost. Monogr.; *Wight;* Podostemon ecostatum, *Griff. MS.* ex Tul.; P. Hookerianus, *Wedd.*, l. c.; *Hooker* in Fl. Br. Ind.; Griffithella Willisiana, *Warming*, l. c.

Spathe tubular to funnel-shaped. Stigmas subulate to fimbriate.

Thallus with growth like that of Dicræa, 1-20 cm. in diameter, most various in ultimate form. Leaves to 5 mm. long. Floral buds usually closely crowded. Bracts usually 4–6, varying much in degree of cowl-shapedness, the leafy tips being attached sometimes at the top, sometimes in the centre of the back of the sheath. Spathe tubular, expanding slightly towards the outer end, to broadly funnel-shaped, and splitting into two, three, or many teeth at the tip. Stamens equalling or slightly or much exceeding ovary and stigmas. Stigmas subulate cuneate, and then more or less toothed, or fimbriate, the upper one then often completely divided into two to the base. Fruiting pedicel 3–15 mm. Fruit varying much in size.

Western Ghats of India, from Bombay to S. Kanara. First found by Law.

G. Hookeriana Bombayensis; Mniopsis Hookeriana, *Tul.*

Spathe long, narrow, tubular or funnel-shaped, splitting into few teeth; stigmas simple, subulate.

Konkan rivers, Law ex hb. Griffith! Atgaon, in the Khadshi river, 25 miles W. of Poona, R. K. Bhide!

G. Hookeriana Willisiana; G. Willisiana, *Warming.*

Spathe short, broadly funnel-shaped, splitting into many teeth; stigmas toothed or fimbriate.

S. Kanara, C. A. Barber, at Beltangadi, S. Ind. Flora, No. 2,515, and Sullia, No. 2,149! N. Kanara, Ritchie, 863, in the Kala Nuddi (Warming, fig.!).

WILLISIA, Warming in Fam. Podost. Kgl. Dansk. Vidensk. Selsk. Skr., 6 Raekke, t. XI., p. 58, 1901; *Mniopsidis sp.*, Bedd., Anamallay Plants, Trans. Linn. Soc., XXV., p. 223, 1865, and t. 25; *Dicrææ sp.*, Wedd. in DC. Prodr.; *Podostemonis sp.*, Benth. in Hooker Fl. Brit. Ind.

Fruit smooth, anisolobous, dehiscent, with ∞ seeds. Thallus small, closely attached. Secondary shoots crowded, erect, with 4-ranked scales and solitary terminal flowers. Spathe bifid at tip.

Flower zygomorphic, naked, sessile. Stamens 2, monadelphous, equalling or exceeding ovary and stigmas, with two staminodes. Ovary ellipsoid. Stigmas 2, subulate (or lobed, fide Beddome), smooth, equalling or shorter than ovary. Capsule smooth, but with slight rib in centre of each valve, anisolobous, sessile, but often apparently on a short or long pedicel owing to the falling away of the cortex and upper scales of secondary shoot ; one valve deciduous, the other persistent on a bifid stalk when the non-vascular tissues fall away. Seeds ∞.

Primary axis not known (? see below). Thallus small, crustaceous, fleshy, to 2–3 cm. in diameter, irregularly lobed or branched, usually more or less ribbon-like, closely attached to the rock by hairs and haptera, with crowded erect secondary shoots forming a dense tuft. On each plant in the vegetative season at least one, and perhaps, but doubtfully, more, axis with non-scaly leaves, the other axes all with scaly leaves. Axis of the first type probably primary, usually non-floriferous, simple or rarely branched, to 50 cm. long, cylindrical, to 5 mm. thick, leafless below when fully grown, thickly leafy above, especially at the tip ; leaves not sheathing but often more or less decurrent, in complex phyllotaxy, to 5–8 or more cm. long, loriform. Axes of second type numerous, densely crowded, endogenous, erect to 2–10 cm. high, stiffly rigid in flowering season at any rate, closely covered with 4-ranked decussate triquetrous scales. Scales acute rigid, with long loriform leafy tips similar to the leaves of the first type of axis, the tips ultimately deciduous and usually only present in the upper few leaves. Tip of axis occasionally scaleless with leaves as on the primary axis, but usually bearing one flower sessile among the upper scales. Spathe urceolate, bidentate at tip, the teeth in a plane at right angles to the uppermost pair of leaves, circumscissile with deciduous tip.

S. India and Burma, rare.

A very curious genus, until lately only known from the Anamalais, but I found in the Calcutta herbarium some fruits of a Willisia from Burma. It was originally found by Beddome, and described and figured by him as Mniopsis selaginoides, on account of its smooth fruit. Weddell transferred it to Dicræa, with which it has very little in common, and Bentham, in uniting this genus with Podostemon, transferred it to the latter. Warming regards it as distinct from any of these genera, and has done me the honour to name it after me. As mentioned above, I regard it for the present at any rate as generically distinct. It shows many points of difference from other Podostemaceæ, *e. g.*, the curious erect secondary shoots with the 4-ranked decussate leaves, bilobed circumscissile spathe, the long leafy axis which is almost certainly the primary, and several characters of the fruit. It would appear to be an old and rather isolated form.

WILLISIA SELAGINOIDES, Wmg., l. c.; Mniopsis selaginoides, *Bedd.*, l. c. ; Dicræa selaginoides, *Wedd.*, l. c. ; Podostemon selaginoides, *Benth.*, l. c.; *Hooker* in Fl. Br. Ind.

Characters of genus.

Anamalais, to 3,500 feet. Beddome ! Wight ! Willis, in the Sholai Aar on Monica estate ! Barber, S. Ind. Flora, 3,799 !

WILLISIA, SP. NOV.?—Burma, in the Yunzalin river, March, 1859, Brandis in Herb. Calcutta ! Fruits only, smaller than fruits of Anamalai specimens ; all stalked, but this may be due, as in W. selaginoides, to the fall of the cortical tissues and the upper leaves.

HYDROBRYUM, Endl. Gen. Pl. Suppl. I., p. 1,375, p.p. ; Tul. in Ann. Sc. Nat., 3 ser., t. XI., p. 103, and in Podost. Monogr., p. 137. *Podostemonis spp.*, Griff., Gardn., ll. cc. ; *Incl. Podostemonis spp.*, Wedd., Benth.

Fruit isolobous 12-ribbed, or anisolobous 8-ribbed, or smooth, dehiscent, with ∞ seeds. Thallus closely attached to rock, crustaceous or branched ; secondary shoots with 3–8 bracts, usually prostrate, and with boat-shaped spathe splitting only or mainly on upper side. Stigmas often dentate or lobed.

Flower on emergence from spathe erect or nearly prostrate, stalked or sessile. Stamens 2 or 1, equalling or exceeding ovary. Pollen didymous. Ovary more or less globose ; stigmas usually rather large, subulate or lobed or dentate, sometimes obcuneate, entire or lacerate.

Fruit small, sessile or stalked, smooth or 8- or 12-ribbed, isolobous or anisolobous, with ∞ seeds.

Primary axis erect, non-floriferous in most cases, larger than in Podostemon. Thallus of phylogenetic root nature, closely attached to the rock by hairs at all points, exogenously branched or lobed, ribbon-like or crustaceous lichen-like. Secondary shoots acropetally formed, endogenous, at first in vegetative condition with included evanescent axis, later some or all floriferous, the axis emerging, apiscopic, and usually prostrate on the thallus, 1-flowered. Leaves in vegetative condition simple subulate, to 10 cm. long; in floral buds some of them ultimately forming scaly bracts by the enlargement of sheathing bases and the fall of the leafy tips. Bracts 2–8, usually about 6, thicker on upper side. Spathe boat-shaped, enlarging at outer end, usually prostrate, and opening by a simple or compound slit on the upper side.

India, Burma, and Ceylon, on water-worn rocks in rapids and waterfalls, common, polymorphic, 5 species.

Endlicher's original description of this genus is vague, and would include most of the Podostemeæ. He included in it the first two Indian species discovered, Dicræa Wallichii and Hydrobryum Griffithii. Tulasne redefined the genus to include H. Griffithii and the two species olivaceus and griseus of Gardner, which agree with it in having a boat-shaped spathe splitting along the upper side, and a ribbed capsule. He makes these into a sub-genus *Zeylanidium* characterized by simple stigmas, while H. Griffithii, with dentate stigmas, forms the sub-genus *Euhydrobryum*. Weddell, followed by Bentham, on a somewhat cursory examination of herbarium material, once more redefined the genus so as to include only the section Euhydrobryum; his genus is thus based simply on the dentate stigmas and the 12-ribbed isolobous fruit. Now we have seen that the twelve ribs may at times occur in Dicræa; the dentate stigma occurs in Hydrobryum lichenoides, Griffithella Hookeriana, and perhaps elsewhere, while at the same time examination of a large number of stigmas of Hydrobryum Griffithii shows that the stigmatic characters are extremely variable, every form from obcuneate to almost subulate occurring, as in H. lichenoides. The latter species and still more H. olivaceum agree with H. Griffithii in the characters of the thallus and of the floral shoots, also in those of the spathe and its mode of opening, differing only in the fruit. I am inclined to lay very great stress, as mentioned above, on these broad points of agreement in thallus and spathe characters, and think that this group of species forms a very natural genus so far as our present knowledge of the order goes. The large well-developed primary axis of H. olivaceum also, which in many respects recalls the tall shoots of Sphærothylax, and is far more developed than the primary axis of our Podostemons and Dicræas. forms another argument in favour of generic separation, at least until we know the characters of the various species of the Eupodostemeæ better. It is true that Hydrobryum now forms a genus in which there is great variety in the fruit characters, usually considered of generic importance, but this is nothing unusual, and the same is the case in the next genus to be considered, Farmeria. I therefore propose, as in several other cases, to reinstate Tulasne's genus with the same sub-genera.

(1) Euhydrobryum, Tul. Fruit with 12 ribs, isolobous. Stigmas usually cuneate or obcuneate, toothed. Thallus crustaceous ... H. Griffithii, Tul.

(2) Zeylanidium, Tul. Fruit with 8 ribs or none, anisolobous, one lobe deciduous. Stigmas deltoid, cuneate, or subulate, sometimes toothed. Thallus crustaceous, lobed, or ribbon-like, regularly branched.

Fruit sessile, smooth ... H. sessile, Willis.

Fruit stalked, 8-ribbed.

Thallus crustaceous. Stamens short ... H. olivaceum, Tul.

Thallus crustaceous. Stamens very long ... . H. Johnsonii, Willis.
Thallus ribbon-like, branched. Stamens of varying lengths H. lichenoides, Kurz.

HYDROBRYUM GRIFFITHII, Tul., ll. cc., *Weddell*, *Bentham*, ll. cc. ; *Hooker* in Fl. Br. I. ; Podostemon Griffithii, *Wall. MS.*, *Griffith* in As. Res., XIX., *Gardner*, l. c.

Thallus crustaceous. Stigmas lobed or toothed. Fruit 12-ribbed, isolobous.

Primary axis unknown. Thallus crustaceous, more or less circular in form, irregularly and deeply lobed, to 10–12 cm. in diameter, thin, reddish green, hard. Secondary axes ∞, scattered irregularly over the upper surface, in flowering condition prostrate, with 4–7 thick cymbiform bracts, the spathe boat-shaped, oval when closed, splitting irregularly on the upper side. Flower nearly prostrate, small, sessile. Stamens 2, united $\frac{3}{4}$ of their length, slightly exceeding the gynæceum. Ovary ellipsoid, symmetrical ; stigmas sessile, obcuneate to ovate, dentate, the upper smaller. Fruiting pedicel 2–3 mm. long, ascending. Fruit 12-ribbed, isolobous, both valves persisting, with three veins on each decurrent into the pedicel, usually nearly prostrate.

In mountain rivers and streams, Assam and Sikkim. First discovered by Griffith. Khasia Mountains in the Bogapani and Kalapani rivers near Cherrapunji, Griffith, 2,436, Kew dis. ! Khasias, J. D. Hooker ! Kalapani river, Willis !* Kamyoom, Namtuwa, in the hills of N.E. Assam, Griffith. Kurseong near Darjeeling, 4,000 feet, Rev. P. Decoly,† Feb. 1899 !

Probably common from Sikkim to Burma, and perhaps in S.W. China or Siam. A very distinct species, resembling

* On rocks on right bank, just above the bridge on the Cherrapunji-Mawphlang road, where a small stream enters the Kalapani under a culvert.

† M. Decoly kindly described the exact spot to me, and I searched it carefully without success. The species may have been exterminated there in the cyclone that caused the landslips at Darjeeling. The locality is the river running about 1,000 feet below a village about 1 mile beyond Toong station going towards Kurseong, and is easily recognized by a tea factory standing near it, as well as a rifle shooting range a little further up the stream.

the other Hydrobryums in its morphological construction, but easily distinguished by its fruit and usually by the stigmas, which resemble those of the S. American Lophogynes. The fruit of some of the Dicræa Wallichii group is very similar. The stigma of H. lichenoides is also often dentate, but not so markedly.

H. SESSILE, Willis, sp. nov.

Thallus branched. Fruit smooth, sessile.

Primary axis not known. Thallus 3–10 mm. wide, and covering an area to 10 cm. diameter, pinnately branched in acropetal alternate succession, branches closely approximated and sometimes more or less confluent into a crustaceous thallus. Secondary axes marginal, ∞, one at each axil of the branching, and along sides of branches; vegetative condition not seen, but probably as in other spp.; in flowering condition consisting of 5–7 prostrate or nearly prostrate bracts, the upper larger, helmet-shaped, often winged on the back. Spathe boat-shaped, dehiscent on the upper side, occasionally slightly scabrous. Flower almost included, the stamens and stigmas projecting. Stamens 2, very long, their common axis equalling the gynæceum, their partial filaments the ovary. Staminodes linear, equalling gynæceum. Ovary nearly globose, curved upwards, smooth. Stigmas long, nearly equalling the ovary, linear, entire, the lower larger. Capsule smooth, nearly sessile, globose, 1 mm. in diameter, dehiscing obliquely, one valve deciduous. Seeds ∞.

Streams of the Western Ghats, rare. Beltangadi in S. Kanara, C. A. Barber, S. Ind. Flora, No. 2,520 !

A very interesting species, with characters which unite several distinct groups. It has somewhat the fruit of Griffithella Hookeriana, and the general characters otherwise of the other Hydrobryums of the Zeylanidium sub-genus. It is interesting to note that the thallus, as in H. lichenoides, tends at times to become crustaceous, like that of H. olivaceus. The plant also seems to have relationships to Farmeria.

H. OLIVACEUM, Tul., ll. cc., including H. griseum, *Tul.*, ll. cc.; Podostemon olivaceus and griseus, *Gardn.*, l. c., *Wight*, Icones, t. 1,918, P. olivaceus, *Wedd.*, l. c.; *Hooker* in Fl. Br. India; *Warming*, l. c.; Podostemon Gardneri, *Harv. MS.* in Thw. Enum. Pl. Zeyl. 223, *Hooker*, l. c.; Dicræa apicata, *Tul.*, Monogr. Pod. 204, *Wedd.*, l. c., *Hooker*, l. c., *Warming*, l. c.

Thallus crustaceous. Fruit 8–ribbed. Stamens equalling gynæceum.

Primary axis an erect hypocotyl, 3–8 cm., crowned with a tuft of leaves to 5–6 cm. long, linear, hairy (P. Gardneri and D. apicata of herbaria), sometimes ultimately floriferous on the hypocotyledonary part or among the leaves. Thallus developed at the base of it, to 25 cm. in diameter, roughly circular in outline when not damaged, olivaceous, reddish or green, crustaceous, irregularly and more or less deeply lobed, growing by marginal increase. Secondary axes ∞, scattered irregularly on the upper surface, in the vegetative period consisting of a few erect linear hairy leaves, in the flowering period prostrate, apiscopic, of 4–8 helmet-shaped bracts. Spathe boat-shaped, dehiscent by median line on upper side. Flower erect, on pedicel 2–5 mm. long; stamens 2, on short partial filaments, slightly overtopping stigmas; staminodes almost equalling ovary. Ovary elliptical, covered like the pedicel with pellucid deciduous cortex; stigmas short, subulate, upper smaller. Pedicel of fruit to 5 mm. Capsule ellipsoidal, clearly ribbed, ribs distinct to apex, one valve deciduous, three ribs of the other valve decurrent into pedicel.

In mountain rivers and streams, Ceylon and Western Ghats, common, 1,500 to 6,000 feet. Occurs in several varieties and forms.

H. olivaceum zeylanicum.

Thallus shallowly lobed, primary axis not floriferous, spathe more or less scabrous, bracts 4–7; thallus not dying before exposure to air.

Ceylon. In the Mahaweli-ganga and its tributaries, Masnawatte in Ambagamuwa, Ramboda, Gardner! Pundalu-oya, E. E. Green! Hakinda near Peradeniya, Thwaites, C. P. 3,065! Willis! Talawakele, H. F. Macmillan! Ramboda, Harvey (P. Gardneri of herbaria, C. P. 2,989)! Also in the Maskeliya river, Trimen!

H. olivaceum anamalaiense.

Thallus more deeply lobed. Primary axis as in preceding. Spathe nearly smooth. Bracts 2–8, early deciduous.

Anamalai Mountains. Sholai Aar, near Monica estate, at 3,500 feet, Willis! C. A. Barber, S. Ind. Flora, No. 3,813!

Very closely allied to the preceding, but recognizably distinct, especially when living.

H. olivaceum griseum (H. griseum, *Tul.*).

Thallus rather deeply lobed. Primary axis larger than in zeylanicum, often floriferous. Spathe scabrous. Bracts coarser than in zeylanicum, often 8. Thallus often decaying between the secondary axes before exposure. Colour grayer when dry.

Nilgiri Mountains. Paikara river, 5,000–6,000 feet. Gardner! Gardner in Tulasne (D. apicata)! Brandis in Warming, l. c. IV. (D. apicata)! Willis!

There are some primary axes, probably of this form or one closely similar, preserved in herbaria, purporting to have been collected near Bombay by Dalzell. It is by no means improbable that this species is to be found there.

This species is very easily distinguishable by its crustaceous thallus and erect stalked clearly-ribbed fruit. H. sessile and lichenoides both at times show tendencies to crustaceous thalli, but one has the fruit-ribs confluent below the apex of the fruit, the other is smooth-fruited. The primary axes, when seen, were formerly described as independent species, Podostemon Gardneri and Dicræa apicata.

H. JOHNSONII (Wight), Willis; Mniopsis Johnsonii, *Wight*, Icones, t. 1,919. Podostemon Johnsonii, *Wedd.*, l. c., *Hooker* in Fl. Br. Ind.

Thallus crustaceous (?). Fruit shallowly 8-ribbed. Stamens much exceeding gynæceum.

Primary axis not seen. Thallus, judging from fragments and from Wight's description, as in H. olivaceum, crustaceous, with ∞ secondary shoots scattered over the surface. Spathe opening by longitudinal slit on the upper side. Flower erect on short pedicel. Stamens $2\frac{1}{2}$ times as long as ovary, on long common filament; staminodes shorter than ovary. Ovary more or less globose, with long subulate stigmas.

Capsule stalked, more or less globular, broadly ribbed, ribs more or less confluent below apex. Pedicel 3–6 mm.

Mountain streams in Malabar, Rev. E. Johnson!

I know this species only from fragments in the Kew Herbarium. Of its separate identity I feel doubtful. Wight describes the fruit as smooth ; if this be really the case it probably is the same species as that I have named H. sessile. I have, on the contrary, found the fruit ribbed like that of H. lichenoides, and opine that Wight relied, as elsewhere in this order, on his native draughtsman. Some forms of H. lichenoides have the stamens very long and the fruit like that of H. Johnsonii, and I think it therefore probable that this species will prove to be synonymous with the former, especially as H. lichenoides has sometimes a more or less crustaceous thallus, and only fragments of H. Johnsonii have been examined. So far, however, as our present knowledge of the different forms goes, this species is a distinct one, marked by its long stamens, ribbed fruit, and crustaceous thallus. Wight's description of the spathe is quite inaccurate.

H. LICHENOIDES, Kurz in Journ. As. Soc. Beng., XII., 1873, p. 103 ; Podostemon microcarpus, *Wedd.* in DC. Prodr., XVII., p. 76 ; P. acuminatus, *Wedd.*, l. c. ; *Hooker* in Fl. Br. Ind. ; Polypleurum acuminatum, *Wmg.* in Fam. Podost., VI., p. 15 ; Podostemon kelensis, *Willis MS.* in herb. and Notes, Trimen, Flor. Ceylon, V., p. 386.

Thallus ribbon-like, regularly branched. Fruit 8-ribbed, anisolobous. Stamens long or short, two or rarely one. Stigmas ovate to subulate or obcuneate, usually toothed.

Primary axis short, with few leaves, non-floriferous. Thallus to 15 cm. long, much branched. Branches acropetal, alternate, again branched with the first secondary lobe on the basiscopic side. Secondary shoots ∞ at axils and on sides of thallus lobes, in vegetative condition with leaves 3–6 mm., in flowering condition prostrate or rarely erect, with 4–8 scaly bracts with deciduous tips. Spathe boat-shaped, dehiscent on upper side, the dehiscence sometimes beginning at the tip, or forming an upper smaller and lower larger lobe. Flower sessile or shortly stalked. Stamens 2, or rarely 1, equalling or exceeding the ovary and stigmas. Staminodes shorter than ovary. Ovary globose or ellipsoidal, stigmas ovate to subulate or to obcuneate, usually more or less lobed or toothed, or even lacerate. Pedicel of ripe fruit 1-8 mm. Capsule 1–2 mm., globular or ellipsoidal, shallowly and broadly 8-ribbed, the ribs often confluent below the apex of the capsule. Fruit anisolobous, with ribs on persistent valve decurrent into pedicel, sometimes with open space between them.

On rocks in rapids and waterfalls, Burma, Assam, Bombay Ghats to Travancore, Ceylon ; common.

This is the most widespread and one of the most variable species in our list, and occurs in many forms. I have given below the forms that seem distinct in my own supply of material, and it may be at once remarked that almost every locality showed a form distinguishable from others. Weddell made two species, Podostemon acuminatus and microcarpus, from Assam and Burma material respectively, but his points of distinction are badly chosen. The fruit of P. microcarpus is ribbed, not smooth as he describes it; the tips of the bracts in acuminatus, as already mentioned, fall at a later period as in most of the Indian species, and the size of the fruit is a most variable character. The Burma material is doubtless different from the Assam, but the distinction must be based on other characters. Kurz' name was published, as indicated on p. 186, some time before Weddell's, and must take precedence. The material of Kurz' species, which I have seen at Calcutta, is evidently the same as that of Weddell's P. microcarpus, both having been collected by Parish, but it is mere powder in both cases.

In giving the following long list of forms, I by no means intend to imply that the species must be divided into just these varieties, or even that these forms have all varietal rank, but rather to point out the important fact of the distinct forms to be met with in almost every locality where this species, like the others, is found. There will ultimately, I have little doubt, prove to be a large group of varieties of this species, each with many sub-varieties, the rank to be given to each form depending on the personal opinion of the worker.

H. lichenoides microcarpum ; H. lichenoides, *Kurz ;* Podostemon microcarpus, *Wedd. :*

Fruiting pedicel 1–2 mm. Capsule 1 mm. Ribs confluent at apex.

Burma, at Tavoy and Moulmein, Parish, in Hb. Kew (named by Weddell); Canti Apeni, Donna Toung, Parish, in Hb. Calcutta (named by Kurz) !

H. lichenoides acuminatum ; P. acuminatus, *Wedd. :*

Pedicel 2–3 mm. Capsule 1–2 mm. Tips of bracts acuminate to late period.

Assam, Khasia Hills, in the Borpani and Kalapani, Hooker, in Hb. Kew (named by Weddell) !

These two forms rest on very insufficient material.

H. lichenoides Nongpoense :

Pedicel 2–3 mm. Capsule 1–2 mm. Ribs confluent below apex. Tips of bracts not divergent. Stamens slightly exceeding ovary. Stigmas ovate, toothed.

Stream by road Shillong to Gauhati at 37½ milepost, Willis !

H. lichenoides Shillongianum :

Pedicel 2–3 mm. Capsule 1–2 mm. Ribs confluent at apex. Tips of bracts very divergent. Stamens slightly exceeding ovary. Stigmas broad, ovate to obcuneate, lobed or toothed.

Khasia Mountains in a tributary (on left bank) of stream at 62nd milepost on road from Shillong to Gauhati, Willis !

H. lichenoides Herbertii :

As last, but tips of bracts not divergent, but rounded. Stigmas ovate to subulate.

Khasia Mountains in the stream at 62nd milepost near Shillong, Willis !

H. lichenoides Moosmaiense :

Pedicel 2–3 mm. Capsule 1–2 mm. Ribs confluent below apex. Bracts more or less acuminate.

Khasia Mountains in stream going from Cherrapunji towards Moosmai, Willis !

H. lichenoides Maamlooense :

Pedicel 2–3 mm. Capsule 1–2 mm. or under 1 mm. Ribs confluent at apex. Ripe fruit on double stalk, formed by vascular bundles to ribs. Bracts slightly divergent. Stigmas ovate to subulate.

Khasia Mountains in stream going from Cherrapunji towards Maamloo, Willis !

H. lichenoides Khandalense :

Pedicel 2–5 mm. Capsule 1–2 mm. Ribs confluent below apex. Stamens as long as gynæceum.

Bombay Ghats, near Khandala in the Bhor Ghat, common, Willis !

H. lichenoides Bhorense :

Pedicel 5–8 mm. Capsule 1–2½ mm. Ribs confluent below apex, shallow. Floral buds more or less erect. Stamens as long as gynæceum.

Bombay Ghats, near Khandala in the Bhor Ghat, common, Willis !

H. lichenoides Kanarense :

Pedicel 2–3 mm. Capsule 1–2 mm. Ribs very sharp, confluent below apex. Stamens much exceeding gynæceum.

S. Kanara, C. A. Barber, S. Ind. Flora, No. 2,327 !

H. lichenoides Fentonii :

Pedicel 2–3 mm. Capsule 1–2 mm. Ribs more or less obsolescent, confluent below apex. Stamens much exceeding ovary. Thallus sometimes tending to become crustaceous.

Anamalai Mountains in the Sholai Aar, Monica estate, 3,500 feet, Willis !

H. lichenoides kelense; Podostemon kelensis, *Willis*, l.c.:

Pedicel 1–3 mm. Capsule 1–2 mm. Ribs clearly marked, confluent below apex. Stamens as long as gynæceum.

Ceylon, in the Dikoya and its tributary the Kehelganga, H. F. Macmillan! Willis!

The most distinct of all these varieties is Bhorense, with its long pedicels. Most of the north-eastern forms have the ribs confluent at, not below, the apex, and they and the Ceylon forms have much darker coloured fruits than the Western Indian forms; but we have seen that the Lawias from the latter district had also lighter coloured fruit, and this may be merely an effect of the rock substratum. The Kanara and Anamalai forms have very long stamens, and probably together form a good variety, while other good varietal groups are probably the Assam forms taken together, and the Burma forms. Until, however, we have a much more detailed knowledge of all the forms, it will be unsafe to group them otherwise than tentatively. Each river or group of rivers appears to have its own form, whose range of variation, though it may at times overlap that of another form, does not coincide with it.

Species Exclusa.

H. Wallichii, Endl. = Dicræa Wallichii.

FARMERIA, Willis, in Notes to Trimen's Flora of Ceylon, vol. V., p. 386, 1900, revised. *Podostemonis sp.* (*Mavœliæ sp.*), Trimen in Fl. Ceyl., III., p. 419.

Fruit dehiscent or not, with 8–10 ribs or none, with few large seeds. Thallus closely attached to rock, ribbon-like, regularly and endogenously branched. Secondary shoots as in Hydrobryum, but behind the branches of thallus instead of in anterior axils.

Flower on opening of spathe enclosed, more or less erect, sessile or (?) slightly stalked. Stamens 1 (? more). Pollen didymous. Ovary more or less globose, with thickened placenta towards the upper end, bearing two or four ovules on the under side; lower loculus more or less abortive. Stigmas large, subulate. Fruit small, the upper lobe larger, in F. metzgerioides 2-seeded, sessile, indehiscent: in F. indica 4-seeded, stalked, 8–10-ribbed, dehiscent.

Primary axis small, non-floriferous. Thallus of phylogenetic root nature, closely attached to the rock by hairs and occasional haptera. narrow ribbon or thread-like flattened, endogenously branched in acropetal succession right and left, the branches appearing rather far back upon the thalli on the anterior side of the secondary shoots. Secondary shoots as in Hydrobryum, most ultimately floriferous. Bracts prostrate, thicker on upper side, usually about 6, scaly, with deciduous tips. Spathe as in Hydrobryum, splitting on upper side.

Ceylon and S. India, on smooth rocks in eddies and rapids, frequent. Two species.

Fruit smooth, indehiscent, completely enclosed in persistent bracts, 2-seeded ...F. metzgerioides, Willis.

Fruit ribbed, dehiscent, anisolobous, shortly stalked, with four seeds ... ...F. indica, Willis.

FARMERIA METZGERIOIDES (Trimen), Willis in Notes, Trimen's Fl. Ceyl., V., 386, 1900; Podostemon metzgerioides, Trim., l.c.

Fruit sessile, smooth, indehiscent, enclosed in the persistent bracts; seeds 2.

Thallus ribbon-like, often more or less zigzag, 2–4 mm. wide. Secondary shoots on upper edges and in posterior axils, at first with included axis and a few linear leaves 5–10 mm. long, later with exserted prostrate axis bearing 4–6 scaly bracts as in Hydrobryum. Spathe boat-shaped, splitting irregularly at tip and on upper side. Flower sessile, curved upwards. Stamen 1, longer than gynæceum, exserted; filament flat, anther cells divergent at base. Staminodes equalling ovary. Ovary more or less ellipsoid or globose, oblique, with swollen apical placenta and abortive lower loculus; stigmas linear or subulate, long, exserted very early. Fruit obliquely globular, 1 mm. long, smooth, with thin membranous wall, included among the persistent bracts and closely held against the rock, with large persistent placenta at upper end, two large seeds in fertile loculus, and a more or less flattened abortive loculus, indehiscent. Seeds large, germinating *in situ*.

Ceylon, endemic. In the Mahaweli-ganga, on rocks at Hakinda rapids, Trimen! Willis! Other non-flowering specimens which probably belong to this species have been found in the Kelani-ganga at Kitulgala, at the confluence of the Guru-oya and Hulu-ganga near Teldeniya, and in the Pasdun korale.

FARMERIA INDICA, Willis, sp. nov.

Fruit shortly stalked, dehiscent, 8–10-ribbed, with 4 seeds.

Thallus thread-like, usually with flat hapterous feet under each secondary shoot like those of Tristicha ramosissima. Secondary shoots as in preceding. Flower not seen. Fruit ½–1 mm. on pedicel of same length, ellipsoidal, anisolobous, dehiscent, 8–10-ribbed, with 4 (3–5 ?) seeds on a persistent terminal placenta.

S. India, in the Tambraparni river, near Tinnevelli, C. A. Barber, S. Ind. Flora, No. 2,849 !

I have only seen specimens dried on the rock, with ripe fruits already open. The extra ribs, when more than eight occur, are on the large upper persistent lobe of the fruit.

It may be convenient to give, in conclusion, a table showing the new position of the various species recognized in Hooker's Flora of British India, first of all adding to that list the new species discovered since its publication :—

HOOKER.	WILLIS.
1. Terniola, Tul.	2. Lawia, Tul.
1. zeylanica, Tul.	1. zeylanica, Tul.
2. pulchella, Tul.	do.
3. Lawii, Wedd. = pulchella, Tul.	do.
4. longipes, Tul.	do.
5. pedunculosa, Wedd. = longipes, Tul.	do.
6. foliosa, Wedd. = longipes, Tul.	do.
	1. Tristicha (Du Pet. Th.), Tul.
7. ramosissima, Wedd.	1. ramosissima (Wight), Willis.
2. Hydrobryum, Endl.	7. Hydrobryum, Endl.
1. Griffithii, Tul.	1. Griffithii, Tul.
3. Podostemon, Michx.	
7. Johnsonii, Wedd.	4. Johnsonii (Wight), Willis.
8. olivaceus, Gardn.	3. olivaceum, Tul.
8*a*. Gardneri, Harv. MS. = olivaceus, Gardn.	do.
8*b*. apicatus, Benth. = olivaceus, Gardn.	do.

Hooker.	Willis.
10. microcarpus, Wedd.	5. lichenoides, Kurz.
9. acuminatus, Wedd. = microcarpus, Wedd.	do.
	2. sessile, Willis, sp. nov.
	4. Podostemon, Michx.
5. subulatus, Gardn.	1. subulatus, Gardn.
	2. Barberi, Willis, sp. nov.
	3. Dicræa (Du Pet. Th.), Tul.
1. dichotomus, Gardn.	2. dichotoma, Tul.
2. stylosus, Benth.	5. stylosa, Wight.
3. algæformis, Benth. = stylosus, Benth.	do.
4. elongatus, Gardn.	1. elongata, Tul.
11. Wallichii, R. Br.	4. Wallichii, Tul.
12. pterophyllus, Benth. = Wallichii, R. Br.	do.
13. minor, Benth.	3. minor, Wedd.
	5. Griffithella, Warming.
6. Hookerianus, Wedd.	1. Hookeriana, Warming.
	6. Willisia, Warming.
14. selaginoides, Benth.	1. selaginoides, Warming.
	8. Farmeria, Willis.
metzgerioides, Trim.	1. metzgerioides, Willis.
	2. indica, Willis, sp. nov.

The species and genera of course are not arranged in exact systematic order in this double list; the positions in the actual lists are indicated by the numbers prefixed to the names.

Finally, it may be again remarked that the above grouping of the Indo-Ceylonese Podostemaceæ is a tentative and preliminary one only, to clear the ground for the morphological paper to follow. It is based on an insufficient knowledge of these very difficult and variable plants. It is, however, I venture to think, a nearer approach to the natural classification of these plants than any previous list, and it clears away many of the errors and confusions of preceding work, though doubtless in itself both incorrect and incomplete. It will at least form a basis for further work, which is very greatly to be desired, and it is to be hoped that botanists who have the opportunity of studying the Indian or other Podostemaceæ in their natural habitat will do so, as there alone can they be properly understood. So far as India is concerned, I would draw special attention to the many excellent localities in the Western Ghats; the best of all, as regards richness in species, and interesting forms, is Beltangadi in South Kanara, but Khandala, between Bombay and Poona, Sullia in South Kanara, Paikara near Ootacamund, and Monica in the Anamalais, are all good. In Ceylon the best locality is Peradeniya itself.

It is also evident that the South American Podostemaceæ will have to be revised and studied in detail before we can feel confident that many of the described species are not also duplicates, like so many of the Indian. Many have been thoroughly worked out by Prof. Warming, but the majority have still to be investigated, and all should be studied on the spot.

Collectors also should be advised to pay more attention to these plants, to get material in all possible stages, both from above the water, from just below it, and from deep water, so as to illustrate as much as possible of the morphology and indicate what are the changes that go on when the plant is exposed to the air, an operation which, as has been indicated above and will be fully described in a later paper, often completely changes the appearance of the plant. Material still attached to the rocks should be taken and preserved both dry and in alcohol, and detailed notes as to all points with regard to each specimen, and as to growth, method of flowering, kind of situation, rate of flow of water, and other points, should be made before leaving the spot.

The detailed observations on which many of the above descriptions rest will I hope be given in a subsequent paper, appearing in the next number of this journal.

Peradeniya, March 30, 1902.

Correction.

On p. 192, lines 2 and 5, for "lignified" read "woody": there appears to be no actual deposit of lignin in Dicræa.

REVIEWS.*

The Settlement of European Peasantry in the Mountains of the Tropics.

By Dr. STUHLMANN.

(Uber die Ansiedelung Europäischer Bauern in den Gebirgen von Ceylon und Deutsch-Ostafrika. Tropenpflanzer, VI., 1902, p. 10.)

In this article the well-known lieutenant of Emin Pasha, now Director of Agriculture in German East Africa, gives an account of his visit to the site of Sir Samuel Baker's experiments in farming near Nuwara Eliya in 1848, and describes their failure, mainly due to the poverty of the soil and other natural causes. He goes on to mention the importation by Baker of European helpers and their subsequent settlement as market gardeners, &c., following this with a discussion of the prospects of successful settlement of German peasantry in the mountains of East Africa. He regards the English and the Germans as much less suited to such permanent tropical colonization than the French, who go prepared to settle finally in their adopted home, and have, *e.g.*, rendered Reunion, Mauritius, and similar colonies almost completely French.

J. C. W.

Glimpses of Tropical Agriculture.

By E. M. WILCOX.

(Columbus, Ohio, 1900.)

A general account of the agriculture of Ceylon and Java, and of the organizations for its scientific assistance, by a former visiting worker at Peradeniya.

J. C. W.

The Agriculture of Southern Asia.

By A. PREYER.

(Einiges über Sudasiatisches Agrikultur ; Berlin, 1901.)

An interesting critical account of the present condition and the future outlook of agriculture in Ceylon, the Straits, and Java, by a former visiting worker at Peradeniya.

J. C. W.

* The articles which appear under this head are written primarily for the Ceylon constituency of this Journal, and deal chiefly with advances in Science which are of immediate local interest.

The Coagulation of Latex.

By J. PARKIN.

(Indiarubber World, New York, 1901.)

A reply to criticisms by Mr. J. H. Hart of Trinidad.

J. C. W.

A Simple Test for Thein.

By A NESTLER.

(Ein einfaches Verfahren des Nachweises von Theïn, und seine praktische Anwendung. Zeitschr. für Unt. d. Nahrungs-und Genussmittel, IV., 1901, p. 289.)

A portion of the leaf to be tested is powdered, placed in a watch-glass, covered with another of the same size inverted, and heated over a small Bunsen flame or spirit lamp. In a few minutes drops appear on the upper glass and soon crystals form, especially if a drop of water be placed on the top of the glass. These are crystals of thein ; they may be tested by Molisch's method, by treatment with concentrated hydrochloric acid and subsequent addition of a 3 per cent. solution of chloride of gold, when long or short yellowish crystals at once form in bundles.

J. C. W.

A Monograph of Niphobolus.

By K. GIESENHAGEN.

(Die Farngattung Niphobolus ; Jena, 1901 ; pp. 226, Mk. 5·50.)

A very full anatomical and systematic monograph of this old world group of ferns. Dr. Giesenhagen spent some time at this work at Peradeniya, and the results of his examination of our living and dried material are included. The Ceylon forms are redistributed to some extent, and a new species, *N. ceylanicus*, Giesn., is described on p. 216 ; this was found in the herbarium of Prof. Christ at Basel, collected by G. Wall, No. 48/278, as *N. adnascens*, Sw.

J. C. W.

The Bacterial Warts on the Leaves of Pavetta indica and other Rubiaceæ.

By A. ZIMMERMANN.

(Ueber Bakterienknoten in den Blättern einiger Rubiaceen. Jahrb. Wiss. Bot., 37, 1901, p. 1.)

The leaves of several species of Pavetta, *e.g.*, *P. indica* (Pawatta. Sin.), have curious warts most prominent on the upper surface. These are found to be due to the presence of bacterial colonies in the leaf. The meaning of this phenomenon is to be the subject of further investigation.

J. C. W.

NOTES.

MM. Michelin & Cie.'s Analyses of Ceylon India-rubbers prepared by Mr. Parkin.

The various methods used for the preparation of indiarubber from the latex of Hevea brasiliensis, Castilloa elastica, and Manihot Glaziovii, the Para, Panama, and Ceara rubbers respectively, have been described in the " Circular " of this Department (Vol. I., Nos. 4, 11, and 12–14). Samples prepared by these various methods were sent to MM. Michelin et Cie. of Clermont Ferrand, the well-known rubber manufacturers, who generously undertook their analysis, the results of which are given below.

It may be well first to briefly describe the methods of preparation of each sample. Prior to Mr. Parkin's work, the method used was that described in Circular 4, p. 29 ; V-shaped incisions were made in the tree-trunk in vertical rows, and a gutter of clay formed round the base of the tree, leading the milk into cocoanut shells, in which it was simply allowed to dry. Samples of Para rubber thus prepared are described below as shell rubber. A considerable quantity of milk dries on the tree in working this process, and the long strings thus formed are rolled up into small balls, described below as ball rubber ; these contain a large admixture of pieces of bark and other impurities, and have a lower market value than the shell rubber, but, on the other hand, they are better dried and so less liable to putrefaction. The shell rubber being in large pieces did not dry rapidly, and became more or less putrid in drying, thus spoiling its quality to some extent. It was valued in London on two or three occasions at a little lower price than the best Para rubber from the Amazon Valley. The latter, as is well known, appears on the market in the form of large slabs, formed by holding the milk on a wooden paddle in the smoke of burning palm nuts. It is thus coagulated and dried layer by layer, and a product of remarkably uniform quality and free from putrefaction is obtained. Analysis of the smoke showed that the result was due to the coagulation of the milk by the acetic acid contained in it, and its preservation from putrefaction by the creosote also present. Mr. Parkin used these facts as the basis of his process, coagulating the milk by acetic acid in the quantity necessary to give the best result, and adding a small amount of creosote to prevent putrefaction. In this way the process was brought under control, and the blackening of the rubber due to the carbon in the smoke was avoided. The method now used for Para rubber is to place a tin vessel containing water under each V cut in the tree, thus avoiding any running of milk down the bark and consequent contamination. The milk is all brought into the factory and filtered to get rid of dirt, then mixed with the calculated quantity of acid and creosote, and placed in round flat dishes about $1\frac{1}{2}$ inch deep. In the course of a few hours the clot of rubber forms, and as soon as firm enough for lifting is taken out, washed, and rolled under heavy pressure to get as much water out of it as is possible. The white or pale yellow biscuit is then placed in a warm, but not hot, dry place, and in a few days is ready for market, forming a thin pale yellowish-brown biscuit, not unlike a sheet of gelatine. Such rubber is cleaner and tougher than the Para native rubber, and fetches higher prices on the market. It retains its good quality for several years, whereas the old shell rubber becomes more or less rotten if kept in Ceylon for two or three years. The process of clotting is quickened if the milk be heated before the addition of acid, almost to the boiling point; this method also enables even more dirt to be removed, for the finest particles which have passed the filter (an ordinary fine metal sieve) float to the top as a scum during the heating and can be skimmed off. Comparison of the analyses below will show the difference between the samples obtained in these two ways.

Another method of clotting and rendering antiseptic, which gives a very good result, is by treatment of the latex with the calculated quantity of mercuric chloride (corrosive sublimate). No creosote need be added. The milk clots in fine particles, which float to the top and form a cream, which is washed and poured out on a slab to dry into a thin sheet.

The latex of Castilloa, as is well known, forms a cream of caoutchouc if simply left to stand, and on this fact is based the centrifugalization method of preparation, which yields such excellent rubber. Mr. Parkin employed for the preparation of the samples, whose analysis is given below, simply the method of creaming. The rubber latex being placed in a tall revolving cylinder with a tap at the foot was allowed to cream and the dirty fluid run off by the tap. Water was added and the milk again churned, creamed, and the water run off, and so on for three or four times till the rubber appeared as a nearly pure white cream which was then spread out on a slab to dry.

The latex of Manihot Glaziovii was coagulated by simple heating, which coagulates the proteids contained in it.

The following table gives the results of analyses made by MM. Michelin et Cie. The methods used are described below :—

Number of Sample ... Description ...	2 Para Shell, 1897. Trees 12 Years.	4 Para Shell, 1898. 22 Years.	5 Para Ball, 1897–98. 12 Years.	11 Para Ball, 1897–98. 22 Years.	3 Para, Hot Acid and Creosote, 1898.	10 Para, Hot Acid, no Creosote, 1898.	9 Para, Cold Acid and Creosote, 1899.	8 Para, Mercuric Chloride, 1899.	1 Castilloa creamed.	6 Ceara, Parkin Process.
Gross weight... ...	447 grm.	241 grm.	451 grm.	336 grm.	224 grm.	447 grm.	452 grm.	266 grm.	273 grm.	53 grm.
Yield of rubber in film washed and dried	98 per cent.	95 per cent.	91 per cent.	94 per cent.	100 per cent.	100 per cent.	98 per cent.	98 per cent.	100 per cent.	81 per cent.
100 parts of rubber in film washed and dried contain :—										
Caoutchouc ...	92·36	91·19	91·86	91·00	94·11	93·43	94·14	94·39	91·78	93·74
Total resins ...	6·51	7·74	5·99	7·02	5·47	5·86	5·62	5·30	7·54	4·38
Ash	0·68	0·69	1·66	1·60	0·21	0·49	0·14	0·21	0·50	1·36
Moisture... ...	0·45	0·38	0·49	0·38	0·21	0·22	0·10	0·10	0·18	0·52
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Portion of resins soluble in acetone per 100 parts of washed and dried film :—										
First experiment ...	3·44	4·78	2·40	4·25	2·92	2·10	2·88	3·17	6·38	3·47
Second experiment ...	3·60	4·80	2·70	4·25	3·06	2·01	2·89	3·00	6·34	3·33

Notes.

1. Rubber in very clean sheets, unusually fine for Castilloa,
2. Brown pieces, dry, with some sticky parts,
3. Pale yellow sheets, very clean, no sticky parts : a beautiful tough rubber of the first quality.
4. As No. 2.
5. Scrap rubber, sticky. Second quality.
6. Scraps packed together, clear brown, whitening when stretched, no nitrogenous odour such as is found with many Ceara rubbers of Brazilian origin.
8. Yellowish gray sheets, very clean. First quality.
9. As No. 3.
10. As No. 3.
11. As No. 5.

Preparation of the Sample.—The total weight was taken, and about half of each sample, after exact weighing, was reduced to a thin uniform sheet under a stream of water in the usual machine employed for the purpose in the rubber industry. The film thus obtained was dried in a dark chamber at 30–35° C. and weighed. (Specimens may be seen in the Peradeniya Museum.) These films were then used for the further analyses.

Estimation of Moisture.—Two grammes of the film were weighed between tared watch-glasses and dried for 6 hours at 60° C., after which the weight is constant, but when exposed to ordinary air increases by the 0·3–0·5 per cent. of moisture, which is normally present in caoutchouc.

Estimation of Ash.—An exact weight, about 2 grm., was calcined in a platinum crucible, the operation being carried on very slowly until complete distillation of the caoutchouc, when a little ignition yields a perfectly white ash.

Estimation of Resins soluble in Acetone.—An exact weight of about 2 grm. of film was extracted in a Soxhlet's apparatus. The form used was a globe of about 100 cc., containing about one-half its volume of pure anhydrous acetone, CH_3 $(COOH)_3$ The film after extraction by four hours' boiling was dried in vacuo. The loss of weight, less the moisture-content determined by the first analysis, gives the proportion of resin. The figures obtained in different analyses were very consistent, as the table shows.

Estimation of Resins soluble in Mixture of Benzine and Alcohol.—Five grm. of film were dissolved in 100 cc. of pure benzine and 150 cc. of strong alcohol (95 per cent. or stronger), then stirred in. The caoutchouc is precipitated as flakes, which run together into a clot ; this is washed several times with alcohol, and dried till the weight is constant on a glass or porcelain dish in a chamber kept at 30–35° C. The loss of weight is regarded as representing the total resin. The repetition of this operation gives a further loss of 0·5 to 1·0 per cent. of the weight of the caoutchouc, and a third operation a further one of usually about 0·25 per cent. The figures given in the table are the result from one operation only and therefore require correction, but are comparable among themselves.

We have now to consider what conclusions may be drawn from these analyses.

In the first place, it is evident that the cleanliness of the rubber prepared by Mr. Parkin's methods is very great. Most commercial Para rubbers after treatment with the machine yield only 84–90 per cent. of rubber, but Mr. Parkin's give at least 98 per cent., and some 100 per cent. Hence the rubber thus prepared should obtain, other things being equal, at least 10 per cent. higher price. In actual fact some of the rubber lately exported from Ceylon obtained 4*s.* 2*d.* per lb. against 3*s.* 9*d.* for best native Para, figures corresponding very closely to the above estimate. MM. Michelin state that the quality of the samples sent to them was at least equal to that of the very best corresponding commercial rubbers, but that an exact valuation could not be given, as the samples were too small.

A comparison of Mr. Parkin's samples with the samples obtained by the old method of tapping shows that the shell rubber of the latter is almost or quite as good as regards the yield of rubber from the sample. It is thus evident that the great advantage in all these processes is their cleanliness in collection of the milk; comparison with the ball rubber of the old process shows the difference. There is no special virtue, as regards the percentage of rubber obtained, in one method rather than the other. In actual fact there is no great gain in using the acid if the climate be fairly dry, so that the natural coagulation and drying can take place quickly; but the use of creosote as a preservative is perhaps always advisable.

The acid or mercury coagulation method, however, seems to have some advantage when we go on to the third set of figures giving the detail of analysis. The greater the proportion of resin in rubber the less its value, and the acid-prepared samples seem to have less than the samples prepared by simple drying. MM. Michelin remark that the proportion of resin soluble in acetone in the Ceylon samples is closely similar to that in the corresponding native rubbers. They remark also that the proportion of resin soluble in acetone or in benzine and alcohol is no greater in rubbers altered by heat or light than in those not so altered; the proportion is only increased when there is a chemical action or oxidation at the same time. Thus, sample 5, though sticky, contains less resin than samples 3, 8, and 9, which are far superior for commercial purposes. Caoutchoucs may be quite spoiled by the action of heat without increasing the proportion of resin. Another point of interest is the difference between the rubber of old trees and younger ones, *e.g.*, as indicated in samples 2 and 4, in which trees of 12 and 22 years old respectively were employed. It would of course be absurd to lay much stress on these figures, but so far as they go they show that the rubber of the old trees is no better, if, indeed, it be not worse (as containing more resin) than that of the trees 12 years old.

From the planter's point of view the chief lesson to be learnt from Mr. Parkin's work and the above analyses is to practise the greatest possible cleanliness in collecting and preparing rubber; any rubber dried on the tree or otherwise contaminated will sell for a much lower price as "scrap" or "negro-head." By Mr. Parkin's method of collection in separate tins under each cut and placing water in the tins the great bulk of the milk can be brought in in the liquid condition and filtered, and can then be treated in clean tins, with or without acid, as local experience shows to be suitable. Quick drying is advantageous, but excessive heat must be avoided, as under its influence the rubber becomes sticky and loses most of its value ; sample 5, which was dried on the tree in more or less sunlight, was thus deteriorated.

In conclusion, the opportunity may be again taken of calling attention to some misprints which unfortunately escaped correction in Mr. Parkin's paper quoted (Circ. R. B. G., I.). On page 148, bottom paragraph, the figures should read 0·9, 3·9, 0·25, and 8·0 respectively, and on page 152, paragraph 2, 0·83 per cent. mercuric chloride instead of 8·3 per cent.

J. C. WILLIS.

Note on the Product of the Latex of the Jak (Artocarpus integrifolia).

As is well known, the jak tree exudes when tapped a large quantity of a sticky milk, which hardens into a brittle substance. Inquiries are frequently made as to whether this substance has any value for rubber purposes. It is so brittle that it is evidently of no use for any of the ordinary purposes for which rubber is employed, but it seemed to me that it might have a value for ebonitising or such purposes. With this in view I sent samples to MM. Michelin et Cie. of Clermont Ferrand, who have kindly reported on it as follows : – " A whitish resin, containing 1·8 per cent. of moisture. Melts completely in boiling water, dissolves in benzine without previous swelling ; on addition of alcohol the products precipitated in small quantity from this liquid do not agglomerate. On a platinum foil it disengages an odour of burnt bread. These characters indicate the absence of caoutchouc or analogous bodies (gutta-percha or balata). We do not think that this product is of any value in the rubber industry."

J. C. WILLIS.

Pith for Microscopists.

In Ceylon microscopists have hitherto relied, almost solely, upon the pith obtained from the Elder and imported into this Island. It has been a common experience when preparing serial hand sections to find the local supply of pith exhausted, and this has invariably resulted in an unsatisfactory series being prepared. The commercial material used for making *topees* is too soft and fibrous, and one has had to fall back upon the tubers of Solanum and Helianthus in cases of emergency.

When I was up-country a short time ago I came across cultivated specimens of Fatsia papyrifera, Hook., known also as Aralia papyrifera, or the Japanese rice paper plant. This plant yields an excellent pith, which has long been used in China and Malaya for making paper and artificial flowers. Though introduced into Ceylon about 1856, its usefulness to microscopists seems to have been overlooked. The plant will thrive at all elevations between 1,000 and 5,000 feet, and can be easily propagated from cuttings. When once established it spreads very rapidly, and a few well-established plants will yield a supply of pith sufficient to meet the requirements of a large laboratory.

The pith is firm, white, and free from vascular bundles. The parenchyma cells are relatively large and the walls are very thin.

It can be obtained in quantity from the old and young stems, and very often attains a circumference of 130 mm. In the young stem the pith is solid to the centre, but in older parts the central area is composed of thin parallel diaphragms of parenchyma alternating with small air chambers.

The petioles and roots do not yield large quantities of pith, the former being hollow and the latter nearly solid (vascular) to the centre.

I am informed that it is also particularly suited for entomological work. Its firmness places it before Helianthus tuberosa, and its homogenous texture and pure white colour render it a much more valuable pith than that from Elder for mounting very small insects.

HERBERT WRIGHT.

Notes of Indian Travel, by a Ceylon Botanist.

Descriptions of the Indian flora and vegetation have usually been given from the point of view of a botanist fresh from the temperate zone. It is much to be desired that more work should be done in India by visiting botanists—there is nowhere a larger or more varied field for study, travel, and investigation. It is true that in certain seasons the heat makes scientific work difficult, but there are many cool hill stations, and the floras of the hill regions are of special interest. It may be of use to future visitors and workers in the Ceylon Botanic Gardens to give a few notes of travel in India in the cold seasons of 1900–01 and 1901–02, in the course of which I visited a considerable number of mountainous districts in my search after the Indian Podostemaceæ, and to give these impressions in terms, not of the very different European flora, but of the comparatively similar flora and vegetation of Ceylon, which is known to many botanists. Ceylon, by reason of its geographical position and good climate, with the conveniences of travel and study which it possesses, forms a good centre for preliminary work to be followed by excursions into India.

Travel in India is now a comparatively simple matter. In some districts the resthouses (dâk bungalows) are furnished, in others not: in the latter case it is necessary to take furniture, and in all cases it is well to carry supplies, as but little can be purchased in most villages.

A good travelling servant is of course a necessity in nearly all districts, as no English is spoken even by the bungalow servants. Hotels are to be found in most of the larger towns, and the inclusive charge is usually Rs. 5 per diem. Travelling in the country districts is very cheap, especially in the south. Most parts of India are now accessible by rail in a short time, and the fares are extremely low.

My first tour was from Bombay to Colombo, by way of the Ghats, Poona, Bangalore, Madras, Ootacamund, and the Anamalais. My second was from Calcutta into the Khasia Mountains of Assam and into the Sikkim Himalaya. The two thus cover some of the most botanically interesting districts of India.

The flat low-country of the Konkan and the lower western slopes of the Ghats east of Bombay resemble the country between Colombo and Kandy, but the vegetation is far less rich, though of the same type. Many familiar Ceylon trees still occur, but the rainfall distribution is very different, an enormous precipitation in the summer monsoon and a drought from November to May. The more Malayan types of vegetation seem to disappear gradually, as the climate in going northwards from Galle to Bombay changes from the well-distributed rainfall and constant humidity of the former to the violent contrasts that mark the latter. Distribution of rainfall appears to be of much greater effect than total rainfall ; the total in the Bombay Ghats is very high indeed. The difference also shows in the cultivated palms on the coast, which in the Bombay District are mainly palmirahs, not cocoanuts. The general effect of the whole district in December is one of great dryness, only to be matched in Ceylon in a few districts of the north and south-east. All exposed places have a brown or yellow colour from the dry grass.

The configuration and scenery of the western side of the Ghats is not unlike that of the Adam's Peak region, but far less rich, and with more precipitous valleys ; many of these are almost cañons, with the streams pouring into their heads over lofty precipices. They are themselves usually well wooded, but the tableland above, which is at an average level of about 2,500 feet, is mostly open grass country, intersected by rocky stream beds, which in December are almost all dry. I stayed at two centres for the study of the rivers, Igatpuri at the top of the Thul Ghat on the Calcutta Railway (good furnished bungalow) and Khandala at the top of the Bhor Ghat on the Madras line (hotels). The former is very dry, and the lower slopes of the Ghat are covered with teak forest. The latter is an excellent headquarters for the study of the flora, and though the open tableland is no richer than the dry Uva patanas, which it much resembles, the valleys contain an interesting jungle flora. On the eastern side of the watershed the land slopes away gradually into the tableland of the Deccan, with quiet rivers meandering through irrigated cultivated country of little botanical interest. The chief tree is the Babul, Acacia arabica. The wild flora is very xerophytic, the district receiving very little rain. The heavy fall in the summer monsoon is only on the western slope of the Ghats, the eastern side remaining dry, like the Uva patanas in the south-west monsoon. At Poona there are some interesting gardens, and there is a herbarium of the Bombay flora at the College of Science under charge of Prof. Gammie.

The dry country continues all the way to Bangalore by the S. M. Railway, but in one or two places, *e.g.*, near Londa, the line passes into the hilly district of the Ghats, and there is a somewhat richer flora with stretches of jungle. At Watara station on this line the road to Mahabaleshwar, the Bombay sanitarium, branches off. This place lies at about 4,500 feet at the top of the Ghats, has an enormous summer rainfall, and is said to be an excellent centre for the study of the Bombay flora. I did not myself visit it.

From Bangalore, which is an interesting place and has a good Botanic Garden, there is a considerable descent into the plains of Madras, the general effect of which is similar to that of the cultivated Tamil country of Jaffna in the north of Ceylon; but there are several ranges of hills, which are covered with a scrubby jungle not unlike in general appearance to that on the hills between Nalanda and Dambulla. Madras itself is of no special botanical interest. The headquarters of the Government Botanist are at Ootacamund in the Nilgiri Mountains, to which I next proceeded. The ascent is very interesting, by a steep cog-wheel railway, leading from the hot steamy valley of Metupalaiyam to the little sanitarium of Coonoor at 5,500 feet. The flora at the foot of the Ghat has the general aspect of that of the North Matale District, and gradually changes on the ascent to a flora not unlike that of Nuwara Eliya ; there is much less cultivation on these slopes than in Ceylon. From Coonoor to Ootacamund the gradual ascent of 2,000 feet is over open rolling hilly country, cultivated in the hollows by the hill tribes. Ootacamund itself, being in the centre of a large plateau, has a comparatively dry climate, the violence of the north-east monsoon spending itself further east, and that of the south-west monsoon further west in the Kunda Hills, which drop suddenly to the low-country at the western edge of the plateau, just like the Ceylon mountains at Horton Plains. In all directions round Ootacamund the country consists of open patanas, like the Uva patanas as seen from Hakgala, but at a higher level. The flora is that of the drier parts of Horton Plains, the jungle being found only in sheltered valleys. To the botanist familiar with the up-country flora of Ceylon, that of the Nilgiris is of singular interest, the genera being mainly the same, but the species commonly different. All these mountain top floras of the south, including those of the Nilgiris, Anamalais, and Palnis, require much further investigation and comparison. Ootacamund is a particularly good station for such work, and there are good resthouses at various places on the plateau ; the climate is perhaps the finest in the East. There is a pretty little botanic garden in the town, and the Government Botanist of Madras also has his headquarters here, with herbarium and laboratory.

After leaving the Nilgiris I visited the not less interesting range of the Anamalais, on the other side of the great Palghat gap. This great mountain range is only now being opened up, and it is still necessary to take all camping materials in order to visit it. Leaving Podanur station, it is about 33 miles to the foot of the hills at Vananthorai, whence a cart road goes up to the planting district, which occupies a portion of the lower central plateau from 3,000 to 5,000 feet in elevation. The ascent is through forests of the type seen about Nalanda and other parts of the north-eastern sides of the Ceylon hills. At the summit level one passes into an evidently wetter region, and the central parts of the range have a very rich and interesting flora. They resemble the Ceylon hills in contour and vegetation, and are very little interfered with by any cultivation. Range after range of rolling hills can be seen, covered with high forest, intersected by clear streams, and broken by stretches of patana on the higher ridges, some of which reach to a height of close on 9,000 feet. The trees in the wet jungles up to 4,000 feet are remarkable for their great size, larger than those of corresponding elevations in Ceylon. There is an ample field for work in the study of the formations into which this flora groups itself; preliminary observations might well be made in Ceylon, where travelling and other facilities are greater, but the Anamalai flora is finer for actual work of this nature, being so much less interfered with by man. By working eastwards across the range the sister group of the Palnis, with a drier climate and greater patana area, may easily be studied, and accommodation can be obtained at the little sanitarium of Kodaikanal.

The journey from the foot of the hills to Tuticorin is through well-cultivated country of the general type of the Jaffna District of Ceylon.

My second tour was commenced from Calcutta, an interesting centre for the botanist from its magnificent botanic gardens and economic museum. It possesses, however, no laboratory accommodation. I first visited the Khasia Hills of Assam, described by Sir Joseph Hooker, much of whose track I followed. The hills can be reached in two ways by steamer from Goalundo, either up the Brahmaputra Valley to Gauhati or up the Surma Valley to Companygunj. The boats are comfortable and the journey easy. I myself followed the northern route, reaching the hills by *tonga* from Gauhati to Shillong, the capital of the Assam Province, and the residence of the Deputy Commissioner of the Khasia Hills, whose permission has to be obtained before travelling in the outlying districts. There is a good road to Shillong, but beyond that it is necessary to walk or ride, or to be carried by a cooly in a *thapa* or chair. Coolies are obtained by applying to the Superintendent of Police; they are very strong, and carry loads of 70 lb. with ease over the roughest mountain country. There are good dâk bungalows in the various villages, but all furniture and provisions must be carried from Shillong, except to Cherrapunji.

The voyage up the Brahmaputra is interesting, but the vegetation somewhat monotonous ; the river flows among broad sandy islands and low banks covered with tall reeds, forest being only visible in the far distance on the higher lands out of reach of the floods. The country between Gauhati and Shillong is very interesting, but is said to be very unhealthy, at least in the lower parts. The first portion of the 64 miles drive is like the foothill country near Mirigama, and then the road passes into the jungle for many miles ; the general type of vegetation is not unlike the Nalanda forests, but there are several unfamiliar forms. Linum trigynum is a beautiful sight along the banks at the roadside. These foothill jungles are very rich, and contain many interesting forms, such as Dipteris Wallichii. Their unhealthiness may be avoided by living in the hills above and making occasional descents into them. At about 3,000 feet the scenery changes to open rolling patana country with strips of forest, and above 4,600 feet the forests in the more open valleys consist mainly of Pinus Khasiana, giving a very northern look to the vegetation and scenery, which is increased by the great number of familiar European genera to be seen among the patana plants, far more even than on Horton Plains or at similar elevations in the Sikkim Himalaya.

Shillong is near the culminating point of the hills, and is a pleasant little sanitarium, commanding beautiful views of the Himalaya. The country to the south, towards Cherrapunji, is a level-looking plateau at first glance, but further acquaintance with it discloses the fact that it is intersected in all directions by extremely abrupt and deep valleys, which ultimately debouch into the plains of the great Surma Valley below Cherrapunji. The latter place stands on a level plain, which at the edges drops suddenly into splendid cañon-like valleys about 4,000 feet deep, with numerous beautiful waterfalls falling over their precipitous cliffs. The higher levels of the plateau are open grass country, but the valleys are mostly wooded, especially on their northern slopes, and the forests are both rich and interesting, while to the botanist from further south there is a great fascination in the many European-looking forms to be met with both in the jungles and on the patanas. Cherrapunji itself has long been famous as the locality of the greatest known annual rainfall. This, however, almost all falls between April and October, and the winter is cool and dry. The plain shows very clearly the effect of the enormous precipitation in its bleak stony aspect and its very scanty flora, while the valleys below are extremely rich. Probably, as Sir Joseph Hooker has pointed out, there is no place on the earth where so large a flora is to be found in so small an area, the Indian, Chinese, and Malayan floras meeting and mingling here, while, though the elevation of the Khasia Hills is small, the mountain flora is that of much higher elevations elsewhere. I know of no better or more interesting headquarters for an ecological worker than Cherra, and it has a good dâk bungalow and fine climate, except in the rains, which may be avoided by going further north to Shillong. It can be most easily reached from Calcutta by steamer from Goalundo up the Surma Valley to Chattuk and native boat to Companygunj, from whence it is a walk of about 25 miles with coolies. Another centre from which interesting excursions may be made is Mawphlang (Moflong) between Cherra and Shillong, but it is a bleak cold place in itself.

My second excursion was into the Sikkim Himalaya in the Darjiling and Kurseong Districts. Sir Joseph Hooker's classical description of the interesting flora and vegetation of this country gives all that is necessary for preliminary information, but it may be worth while to point out to European botanists that this region is now very much opened up, excepting in Nepal. Darjiling is a large town, within 22 hours of Calcutta by rail, and there are now resthouses at easy stages throughout the Sikkim routes followed by Hooker up to elevations of 12,000 feet. The flora has been well worked from a purely taxonomic standpoint, but there is a vast field for ecological work in this region ; botanists familiar with the Swiss or Pyrenean floras should find it of particular interest. At the same time the flora of the lower slopes, *e.g.*, about Darjiling itself (7,500 feet), is very like that of Horton Plains and other high levels in Ceylon, but mingled, like the flora of the Khasia Hills, with many more northern types. The whole formation and scenery of the Lower Himalaya, as seen from the Darjiling Railway, is very closely similar to that of the western side of the Ceylon mountains. From the foot of the hills to Calcutta the line passes through cultivated country, which in the last portion is very like the neighbourhood of Colombo, but evidently drier.

I take this opportunity of expressing my thanks to the various Government Botanists of India, Curators of Botanic Gardens, and other officials in the districts which I visited, for the hospitality and kindness shown to me at every stage of my journeys, and for the help rendered in arranging details of tours, &c.

J. C. WILLIS.

Opening of the Experiment Station at Gangaroowa, Peradeniya.

In the article on the history of the Botanic Gardens with which this volume opened, it was mentioned on page 12 that the chief desideratum for a complete modern organization of the Department was the opening of an experiment station or garden, where experiments could be tried on the large scale with staple products or with new products not yet staples. This station is now opened, the Government having purchased at the beginning of this year the almost historical estate of Gangaroowa, lying on the opposite side of the river to the Botanic Gardens. The estate is of 550 acres, and of approximately horse-shoe shape, forming the opposite bank of the Mahaweli-ganga up to the sky line all round the north, east, and west sides of the Botanic Gardens, while on the east side between the river and the hill there are about 200 acres of nearly level land with good soil. Visitors to the gardens will remember that many of the most beautiful views are obtained at places where the river curves, and that their beauty is due to the banks of the river itself and to the wooded hills behind. All these hills are included in the new experiment station, and are to be worked as forest reserves, so that there will be no interference with the scenic beauty of the neighbourhood. The experimental plots of economic plants will be laid out on the lower and more level land of the estate, which at present is mainly cultivated in cacao, pepper, cocoanuts, grass, arecas, and croton.

The estate is of historic interest in two ways. Round the bungalow enclosure may be seen the remains of the earthworks of the former Portuguese fort, the scene of a great defeat and slaughter of one of the armies which invaded Kandy. About 1824 the estate was opened in coffee, indigo, sugar, &c., by the then Governor, Sir Edward Barnes, who was one of the very first pioneers in the planting enterprise, which soon afterwards spread so rapidly over the central districts of the Island.

The New Branch Garden at Nuwara Eliya.

The Government having decided to open a small branch garden for experiments with cultivation of useful and ornamental plants in the peculiar soil of Nuwara Eliya, a small site of about 5 acres has been set apart for the purpose in the new park, and is now being brought into cultivation. It will be worked, like the Badulla garden, as a branch of Hakgala. The land lies at an elevation of about 6,200 feet, and is at present mainly patana with scattered Rhododendrons and a small piece of swamp.

The New Resthouse at Peradeniya.

This building, mentioned on page 21 of the present volume as in progress, was opened to the public on 10th March, and is very convenient for visitors to, and workers in, the gardens. It lies about 200 yards from the principal entrance to the Botanic Gardens, contains dining and sitting-rooms, and four large bedrooms, and is fully furnished with all necessaries. Visitors working in the Peradeniya laboratories have a prior claim to some of the rooms, for which a charge of Re. 1 per day is made. Meals are supplied according to arrangements to be made with the resthouse-keeper.

Publications.

THE Catalogue of the Library of the Peradeniya Gardens to the end of November, 1900, prepared by Mrs. Willis, was issued in book form in March, and may be obtained for Re. 1·50, or through Messrs. Dulau & Co. for 2*s*. Visiting botanists will find it useful in showing them what literature it is or is not necessary to bring with them for their work.

The following numbers of the first series of the "Circulars" have lately been issued, completing the first volume :—

22.—School, Bungalow, and Resthouse Gardens, and some Hints on how to plant them. By J. C. Willis.

23.—Cacao Canker in Ceylon. By J. B. Carruthers.

24.—Camphor. By J. C. Willis and M. K. Bamber.

25.—Mosquitoes and Malaria. By E. E. Green.

Personal Notes.

ON the 28th February, 1902, Mr. William de Alwis, Draughtsman of the Department, retired, and his son, Mr. Alfred de Alwis, was appointed in his place. The long connection of this family with the gardens, referred to on page 6 of this volume, is thus likely to continue unbroken for a considerable period.

William de Alwis Seneviratne, Mudaliyar, was appointed draughtsman on 1st November, 1865, and has thus served for over thirty-six years, under Drs. Thwaites and Trimen as well as under the present Director. The library at Peradeniya contains many hundreds of beautiful drawings of native and exotic plants made by him, and he has also for many years been responsible for the upkeep of the herbarium, in which work his extensive acquaintance with the native flora has proved of much service to the institution. Among the published examples of his drawings may be mentioned many of those in Trimen's Flora of Ceylon (the rest being by other members of his family) and the drawings of butterflies, &c., in Moore's Lepidoptera of Ceylon. The honorary native rank of Muhandiram was bestowed upon Mr. De Alwis in 1896, and the higher rank of Mudaliyar in 1901.

Studies in the Morphology and Ecology of the Podostemaceæ of Ceylon and India.

BY

J. C. WILLIS.

(With Plates IV.–XXXVIII.)

INTRODUCTORY.

IT is a matter of common knowledge with regard to families that consist entirely of water plants, that the morphology of the vegetative organs is usually complex, that the flowers are of simple structure (whether this be primitive or due to reduction), and that it is very difficult to determine the systematic position of the order. Well-known instances are the families Potamogetonaceæ, Nymphæaceæ, Ceratophyllaceæ. To none do these remarks apply with greater truth than to the Podostemaceæ, and perhaps no family is as yet so imperfectly known. In saying this I by no means forget or undervalue the splendid work of Tulasne and Warming, but there is yet room for a vast amount of research before our knowledge of this order can be regarded as anything like complete or accurate. We have, thanks to Tulasne, a good knowledge of the general morphology of the flower and fruit, and thanks to Warming of the morphology of the secondary shoots and thallus of many genera, chiefly South American, but this is practically all. The germination, the morphology of the primary axis, the development of the mature plant from the seedling, and

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the general life-history are unknown even for the comparatively accessible forms, such as Podostemon Ceratophyllum, and the systematic position of the order is a matter of great differences of opinion, some writers putting it in one, some in another place ; *e.g.*, near to the Saxifragaceæ, Caryophyllaceæ, Lentibulariaceæ, Pistiaceæ, Lacistemaceæ, Elatinaceæ, Nepenthaceæ, Sarraceniaceæ, Piperaceæ, and elsewhere. The present paper is an attempt to clear up some of the darkness surrounding our knowledge of this order, so far as the Asiatic species are concerned. No one can be more conscious than myself of the defects and gaps in the work, but I hope that its publication may stimulate botanists who have the opportunity to study these plants in their natural habitats, where alone they can be properly dealt with.

As to many botanical students the order is nothing but a name, it may be well at starting to mention that it consists entirely of submerged water plants, living only in rapids and waterfalls, firmly attached to the rocks on which they grow ; that their vegetative organs frequently consist very largely of *thalli*, which are very often of (phylogenetic) "root" nature ; and that both in external form and internal structure they simulate in the most remarkable way Algæ (*e.g.*, Fucus), liverworts, mosses, and lichens. A glance at the plates at the end of this paper will show this.

My observations have as yet been almost entirely confined to the Indian and Ceylonese species. By no means one of the least troublesome parts of the work has been the purely taxonomic labour of determining the limits of the genera and species, which have hitherto been very inaccurately defined. This work is as yet very incomplete, but so far as possible I have worked out the Indian and Ceylon forms, and the somewhat sweeping changes in the nomenclature and taxonomy which I have found necessary have been described in a preceding paper with the view of clearing the ground for the present work.* As there explained, I first

* Willis, A Revision of the Podostemaceæ of India and Ceylon, Ann. Perad. I., 1902, p. 181.

studied the Ceylon species, then visited Europe to study the Indian forms, but found the material hitherto preserved to be practically valueless, and visited India myself and collected fresh material of all but two of the recorded forms, and of several new ones. I am indebted for valuable assistance to the various friends there mentioned. The life-histories of the Indian species have still, however, to be worked out upon the spot.

As there is no good account of this family in English, and as Warming's classical papers are written in Danish, it will be well to commence with a short account of what is already known about these plants. The chief literature extant is given in the following list, to which reference will be made by number only in the rest of the paper :—

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(2) Baillon, Hist. des Plantes, IX., 1886, p. 256.
(3) Beddome, Anamallay Plants, Trans. Linn. Soc., xxv., 1865, p. 223.
(4) Bentham & Hooker, Genera Plantarum, III., p. 105.
(5) Bischoff, in Flora, xxvii., 1844, p. 416, t. 1.
(6) Bongard, Mém. de l'Acad. de St. Pet., VI., ser. III., 69, 1834.
(7) Brown, B., Canoe and Camp Life in Brit. Guiana, London, 1876, p. 11.
(8) Cario, Anatom. Unt. von Tristicha hypnoides, Bot. Ztg., 1881, p. 25.
(9) Du Petit Thouars, Gen. Nov. Madag., ii., 1806 (Hydrostachys).
(10) Endlicher, Genera Plantarum, p. 268.
(11) Engler, Podostemonaceæ africanæ, Engl. Bot. Jahrb., XX., p. 134, 1894.
(12) Gardner, Structure and Affinities of P., Calc. Journ. Nat. Hist., vii., 166.
(13) Goebel, in Pflanzenbiol. Schilderungen, I., 166, II., 331, 374.
(14) do. Organographie d. Pflanzen, pp. 212, &c.
(15) Griffith, in Asiatic Res., xix., p. 103.
(16) do. Icones Plant. Asiat., t. 541–544.
(17) do. Notulæ ad Pl. As., p. 376, &c.
(18) Hooker, Sir J. D., Flora of Brit. India, V., p. 61.
(19) Hooker, Sir W. J., Icones Plant., t. 2,356, 2,357.
(20) do. Companion to the Bot. Mag., II., pl. xx., and p. 23.
(21) Humboldt & Bonpland, Plantæ Aequin., I., 39, t. 11, 1808.

(22) Im Thurn, Among the Indians of Guiana, London, 1883, p. 105.
(23) Jussieu, A. de, in Delessert, Icones Select., iii., 91–94 (Hydrostachys).
(24) Klotzsch, in Peters, Reise Mossamb. Bot., 506, t. 52 (Hydrostachys).
(25) Kohl, Kalksalze und Kieselsaure in d. Pfl., Marburg, 1889, p. 249.
(26) Kurz, in Journ. As. Soc. Bengal, xlii., 1873, ii., 103.
(27) Lindley, Vegetable Kingdom, p. 482.
(28) Martius & Zuccarini, Nov. Gen. et sp., I., 6, 1822.
(29) Michaux, Flora Bor.-Am., ii., 164, t. 44, 1803.
(30) Möller, Cladopus Nymani, Ann. Jard. Bot. Buitenz., xvi., 1899, p. 115.
(31) Müller, Fr., in Nature, xix., 1879.
(32) Richard, in H. B. & K., Nova gen. et sp., I., 246, 1815.
(33) Spruce, Notes on Plants collected chiefly in the Rio Uaupes in 1852. Herb. Kew, quoted in Goebel, Pfl. Sch., ii., 335.
(34) Strasburger, Bau und Wachsth. d Zellhäute, 1882.
(35) Thwaites, Enum. Pl. Zeylan., p. 222.
(36) Trimen, in Journ. Bot., xxiii., 1885, p. 173.
(37) do. Flora of Ceylon, iii., 415, and v., 386 (Willis).
(38) Tulasne, Podost. Synopsis Monographica, Ann. d. Sc. Nat., III. ser., t. xi., 1849, p. 87.
(39) do. Monographia Podostemacearum, Arch. du Mus. d'Hist. Nat., vi., 1852.
(40) do. in Martii Flora Brasil., IV., pars 1, 1855, p. 229.
(41) Wächter, Weddellina squamulosa, in Flora, 83, 1897, p. 367.
(42) Warming, Familien Podostemaceæ, I.-VI., Kgl. Dansk. Vidensk. Selsk. Skr. 6 Raekke, ii., 1881, ii., 1882, iv., 1888, vii., 1891, ix., 1899, xi., 1901.
(43) do. Podostemaceæ, in Engler & Prantl, Nat. Pflanzenfam., III., 2a, p. 1, 1890, and Nachtrag, p. 179.
(44) do. Note sur le genre Hydrostachys, Bull. Ac. roy. danoise, 1890.
(45) do. Podostemaceæ, Flora of Koh Chang, Bot. Tidsskr, 1901.
(46) Weddell, Monograph in DC. Prodr., xvii., 1873, p. 39.
(47) do. A new African genus of P., Journ. Linn. Soc. Bot., XIV., p. 208, 1874.
(48) do. Sur les P. en gén. et leur distr. géog. en partic., Bull. Soc. Bot. France, XIX., 1872, p. 50.
(49) Wight, Icones Pl. As., V., p. 31, t. 1,916–1,920.
(50) Willis, A Revision of the Podostemaceæ of India and Ceylon, Ann. Perad., I., 1902, p. 181.
(51) do. Additions and Corrections to Ceylon Flora. Trimen, Flora of Ceylon, V., 1900, p. 386.
(52) do. in Nature, vol. 61, Nov. 1899, p. 68.
(53) Woodrow, in Rec. Bot. Survey India, I., p. 95, 1895.

In earlier times these plants were commonly mistaken for algæ or lichens or even mosses ; the resemblance is so great in many cases, especially in the vegetative condition, that such mistakes are quite excusable. The resemblance is also indicated by the frequency of such specific names as bryoides, fucoides, algæformis, lichenoides, &c. The first to be described and made the type of a distinct family was Mourera fluviatilis, found in 1775 by Aublet (1) in French Guiana. He describes it as growing upon the rocks at a great cascade in the Sinemari river, where it is always submerged, only the floriferous part coming above the water. Little progress was made in the knowledge of these plants, and comparatively few had been described, until the publication in 1849 and 1852 of Tulasne's monographs (38, 39). He divides the order into 21 genera, describing 79 species, most of them for the first time. The second paper is illustrated with beautiful figures, which show in a very striking way the great variety of form which exists among these plants. Tulasne's descriptions and detailed analyses are very accurate, much more so than those of some of his successors. It will be noticed that in the preceding paper I have returned almost completely to his definitions of the generic and specific forms of the Indian Podostemaceæ. His interpretations of the morphology, as is only to be expected in a work of that period, are often misleading.

The systematic part of Tulasne's work was continued by Weddell (46), whose monograph has been the standard for subsequent classifications of the order. His work, however, at any rate so far as the Indian forms are concerned, is inferior to that of Tulasne in accuracy and insight, and he does not deal at all with the morphology or ecology, except in a separate paper (48), where he treats the order with reference to its geographical distribution, and in which he calls attention to the limited distribution of the species as compared with most water plants, noting especially the curious fact that in the rivers which he studied in South America the forms were different at each cataract passed in ascending the rivers. The same fact has been noted by Goebel (13) in the rivers of British Guiana, and my own work described in the preceding paper inclines me to believe that the same is the case in the rivers of India and Ceylon.

The latest and most complete account of the family has been given by Warming in a beautiful series of monographs (42), with which we shall now proceed to deal. In the first he describes Podostemon Ceratophyllum, Michx., found in the United States, and two South American species of Mniopsis, showing that the mature plant consists of a thin filamentous creeping "root," closely attached to the rock, often by special organs which he terms haptera, exogenous outgrowths of the root or stem, very common in the whole family. They are sensitive to gravity and contact, grow downwards to the rock and spread themselves out on it, being fastened very firmly by the development of rhizoids or by a gummy secretion. The creeping root may be termed the *thallus;* it bears a more or less aborted root-cap, is green, and takes part in the work of assimilation. From it, at regular intervals and in acropetal succession, are developed secondary shoots, arising endogenously in the tissues of the root, and emerging and growing upwards through the water. These shoots have a complex morphology of their own, and ultimately bear the flowers, usually terminal on the branches, which themselves arise in the under axils of dithecous leaves (leaves with a stipular outgrowth on the under as well as on the upper edges). During the vegetative season the whole plant is submerged, but as the water falls the flowers emerge.

In his second paper, Warming describes two new types of form. The first occurs in the South American Castelnavia princeps, which has a thallus composed of combined shoot structures, united to form a flat creeping body bearing leaves on the margins (*l. c.*, pl. XIII.), and with the flowers emerging from small cavities in the thallus during the dry season when the water-level is low. The second occurs in the Ceylon species Dicræa elongata and D. algæformis (D. stylosa), where the thallus is more or less dimorphic, a part of it creeping on the rock and branching in the plane of the rock, part of it consisting of long filamentous or ribbon-like organs arising from the creeping parts and streaming out freely in the water. These thalli are phylogenetically of "root" nature. On the streaming thalli the secondary shoots arise endogenously, as in Podostemon, but are only single-flowered and very short.

In the third paper several species of Podostemon are described, which resemble P. Ceratophyllum in their morphology. Some species of Apinagia and Ligea are also described, in which there is a more complex shoot than in Podostemon, which has many leaves, and drifts out in the water, bearing at the usual season a complicated inflorescence. The shoot and not the root is the principal growing and assimilating part in these forms. Mourera aspera, which has a sort of rhizome, bearing large leaves and complex inflorescences, is then described.

The fourth paper deals first with the curious African genus Hydrostachys, which Warming has since placed in a separate family. The Abyssinian form Sphærothylax (Anastrophea, Wedd.), which has both a flat lichen-like thallus and a tall erect stem, is then described. The thallus is shown to be of "root" nature like the thallus of Podostemon, and it bears small endogenous flowering shoots all over its surface. This very remarkable structure is repeated in Hydrobryum olivaceum, a Ceylon species described in the same paper, only that here, so far as Warming's observations (made on spirit material collected in the dry season) show, the plant has only the thallus, and thus practically consists of a "root" alone ; this is, as we shall see, not quite the case, but the tall primary axis when seen in 1854 was mistaken for a distinct species, and received the name Podostemon Gardneri. This very curious plant is also described by Warming in an earlier part of the same paper under the name of Dicræa apicata of Tulasne. The full life-history is given below. Prof. Warming also describes in this paper two species of Lawia. L. foliosa is correctly described; it has a flat creeping thallus composed of combined shoot structures (as in some Castelnavias), and bearing flowers. We shall see below that this is also the case in L. zeylanica, but in the spirit material of this Ceylon species, which was all that Prof. Warming had for examination, and also in the specimens preserved in herbaria, the growing points were not present, and so the true nature of the thallus was misunderstood, and it was described as a "root" structure like that of Hydrobryum olivaceum.

In his fifth paper, Warming deals with Tristicha hypnoides, a form widely distributed over the world, and having a peculiarly complex form of shoot arising from a creeping root. He also describes several new species of Mourera, Podostemon, &c., and creates a new genus, Leiothylax.

Finally, in his sixth paper, Prof. Warming describes several new species in detail, establishes several new genera upon the Indian material, as already described in my first paper, and deals with the morphology of Marathrum. He also describes the Indian species Griffithella Willisiana (Hookeriana, var.) and Hydrobryum lichenoides (Polypleurum acuminatum, Wmg.). This paper ends with a discussion of the classification of the order, which has been already mentioned in my preceding paper so far as it concerns the Indian forms.

But little has been written by any other authors on the general life-history or ecology of the Podostemaceæ. The most readable account is that given by Goebel (13), who describes the plants from his own observations in British Guiana. He also points out again, what was first noticed by Weddell, that the range of distribution of the species is, as a rule, very limited, and that even in one river there may be a different set of species or forms at each successive cataract. He describes the way in which the Podostemaceæ grow only in rapids, flowering when the fall of the water level expose them to the air, and he deals with the morphology of the forms found by him; this work was continued by his pupil Wächter (41), who has described Weddellina in detail. The only other recent paper dealing with any of the family in full detail is that of Möller (30) on the newly discovered Javanese species Cladopus Nymani; his account is criticised and amended in Warming's sixth paper already quoted.

The special literature of the Asiatic forms has been already dealt with in detail in my first paper, and from the morphological point of view mention need only be made of the work of Griffith (15–17), in which many interesting observations may be found scattered in various places, and of Gardner, who described many of the Ceylon and South Indian forms for the first time, and also gave a very interesting account of the order, with which he had also worked in Brazil.

GENERAL CONDITIONS OF LIFE.

Habitat.—So far as is yet known, all Podostemaceæ live in rapidly moving water, usually in very rapid or even broken water, such as is found in the rapids and waterfalls of mountain streams. They are only found attached to rocks as a rule, but occasionally may be seen growing upon logs of wood or other objects which have become firmly wedged in the rocks. Each species appears to affect a particular class of habitat, probably chiefly determined by the speed, depth, and degree of brokenness of the water, and the species do not intermingle very much, as will be more fully described under each. A description of the chief locality at which I have studied these plants will thus serve in general as a description of the usual habitat of the plants of the order.

All but one of the Ceylon species as yet known occur abundantly at a place called Hakinda, on the Mahaweli-ganga, at the extreme north-east boundary of the Experiment Station at Peradeniya, and about a mile from the Botanic Garden, at an elevation of about 1,500 feet above sea-level. The Mahaweli-ganga, as it flows round the Botanic Gardens, is a swift smoothly-flowing stream about 80–100 yards wide during ordinary weather. It is subject, like other mountain streams, to sudden and heavy floods during rains, and I have seen it rise 10–15 feet in a day. The current is very swift even in the driest weather, and the water is always muddy, owing to the wash from paddy fields and tea estates on the hills which it drains. In the driest weather it has a pale straw colour, and in rains it becomes a thickly turbid stream, the colour being that of strong coffee mixed with a moderate amount of cream. The rise and fall of the water-level is rapid and decided; in former years, before the mountains of the Central Province were so largely cleared of their forests for planting purposes, this was probably much less pronounced, and the water, too, was probably less muddy, and so perhaps the plants submerged in it could live at a greater depth.

At Getambe, just below the gardens, the river enters a deep rocky gorge and becomes a furious torrent, resembling the Clyde above Cora Linn, or the Wharfe near the Strid. The stream is closely confined by hard steep gneiss rocks full of potholes, and in many places is reduced to a fraction of the width that it has at Peradeniya. This gorge continues for about half a mile to Hakinda, where it turns a corner, and at the same time the steep hillsides fall back a little from the glen, and the river widens out into a broad basin, running among numerous small rocky islets. The current is still very rapid, but has less depth and force, and it is therefore practicable to wade about in many places, an impossible feat in the narrow gorge higher up. All along the rocky part of the river just described the rocks are more or less overgrown with Podostemaceæ, wherever they are covered by water during ordinary weather. These plants grow only on places where the water is in constant motion, and never in stagnant water. They even flourish on the rocks at the sides of the waterfalls, with the furious current rushing right over them. If the level of the water falls at any time those plants which become exposed to the air soon die, and so we see a sort of tidemark traced upon the rocks by their covering of Podostemaceæ. This mark indicates the average level to which the water falls during their growing season, above which it may temporarily rise during heavy rain, or below which it may sink during exceptional dryness of the weather.

Plate IV. shows a view of a portion of the rapids at Hakinda, photographed in the dry season, with fruiting Podostemaceæ on the rocks. These plants do not show very distinctly in a photograph, owing to their dull gray colour, which is not very distinct from that of the rock itself, but it is not difficult to make out the band of exposed dead plants forming a kind of tidemark on the rocks for some few feet above the present water-level. At the places of most violent rush of water the thalli are chiefly the flat closely attached Lawias and Hydrobryums, while in the less violent parts the Dicræas occur, and in the eddies Podostemon and Farmeria are abundant.

The Rainfall and its Distribution.—Perhaps the most important factor in the life-history and ecology is the rainfall and its distribution throughout the year, as this factor controls the level of the water, and hence the local distribution and the period of flowering of the plants. The following table, taken from the meteorological report of the Surveyor-General for 1898, gives the average rainfall for twenty-six years at Kotmale (Gingran-oya), in the centre of the mountain basin of the Mahaweli-ganga ; the distribution of this fall is a fair index of the general state of the water-level of the river at Peradeniya at the various times of the year :—

Month.	Inches.	Days.	Month.	Inches.	Days.
January ...	2·93 ...	7	July ...	21·41 ...	23
February ...	2·19 ...	5	August ...	16·59 ...	22
March ...	4·92 ...	8	September ...	15·44 ...	20
April ...	9·34 ...	15	October ...	17·60 ...	23
May ...	12·11 ...	16	November ...	11·72 ...	16
June ...	24·99 ...	25	December ...	8·36 ...	13

Total 147·60 on 193 days. Greatest fall in 24 hours 11·40 inches. [If a coefficient of about 25–30 be added to these figures, they may fairly represent the average level, *e.g.*, 28–33 in January and 50–55 in June.]

It will be observed that there are two seasons in the year, each of about six months' duration, corresponding to the two monsoons, beginning with much rain and gradually becoming drier. The north-east monsoon begins about the middle of October, and there is much rain until about Christmas, with high water-level in the rivers. The rocks seen in the photograph of Hakinda are very commonly all submerged at this time, though the rapids are about 200 metres wide. About the end of the year the rainfall slackens, and the dry weather of this monsoon, the "dry season" of S.W. Ceylon, sets in. The Podostemaceæ, lately deeply submerged, now become gradually exposed to the air as the level of the water sinks, and as they become exposed, the flowers, which are quite ready for anthesis, open, become fertilized, and quickly ripen their fruits, shedding the seeds upon the dry rocks, while the old plants usually die. In this condition they remain until April, when the south-west monsoon begins, with gentle winds and a good deal of rain. This first onset of the monsoon is not violent, and is locally known as the "little monsoon," but there is usually enough rain to raise the water-level so high that all the seeds germinate. A fall of water-level takes place in May, at which time it is usually practicable to get at the plants once more and to search for seedlings, and then about the end of May the "big" monsoon sets in with violent wind and rain from the south-west, causing the river to rise very high. During June and July it usually remains high, but in August and September there is usually less rain, and the level of the water sinks, often so low as to expose some of the plants to the air. If this happens the exposed parts of the plants usually die unless quickly re-submerged, and they have not yet developed their flowers.* The development of the flowers takes place during the high water of the last two months of the year, and by the middle of December the flowers are generally completely formed, ready to open as soon as exposed to the air.

The general life-history at Peradeniya is then briefly this : the seeds are shed upon the rocks in January and February, germinate in April; the plants reach their full vegetative development in September and October, and develop their flowers subsequently ; the flowers are exposed to the air by the fall of the water at the beginning of the dry season, and the exposed plants wither and ultimately die.

Hitherto the life-history of these plants has never been thoroughly investigated, all descriptions having been written from material collected at the flowering season. During the greater part of their life the plants are deeply submerged in violent torrents of usually muddy water, and their study is a matter of difficulty and even of danger ; during the height of the monsoons it is practically impossible to get at them. Fortunately, however, there are often periods when the water-level is lower for a short time, and by combining these periods over several years I have been so fortunate as to be able to work out the complete life-history for most of the Ceylon forms, with the exception of the development of the floral shoots towards the end of the year.

Podostemaceæ are found abundantly in all districts of India and Burma, where there is rain in the south-west or summer monsoon, but on the whole their vegetative season is shorter than in Ceylon, and the more so the farther north we go in each region, the rains beginning later and ending earlier in the year. The following tables of rainfalls in various localities where Podostemaceæ have been found (taken

* If submerged again within a very short time, rejuvenescence takes place, new growing points being formed behind the withered portion.

from Blanford's "Climates and Weathers of India, Ceylon, and Burma," 1889) will illustrate this :—

Month.	Ootacamund.	Merkara.	Mahabaleshwar.	Lanauli.	Darjiling.	Cherrapunji.	Shillong.	Moulmein.
January ...	0·5	0·3	0·4	0·1	0·7	0·6	0·4	—
February ...	0·2	0·1	0·1	0·1	1·3	2·6	0·8	0·1
March ...	1·2	1·1	0·4	0·1	1·7	9·0	2·0	0·1
April ...	3·9	2·2	0·9	0·1	5·3	29·6	3·7	3·0
May ...	6·2	6·1	1·4	0·6	7·7	50·0	10·0	19·7
June ...	6·0	25·8	47·3	28·1	28·4	110·0	17·0	38·4
July ...	5·6	42·1	102·1	65·3	28·5	120·5	14·0	43·9
August ...	4·2	25·7	68·6	40·4	28·5	78·9	14·4	43·0
September ...	3·7	12·3	32·9	23·8	16·9	57·1	15·4	30·3
October ...	9·8	8·0	5·8	4·8	7·5	13·6	6·2	8·4
November ...	2·9	2·6	1·1	0·4	0·1	1·8	1·0	1·5
December ...	1·6	0·6	0·4	0·2	0·5	0·3	0·4	0·1
Total ...	45·8	126·8	261·4	164·0	127·1	474·0	85·3	188·5

Thus, in the Nilgiris the vegetative season is not much shorter than in Ceylon, in the Merkara Ghats it is practically over in November, and in the Bombay Ghats (Lanauli) in October. In comparing these figures, the proportions rather than the total fall should of course be taken. Thus, the Bombay streams fall greatly in October, though the total rainfall is still considerable. The Assam and Burma districts have a rather longer wet season than Bombay.

The rivers in the higher levels of the Western Ghats of the Bombay Presidency are represented in December, the period at which I saw them, by long dry torrent beds, filled with immense numbers of boulders and stones of all sizes, but with occasional, usually steeper, stretches of firm rock. On the latter, but not on the loose stones, however large, unless firmly wedged in some immovable position, Podostemaceæ, and especially Lawia, abound in the districts I examined. During the rains, as may be imagined from the rainfall tables, these streams are large and violent, but by December many are completely dry, and in none is there more than a mere trickle of water. In this the few Podostemaceæ that have not yet fruited are found, their green or red thalli shining brightly in the sun and forming a very pretty sight. On the rocks above the water-level are thousands of fruits borne on the dead withered thalli. Higher still, and this is a circumstance of rare occurrence with the greater uniformity of level of the Ceylon rivers, may be seen dry plants, which have been exposed so early in the season that they have not formed any flowers, and at times even seedlings may be found by any one who has seen them in the living condition, and thus can recognize them. A good deal of information was obtained from the study of the early stages thus preserved. The rejuvenescence of the thallus, on the other hand, which is so marked a feature of the Ceylon forms, enabling them to overcome the difficulties caused by changes in the water-level between the rainy seasons, is rarer and of less importance in the Bombay districts, where the rivers run quite dry.

At Darjiling the periodicity must evidently be very much the same as in the Merkara district of the Western Ghats. Only one species has been recorded from Sikkim, Hydrobryum Griffithii, found by the Rev. P. Decoly in a stream near Kurseong. I visited this stream, and found it to be one of the rivers of the foot-hills, rising at about 7,000 feet, and thus not fed in summer by snow water. No Podostemaceæ have as yet been found in streams fed by melting snows.

In the Khasia hills of Assam the periodicity is very similar. I spent part of December, 1901, among these hills. The season had been fairly normal as regards rainfall, but the water in the rivers was far less low than in the Bombay Ghats, though low enough to have exposed most of the Podostemaceæ. In general the rivers were like those of Ceylon in this respect, and they evidently do not run dry like the Bombay streams. Many of the plants showed a certain amount of rejuvenescence where they were still covered with water. Hooker, in his Himalayan Journals (vol. II., p. 314, note), says under date September, 1850 :—"Podostemon grew on the stones at the bottom : it is a remarkable water plant, resembling a liverwort in its mode of growth. Several species occur at different elevations in the Khasia, and appear only in autumn, when they often carpet the bottoms of the streams with green. In spring and summer no traces of them are seen ; and it is difficult to conceive what becomes of the seeds in the interval, and how these which are well known, and have no apparent provision for the purpose, attach themselves to the smooth rocks at the bottom of the torrents. All the kinds flower and ripen their seeds under water, the stamens and pistil being protected by the closed flower from the wet. This genus does not inhabit the Sikkim rivers, probably owing to the great change of temperature to which these are subject."

The specimens which were collected by Sir J. D. Hooker at this time were in flower or fruit. Whether the statement that the flowers are fertilized under water is always correct or not should be settled upon the spot. My own visit was too late in the year for this purpose, but I saw evidence leading me to suppose that in Dicræa Wallichii there might have been cleistogamic fertilization. In the Hydrobryums I did not see any evidence of cleistogamy. Cleistogamic flowers occur in Podostemon Barberi, so that there is no reason to doubt that they may occur in others of the order, and indeed one is only surprised that this is not a more common phenomenon.

We have thus seen that the depth of the water at the various times of the year, itself regulated by the distribution of the rainfall, is the immediate determinant of the phases of the life-history, and we must now go on to consider the other chief general factors in the life of these plants.

Temporary Variations in Depth of Water.—Not merely does the grand period, as we may call it, of the water depth determine the great outlines of the life-history, but the more temporary variations in depth have a most important effect on the ecology of these plants. In the slowly moving streams affected by most water plants the changes of level are slow and slight, and there is at any rate little prospect of the plants being actually exposed to the air, and that, too, on a substratum of bare rock rather than of water-retaining mud. In rapids and in mountain streams generally, however, the water-level is liable to frequent changes, whether of sudden rise or of fall sufficient to expose the plants to the sun and air on the bare rocks, or in very shallow water. It is by no means uncommon in August or September to find, at Hakinda, large quantities of Podostemaceæ exposed on the rocks by the fall of the water, and when exposed at this period the plants cannot form flowers, and simply die if not re-submerged within a short time. I am inclined to think that the gradual adaptation of the Indian Podostemaceæ to meet this danger has been one of the most marked features in their evolution. It seems to show especially in two ways, in the enormous capacity of rejuvenescence that the plants possess, and in the great dwarfing of many of the most highly evolved forms; it probably shows also in the increase of number and diminution of size of the secondary shoots, and in the partial amphibiousness of the thalli. We shall return to this at the end of the paper.

Ultimate Exposure.—Whatever may be the effect of the temporary changes of water-level, the plant must ultimately be completely exposed by the great fall of the water-level in the dry season, and adaptation of the life-history to this fact is an absolute necessity. This is clearly marked in the way in which the flowering takes place only at this time, while during the period of high water-level the plant is vegetative only, storing up large reserves of material to enable it to flower and ripen its seeds very quickly when the exposure does come, because, though able to live for a short time above water, the thalli are not usually capable of standing very long exposure.

Aeration.—Another important factor in the life-history is probably the aeration of the water. Instead of the almost stagnant water with a muddy bottom in which so many water plants live, the Podostemaceæ have constantly and rapidly moving water with a rocky bottom, and the water is well aerated. The necessity which thus appears to exist for many water plants of providing means of supplying oxygen for respiration to their more deeply submerged parts is absent in the case of the Podostemaceæ.

Light.—The depth of the water acts in another way upon the dis tribution of the plants in the vertical direction by regulating their light supply. The vertical range of the plants in the Hakinda rapids is small, extending only over about three or four feet, or less in many places. The lower boundary is mainly determined, it may be well supposed, by the amount of light there available to the plants. Possibly the actual pressure due to the water may join in producing the result, but most probably the light is the larger factor, and both depend directly on the depth of the water. During periods of high water the plants seem to tend on the whole to grow upwards rather than downwards.

The depth varies considerably at different seasons, so that the light supply also varies, and the effect is intensified by the fact that the muddiness is usually greater in the deeper water. The earliest stages of the life-history must go on in comparative darkness (especially as there is less sunshine in the wet weather), while in August, September, and early October, the period of greatest vegetative activity, the plants are exposed to fairly bright light, being at that period close to the water surface. With the reserve materials stored up during this period the development of the floral shoots is ultimately carried out towards the end of the high water-level and comparative darkness of the north-east monsoon, and reserves are also provided for the ripening of the seeds. In the more northern stations of the Western Ghats this statement must be modified, for there is there no drier period between two wet ones. The life-history in this district has yet to be studied, but probably during the time of greatest depth of water the plants are vegetative only, while they store their reserves and develop their flowers during the gradually decreasing water depth and increasing light of the last months of the rains.

That the plants have need for a considerable amount of light is shown by the fact that they are rarely to be found in shady places where the water is not exposed to the sunlight for at least some hours daily. They affect chiefly open sunny rapids.

In this connection it may be mentioned here that nearly all these plants have a great amount of anthocyan in the surface cells, so that when alive they have a red rather than a green colour.

Light, as is well known, tends also to have a dwarfing effect on plants. Progressive dwarfing is one of the marked features of the evolution of the Podostemaceæ, but to what extent, if at all, light has operated in this must be a matter for future investigation.

Temperature.—With regard to temperature, there is little to be said. The Podostemaceæ inhabit, with few exceptions, the tropical zone, where the temperature of the water is very uniform, and the few that live in more northern regions, *e.g.*, those of Assam and Ohio, carry out their life-history in the summer months. The forms living in the low-country of Ceylon or South India have a very constant water temperature of about 80° F. (27° C.), and those of the hills in these countries a similarly constant though lower temperature, *e.g.*, at Peradeniya of about 75° F. (24° C.), or at Paikara in the Nilgiris of about 58° F. (15° C.). In the Khasia Mountains of Assam the life-history is over by the time that the coldest weather begins, and the coldest water in which I found any species in that district in December, 1901, was about 57° F. (14° C.). The temperature is so uniform in most, if not all, cases that it may probably be almost ignored as a morphological factor, but it appears to regulate the geographical distribution to a large extent. No Podostemaceæ have yet been found in really cold water, and even in India and South America they are, so far as yet known, absent from streams fed by melting snow.

Speed of Current.—The next factor to be considered is the speed of the current of water in which the plants live. Leaving out of account the effects of scour, to be considered presently, there seems to be no speed of current in itself too great for the plants to be able to live in it. Podostemaceæ are frequently found in the very rapid currents flowing over the waterfalls and in the swiftest parts of rapids. On the other hand, it is not all the species that are able to live in the very swift water. The swifter the current, the greater the strain on the plants submerged in it, tending to drag them down stream. As might be expected, all the Podostemaceæ show very well adapted structures for resisting this strain. The very swift waters are inhabited, as a rule, only by the best adapted species, *i.e.*, in general the most dwarfed and lichen-like ; the edges of waterfalls and the violent rapids in Ceylon and India are usually inhabited by the flat lichen-like Lawias and Hydrobryums, while the larger Dicræas, Griffithellas, and still more Tristicha, are found in places with less swift and violent water currents. As is already well known, the Podostemaceæ differ from other water plants in the absence of the intercellular spaces which are so marked a feature in the latter, and this peculiarity is perhaps partly connected with the fact that they require to lie flat down upon the rocks to avoid the strain of the current as much as possible. A fragment of one of these plants at once sinks in water if thrown into it.

Scour.—An important factor in the local distribution at any rate is the scour of the current, due to the quantity of suspended matter contained in the water, whether at all times, as in the Mahaweli-ganga, or only at seasons of high floods. If a very large scour goes on by the rolling of stones, pebbles, and gravel down stream, the Podostemaceæ are not able to survive this action, and places of much scour are found to be free of these plants, except in sheltered bays in the rocks. On the other hand, the plants may live successfully for many years in a particular locality, and may be exterminated or nearly so by a high flood causing an unusual scour. To such a cause, I think, must be attributed the fact that the river below Toong in the Sikkim Himalaya, which in 1899 contained large quantities of Hydrobryum Griffithii, now appears to contain none ; the great cyclonic storm, on the occasion of the Darjiling landslips, must have caused an immense scour. So also, though I searched the stream in which Griffith originally found the species just mentioned, I was quite unable to find a single plant ; it seems to have been exterminated there since 1835 by natural causes.

Substratum.—As might be expected, the common substratum upon which these plants are found is smooth water-worn rock, but occasionally, when a log of wood or other object has become firmly wedged among the rocks, plants may also be found upon it. They are never found on unstable substrata, with the exception of one or two species which grow in slower water, and are found attached to pebbles, which they usually fasten together by their creeping thalli. This is often the case with the Indian Tristicha ramosissima and the North American Podostemon Ceratophyllum. The actual composition of the rock seems to be a matter of practical indifference, and it is very doubtful if the plants absorb much or any food from the rock upon which they grow, unless perhaps silica, with which they are often very largely provided.

Deposit.—A considerable amount of silt is often deposited on these plants, especially at times when the speed of the current slackens and the water-level falls. It must affect their assimilation, and at times is heavy enough to injure or kill them.

Biological Factors.—Competition with other plants is a factor of very slight importance indeed with all the more modified Podostemaceæ ; they live in water so rapid that no other flowering plant, and only occasionally any Cryptogam other than a minute alga or two, is found there. The less modified forms, such as Tristicha, often share their habitat to some extent with aquatic mosses, and on rare occasions with a fern or an Eriocaulon. In the dry season, when the water-level falls slow enough to bring the Podostemaceæ to the surface, they become covered with filamentous algæ, but by this time it can matter but little to their success or life. These plants escape from competition to a degree that is very rare in the vegetable kingdom. They hardly even compete with one another for position, as each species on the whole affects, as already mentioned, its own particular kind of locality, and only to a small extent mixes with others. This absence of competition is probably a very important factor in the morphological features of these plants; they have been enabled to adapt themselves structurally, mainly in relation to the physical factors of their environment, rather than to the biological.

Animal life also seems to have but little effect on the Podostemaceæ. The movement of the water is too swift to allow them to be attacked by fish, and the only animals that seem to have any effect are the larvæ of various water insects; these feed greedily on the thalli, which are usually very rich in starch. Indirectly, wading birds are probably of much importance, because they walk about on the rocks with wet feet in the dry weather, and the small sticky seeds must cling to their feet, and thus probably be at times carried to suitable places for growth in other localities.

Evidently, then, we have in the Podostemaceæ a group of plants of singular morphological and ecological interest, and one in which there is still a very large field of work open to modern methods of research in these lines. The present paper hardly does more than clear up the darkness that has hitherto surrounded these organisms in regard to many interesting features of their life-history and general morphology, leaving a vast amount of work still to be done.

Not merely are these plants directly interesting in themselves, but they afford a group in which the connection between the change in morphology and the changed ecology can be well studied, as we have already a very fair knowledge of the morphology of the ordinary submerged plants of quiet waters. The most striking feature about their general morphology is the remarkable similarity which they exhibit to the lower forms of the vegetable kingdom, in particular the mosses, liverworts, and algæ, and in the latter more especially the algæ of moving water, such as the Fuci of the rocks on the sea coast. This similarity may be only "accidental," or it may be due to the action of similar causes. The Podostemaceæ are evidently very plastic, and we shall see in the Indian forms a series of plants of gradually increasing plasticity, and find that on the whole as the plasticity increases the plant becomes more and more like the lower vegetable forms. Once the plasticity is well established, so to speak, there seems little limit to it, the more so as these plants have no competition with other living organisms to modify their adaptation to the physical factors of their environment.

We shall proceed to deal with the Indo-Ceylonese species in order. As described in the preceding paper, they belong to two widely separated groups, the Tristicheæ (Tristicha and Lawia) and the Eupodostemeæ (the other six genera). So far as possible the systematic order there given will be followed, but for the sake of simplicity of treatment certain genera and species will be described out of their proper order. We shall deal first in a general way with the genus, and with preceding literature relating to it, and then with its species. The habitat of each will be first described, then the dry season appearance, which hitherto has been the only one observed by botanists, then the germination if known, the development of the thallus, its morphology, the appearance of the secondary shoots, the life-history during the vegetative season, the development of the floral shoots, the opening, structure, and fertilization of the flowers, and lastly, the fruit, seed, and phenomena of rejuvenescence, with any other special features of biological interest. The genus as a whole will then be considered in relation to the general conditions of life.

As may easily be conceived, and as Warming has pointed out, the anatomy of these plants, with their highly organized dorsiventral thalli and their peculiar habitat and mode of growth, is of great interest. To deal with it in detail in this paper would, however, enormously increase its already considerable bulk, and therefore I have dwelt only lightly on the anatomical features, so far as they are necessary for the treatment of the general morphology, reserving details for a later paper. The same statement applies to developmental features of the flowers, &c.

The genera will now be dealt with in the following order : Tristicha, Lawia, Podostemon, Dicræa, Griffithella, Willisia, Hydrobryum, Farmeria.

TRISTICHA.

[Du Pet. Th. ; Willis, Rev. Podost. Ind., Ann. Perad. I., p. 207.]

This almost cosmopolitan tropical genus is represented in India by the single species T. ramosissima (Wight), Willis, found in Travancore and Malabar, and to which I have given a separate sub-genus Dalzellia. The other two species of Tristicha are placed in a sub-genus Eutristicha.

Cario (8) has described the anatomy and to some extent the morphology of the widespread form T. hypnoides. This he collected among mosses in a stream in Guatemala, growing in little tufts. He commences by criticising the accuracy of Tulasne's figure (39), but, as Warming points out, both authors are right in general ; we have here one of the many cases of confusion that have been caused by the complex morphology and the polymorphism of these plants. Cario describes the creeping root- or rhizome-like structure which is closely attached to the rock, and which bears the tufted leafy shoots, on which latter the flowers arise. He names this creeping organ the thallus, and regards it as an organ *sui generis*—not a root, because it has no cap, and not a shoot, because it has no leaves. He describes its branching as endogenous. It is traversed by a single vascular strand, in which are two xylem groups towards the upper side. The delicate moss-like leafy shoots are borne endogenously on the flanks of the thallus, and have thin simple leaves, one cell thick, arranged in three ranks, one upper and two at the sides. They are occasionally branched, chiefly at the base. The flowers are borne on lateral branches of these shoots, subtended by a couple of larger leaves at the base of the stalk of the flower. Warming (42, V.) gives a fuller and better account of the morphology. He regards the thallus as root, chiefly from analogy with similar organs in other Podostemaceæ. The secondary shoots may be divided into two classes, those of limited, and those of unlimited, growth. The former are assimilatory, not erect, dorsiventral in structure, with tristichous leaves, and grow only to a comparatively short length ; the leaves towards the outer end are usually longer, and the last leaf seems to be terminal or nearly so, and is on the upper side. The shoots of unlimited growth are longer, more or less erect, with a more complex phyllotaxy. Their branching is peculiar ; the branches are of two kinds, and are usually arranged in pairs, one above the other, alternately on the two sides of the main shoot. Of the pair of branches at each node, the lower is a shoot of limited growth, the upper is one of unlimited growth, repeating the structure of the main shoot. These short shoots in the case of T. ramosissima have been termed ramuli in systematic descriptions, and the name is convenient for use. The flowers are borne on the shoots of unlimited growth.

In a later paper (42, VI.) Warming describes the various existing herbarium specimens of Tristicha, and figures many of them to show their branching and other morphological features. He reduces them all to two species, T. hypnoides, Spr., in America and Africa and T. alternifolia, Tul., in Africa. The latter commonly has its ramuli forked into two.

The very curious shoot morphology here described is found again in Weddellina, the only species of which, W. squamulosa Tul., has been investigated by Goebel (13, p. 349) and his pupil Wächter (41). I have also examined Prof. Goebel's material, which he has kindly presented to me, and verified most of their observations. The floral shoots here arise from the root thallus independently of the vegetative ones. The latter are branched in two ranks in one plane like Tristicha hypnoides, and bear large numbers of curious scale leaves, in many of whose axils are ramuli, while the shoots also branch into shoots of unlimited growth. The pairs of shoots seen in Tristicha do not appear here. The leaves of the ramuli, instead of having nothing in their axils, have what Goebel calls Kiemenbüschel, small shoots bearing a few slender leaf-like organs. Similar tufts occur on the surface of the thalli or leaves of some S. American Podostemaceæ; they appear to be assimilatory organs, but whether they are homologous in all cases remains to be discovered.

The Indian sub-genus Dalzellia is distinguished chiefly by the three stamens of the flower, the connate leaves at the base of the flower-stalk, and the absence of tristichy in the ramuli. The last point is led up to by the form lately discovered by Miss Lister in the Nile, T. alternifolia, var. pulchella, Wmg., in which the lower part of the ramulus has broad tristichous leaves, the upper narrow leaves irregularly arranged.

In many respects the Indian species seems one of the most primitive among the Podostemaceæ, though its anemophilous flowers may perhaps indicate it as reduced in some respects; we know too little, however, about the phylogeny of the order to say whether it is descended from anemophilous ancestry or not. At any rate, T. ramosissima lives in very much less violent water than most of the Podostemaceæ, and has, much more than most of them, the appearance we are accustomed to look for in water plants; and in view of the great difficulties in tracing the phylogeny of this family, it deserves most careful study in detail.

Tristicha ramosissima (Wight), Willis.

(Plates V.–IX. and XXXVIII.)

My first acquaintance with this species was from material kindly collected for me by Mr. T. F. Bourdillon at Mundakayam in Travancore in July and December, 1898. Subsequently Mr. C. A. Barber collected a splendid supply of material in S. Kanara, and I have myself obtained some in the Anamalais. As I have already mentioned in a preceding paper, most of the Indian Podostemaceæ differ in detail in almost every locality in which they grow, and therefore in describing the material I have examined I shall in general mention its exact origin. The plant still needs detailed investigation at different times of year on the spot where it grows; its germination phenomena in particular ought to prove of considerable interest.

Habitat.—The plant lives in slow-moving or somewhat rapid water at elevations to 4,000 feet, forming tangled masses of green weed. Mr. Bourdillon found it in waterfalls. It is sometimes mixed with Griffithella Hookeriana.

Dry Season Appearance.—We shall begin with the dry season appearance of the plants, as seen in Mr. Barber's Nos. 2,517, 2,518. The rocks above water are covered with a muddy tangle of dead weed; if we remove the loose parts we find the rock thickly covered with creeping filamentous rhizome-like thalli (Pl. XXXVIII., fig. 6) running in all directions, frequently branched, the branches usually at right angles to the main thallus (Pl. VII., 1). At frequent intervals along the thalli are curious "feet," thin flat disc-like organs springing from the sides of the thalli (Pl. VII., 1) and spreading out upon the rock, to which they are fastened very firmly. These discs are most commonly in pairs, one on either side, and examination shows that the tall withered shoots which we have removed spring from their upper surfaces. These shoots can be seen to have a complex branching; they bear numerous solitary flowers (Pl. VI.), represented now by the stalked fruits, which all point one way, as the flowers emerged through the water. Frequently, however, we find merely a very short one-flowered shoot springing from the thallus, and in this case as a rule there is no large foot. In specimens from other localities the feet are not so markedly disc-like; *e.g.*, in material from the Anamalais they are stouter, and more or less lobed (Pl. VII., fig. 5). In Mr. Bourdillon's material, again, and in some of Mr. Barber's, the foot is represented by a comparatively long peg-like organ, which projects downwards from the thallus, tapering almost to a point, but expanding at the tip when it touches the rock, to which it becomes firmly attached (Pl. VII., 8, 9).

Mature Structure.—Closer examination of the thallus must be made on living material. The dead plant sheds its seeds upon the rocks, and germination takes place with the onset of the rains. We have no knowledge of the early stages in the life-history, or of the primary axis, though we may assume that it gives rise to the creeping thalli. Inspection of the tip of a thallus shows that it is almost cylindrical, about 0·5 mm. thick, and that it has a well-marked root cap (Pl. VII., fig. 2). Taking this fact together with that of the endogenous development of the lateral branches, we need have no hesitation in regarding the thallus as of "root" nature. The thallus may grow to a length of many inches, and is more or less closely appressed to the rock. When it touches it, it is fastened by root-hairs, which spread out at their tips in the usual way (Pl. VII., figs. 3, 4) and secrete a dark-coloured cement-like substance. A little way back from the tip of the thallus the secondary leafy shoots may be found in course of development (Pl. VII., fig. 5). In the Anamalai material figured the shoots appear in approximate pairs, one on either side of the thallus, breaking out endogenously from lateral expansions of it, while at the same time haptera or fastening organs develop from these expansions, underneath them. As these organs will be constantly met with in subsequent descriptions and occur in a great many Podostemaceæ, it will be as well to describe them here in a little detail, and reference may be also made to Warming's descriptions and figures. A hapteron may appear at any part of stem or root which is near the rock ; it appears as an exogenous cap-less outgrowth, growing by a meristem at the apex, and bending downwards under the influence of gravity to reach the substratum, on which it flattens itself out, often developes root-hairs, and becomes very firmly attached by a kind of dark-coloured cement which is secreted by the root-hairs, or perhaps sometimes by the surface cells. It very often branches exogenously, or is merely lobed. All cases may be seen in the various figures given below and by Warming.

A hapteron may be looked upon physiologically as a gigantic rhizoid, and acts in the same way as an ordinary unicellular rhizoid, bending down to the substratum and adhering to it, often becoming lobed or branched. The size and form of the haptera in the species now under consideration seem to depend largely upon whether the thallus is touching the rock or not at the point where they form, and also upon the strain caused by the water current. In the Anamalai material, where the thallus touches the rock, the hapteron grows into a more or less discoid foot ; in the S. Kanara material, which grew in less rapid water, the disc, as the figures show, is very regular and thinner, while in the Mundakayam material collected by Mr. Bourdillon upon the edges of waterfalls, where the strain is greater, the haptera are larger, more lobed, and stretch further out upon the rocks (Pl. VII., fig. 10). The formation of a discoid hapteron seems to be dependent on the thallus touching the rock ; when, as frequently in the material from S. Kanara and Mundakayam, the thallus is above the rock, a long tapering peg-like hapteron is formed, which grows down to the rock and spreads out upon it, while the secondary shoot appears endogenously at the upper and outer side of the peg (Pl. VII., fig. 9).

The formation of secondary shoots appears to be practically always accompanied by the simultaneous or previous development of haptera, as indeed we might expect on mechanical grounds, and as the secondary shoot grows larger the haptera tend to increase also both in size and number, to provide the necessary power of adhesion to the rock. In the S. Kanara material the hapteron ultimately forms a disc in most cases, whilst in the material from the Anamalais and Travancore it is usually branched, and this the more as it increases in size. In some of the Travancore specimens the hapterous feet at the bases of the full-grown secondary shoots were as much as 2–3 cm. across (Pl. VII., fig. 10), forming a holdfast of great power. Part of this foot appears to have been due to further development of haptera from the base of the stem, a very common occurrence. The endogenous shoot arises from the upper side, and is at first more or less horizontal (Pl. VII., figs. 5, 6, 7), but soon bends upwards. It is always more or less flexible, and sways with the movement of the water.

The thallus itself is of simple structure, with a simple central vascular bundle, which seems very like that of T. hypnoides as described by Cario, or that of Weddellina, as described by Wächter (41); I have not made a detailed study of it. The cells near the edge contain much silica, so that the thallus is very hard to cut in section, and also very brittle. This development of silica is very characteristic and abundant in very many of the Podostemaceæ, and has been described by Cario (8), Kohl (25), Warming, and others (and *cf.* Lawia, below). It is so plentiful in many thalli that a razor is almost completely blunted in cutting a single section. A physiological function in helping to make the organs containing it more or less amphibious has been denied to this silica development, but not, I think, altogether on good evidence. That the thalli are more or less amphibious, *i.e.*, that unlike most water plants they are able to survive a considerable period of exposure (and that, too, on naked rocks), we shall have occasion to see below in the case of several of the Ceylon species, and I am inclined to think that the silica in the outer cells may have some function in making the inner tissues more retentive of their water, just as is supposed to be the case in some of the Crassulaceæ, *e.g.*, Rochea falcata. The silica is by no means universally present, nor in all parts of the plant ; it is confined mainly to the thalli, which are the parts most able to produce new growing points and resume their growth after a period of exposure.

Passing on now to deal with the secondary shoots, which in this species make up the bulk of the plant, do most of the work of assimilation, and ultimately bear the flowers, we shall consider first the most fully developed type of shoot, and afterwards the reduced shoots mentioned above as sometimes found on the thalli.

The growing point emerges endogenously from the thallus, as already mentioned. It is of an ordinary shoot type, bearing leaves closely packed together. The phyllotaxy is complicated, and I have not been able to make it out satisfactorily. The leaves are of simple structure, very delicate, not unlike the leaves of a moss ; they resemble those to be described below for the ramuli, but are larger, and have often a central portion more than one cell thick, like the leaves of Lawia described below.

The most noticeable feature about the growing point is the very early formation of shoots of the second order, which grow very rapidly and cover up the main apex with their leaves, thus rendering it difficult to dissect out the principal growing point. These shoots are shoots of limited growth, or, as we have called them above, ramuli ; they do not repeat the structure of the main stem. The growing point of a ramulus is figured in Pl. VII., fig. 11. It has a well-marked dermatogen layer, with inner meristematic layers, and gives rise to a large number of leaves lower down, these leaves being only one cell thick, four cells broad (in the S. Kanara material), and exceedingly delicate. The tip of one of these leaves is shown in Pl. VII., fig. 13, and the basal part in optical section in fig. 14. The basal cells have rather thicker walls. The leaves contain chlorophyll, and form the chief assimilating organs of the plant. In the material from the Anamalais and Travancore the ramuli have broader leaves (Pl. VII., *cf.* figs. 15, 16). The ramulus grows only for a short time, and soon reaches its full length. The general appearance of a plant covered with these ramuli is well shown in Pl. V. The ramuli near the tip of the stem far overtop the main axis. Later in the life of the stem the ramuli either drop off altogether, or lose their leaves ; the latter case is very evident in the right-hand part of Pl. VI.

It is very difficult, as Warming has already pointed out, to determine the exact relationship of position of the ramuli to the leaves borne on the main stem, and I have not yet succeeded in satisfying myself on this point. When very young, the ramulus seems often to lie exactly in the axil of a leaf, but when older and expanded it is very commonly not so arranged, but frequently has a leaf a little to one side of itself, as in Pl. VII., fig. 12. There is not as a rule a ramulus for every leaf. The axis of the ramulus contains a very slender central vascular strand.

A little way back from the growing point, at the part where the ramuli have reached their full development or nearly so, buds may be seen in the upper angles between them and the main stem (Pl. VII., fig. 15) ; these buds give rise to shoots of unlimited growth, which repeat the structure of the main axis. Commonly many of these buds remain more or less dormant, until the flowering period. Thus at every node there may be two shoots, an upper long one of unlimited growth repeating the structure of the main axis, and a lower ramulus. By this time the leaves of the main axis have usually fallen away, leaving no trace, so that when, as often happens, the ramulus has also lost its leaves one is liable to mistake the two shoots for a leaf with shoot in its axil. In Plate V., and still better in the left-hand part of Pl. VI., this arrangement of the shoots can be very clearly seen, especially with the aid of a lens.

These secondary shoots, thus constructed, may grow to a length of 30–40 cm. and branch freely, and as 20–50 may form on one thallus, and the thalli often branch very freely, while many plants may grow intermingled on a single piece of rock, the result is a great tangle of vegetation. Plate V. represents a single plant, not quite complete.

The internal structure of the secondary axis in the vegetative condition is simple. A cross section near the apex (Pl. VII., fig. 17) shows that the stem is cylindrical, with a well-marked epidermis, parenchymatous cortex, and central vascular strand. Further down (fig. 18) the stem is thicker, and two layers of collenchymatous cortex have been developed, one at the margin and one round the vascular tissue. The bundle itself is central, and of very simple construction, composed of phloem-like tissue containing sieve-tubes, mixed with an irregular mass of parenchyma ; there are no pitted or lignified xylem elements so far as I have observed. A cross section of the bundle is shown in Pl. VIII., fig. 1. A certain tendency to grouping, where recent divisions have occurred, is seen in the tissue, but more detailed study is required to make out the exact anatomical relationships of all the tissues, and such is not necessary for this paper. The chief feature of general interest in the section is the entire absence of intercellular spaces of the kind one is accustomed to look for in water plants ; this feature is general to the whole order, as has frequently been pointed out. Its meaning will be discussed later.

Further down in the stem there is often to be seen a small amount of somewhat irregular cell division going on in the outer parts of the vascular strand, but there does not seem to be any regular cambium layer formed. The cells of the cortex enlarge considerably in the older parts of the stem, but I have not seen any growth of the stem in thickness by actual division of these cells as described by Wächter (41) in Weddellina.

We have now brought our consideration of the vegetative growth and structure of the plant to the full-grown stage represented in Plates V. and VI. (left side). The former especially gives an excellent representation of the habit of the mature plant. I owe its success to my friend Mr. Barber, who prepared the herbarium specimen from which the photograph is taken, by cleaning the plant of algæ and mud and then floating it out upon paper under water, as in the method usually employed with delicate algæ. The creeping thallus is clearly shown with the numerous secondary shoots springing from it.

On some of the Travancore material shoots were found of the kind represented in Pl. VIII., figs. 2, 3. Here the secondary axis had given rise to branches which grew out only for a short distance and then seemed to check in their growth, forming short spurs with a number of ramuli.

Towards the end of the wet season the plant developes its flowers. As a rule, the tip of the shoot does not become floriferous, but most of the lower portion does. What appears to occur (further investigation is required through the whole process, on living plants) is that in the axils of many ramuli or former ramuli, the buds hitherto dormant form floral shoots. Almost every axis other than near the tip of the plant seems to form a flower. The flower is terminal on the axis bearing it, and its pedicel is surrounded by the uppermost leaves of the axis, the innermost of which are more or less connate into a shallow cup round the base of the pedicel (Pl. IX., figs. 2, 3). These leaves are a little larger than most of the other leaves of the plant. In the axils of two, or sometimes three, of the lowest leaves on the short flowering shoot ramuli are developed, so that the flower is almost always accompanied by a couple of ramuli, as described by Wight. Some of these ramuli can still be seen at the bases of the shoots (now in fruit) figured in the right-hand half of Pl. VI.

In this way a flower is formed at nearly every node in the plant, but the buds on the outer parts of the branches of the shoots usually remain in a very rudimentary or abortive condition. It will be noticed that at the base of nearly every branch, in the place formerly occupied by the ramulus on the main stem, there is a floral shoot. This seems to develop from the same axis that once gave the ramulus, but of this I cannot be certain from the material at my disposal. Instead of being, as the ramuli were, exactly under the branches of unlimited growth, the flower shoots are usually displaced upwards towards one side.

As Plate VI. shows, the floral shoots are very short, consisting simply of the very short axis with leaves, ramuli, and cupule, with the flower stalk emerging from the latter. The flowers certainly open in the air before the water has fallen so low as to strand the shoots upon the rocks, but whether the pedicel lengthens while still under water so as to bring the flower above the surface, as in many ordinary water plants, or whether it remains of constant length till the flower is exposed to the air, I cannot certainly say ; the former is more probable from analogy. All the floral shoots bend upwards, evidently being very sensitive to the stimulus of light or of gravity at this period.

Before proceeding with the consideration of the flowers we must go back to deal with the shoots mentioned as often found upon the thalli, which are not fully developed like those we have considered. Very often there may be seen a couple of ramuli apparently springing from the thallus ; on closer examination these are found to spring from a short secondary axis which has not lengthened in the ordinary way. A not infrequent type of shoot to be found on the thallus is that shown in Pl. VIII., figs. 4, 5. A short stout axis, bearing leaves which persist somewhat longer than is usual with leaves on the main axis, springs from the thallus to a height of 1–2 cm., with a stout hapterous foot. It sometimes branches once or twice, but very commonly is quite simple, usually bearing one or two ramuli, and ending in a flower, at the base of whose stalk is a cupule, as usual. Sometimes, as shown at x in fig. 5, the floral shoot is even more simple, and is like one of the shoots already described which arise at the nodes of the main axis. This type of shoot is very frequent on the thalli of the S. Kanara material, which

Mr Barber describes in his notes as giving the impression that the rock itself was covered with flowers. Several such shoots are shown in Pl. XXXVIII. (right-hand rock), but are difficult to distinguish.

The flower stands on a short pedicel, which lengthens rapidly during and after anthesis. The structure of this pedicel is interesting, and it will save repetition to describe it here, as the same features occur in most of the subsequent species to be described. At the time when the flower opens the pedicel is short and stout, and shows the central vascular strand quite clearly through the pellucid cortical tissue. As seen in section (Pl. VIII., fig. 7) it has an epidermis, thin walled cortex, and a central vascular strand with more or less pith cavity in the middle. After flowering the pedicel lengthens, and at the same time the small-celled tissue surrounding the vascular tissue becomes thick walled and lignified (Pl. VIII., fig. 8, *lig.*), the vascular bundle itself remaining as before. Finally, when the fruit is nearly ripe, the outer cortex falls away altogether (fig. 9), leaving the fruit standing on a long filamentous stalk, which is very much thinner than the original stalk of the flower. The vascular bundle itself is shown in Pl. IX., fig. 1. In the middle is the intercellular space, with several annular vessels in it (somewhat as in Maize), and round this is some phloem-like tissue and the outer fibrous band, which ends off sharply against the parenchymatous cortex.

The flower itself is simple (Pl. VIII., fig. 6), and requires only a brief description. The perianth is membranous, united to about $\frac{3}{4}$ of its height, and finally marcescent. There are three stamens alternating with the segments of the perianth, with long flexible filaments and large anthers with loose powdery pollen. The ovary is superior, with three loculi and three long hairy stigmas. The flower is anemophilous, and probably largely self-pollinated; most of the flowers seem to set a full complement of seed. In transverse section the ovary wall and structure are like those of Lawia, with ribs in corresponding places, and after fertilization a fruit of exactly similar type is produced (*cf.* below).

Rejuvenescence.—To what extent rejuvenescence, *i.e.*, the formation of new growing points if the old ones are damaged, and the consequent resumption of growth of the thallus and formation of new secondary shoots, takes place in this species, I do not know, but there is evidence upon the material in my hands to show that it does take place, and probably it is common enough, as in the Ceylon forms.

Before going on to the next genus, we must briefly consider the morphology of Tristicha in connection with its ecology, or in relation to the general conditions of life. All three species seem to be very similar both in morphology and ecology. Comparing these plants with most other water plants, it is evident that they are as highly modified to suit a submerged existence as any others, and that they may well be compared with the members of such families as the Ceratophyllaceæ. They show most of the characters one is accustomed to look for in submerged plants, *e.g.*, much vegetative growth, frequent branching, great vegetative reproduction, absence of stomata, reduction of vascular tissue, especially of the water-carrying elements, central vascular bundles, delicate leaves, chlorophyll in the epidermis, absence of palisade tissue, &c. On the other hand, they show a few marked features which are not usually present in such plants.

To take these in order, the thallus, speaking in the ordinary sense, is evidently morphologically a creeping root, such as in other water plants and even land plants is not uncommon, where the primary root owing to the mode of growth in relation to the substratum is unable to develop in the ordinary way, and is replaced by adventitious roots laterally developed. This development is carried to an extreme in the plants now under consideration, as the root is used as the means of large vegetative multiplication of the shoots, instead of being, as sometimes is the case with such adventitious development of lateral roots, intended mainly for anchorage or absorption. There is no great assimilatory function performed in the thallus in this genus, but we get a distinct stage on the way to such cases as Dicræa or Hydrobryum. Anatomically, almost more than morphologically, the root shows great dorsiventrality.

In the haptera, we meet with organs for which there appears to be no precedent in other water plants. Their function is evidently to act as holdfasts, and they may therefore be regarded as adaptations to the peculiar mode of life, except that, so far as we know, they are not hereditary in the strict sense, but are developed apparently in response to a direct stimulus, at any point where they are required. Their size and form also seem to be directly dependent on the mechanical conditions of life.

The secondary shoots are endogenously developed on the root-thalli, and here we meet with one of the most marked general features of the whole order. Such formation of secondary shoots upon roots is not entirely unknown elsewhere, but it is not carried to the extreme pitch of frequency, regularity, and complexity that is found in this family. In the absence of other families of plants living under similar conditions of life, or showing this peculiar feature under different conditions, it is difficult to decide whether this development of numerous secondary shoots is really an adaptation to the conditions of life or not, but I am inclined to think that it is. In this place, however, it is sufficient to point out its advantages, in that it reduces the risk of extermination when a temporary fall of water occurs other than at the regular flowering season, which, if there were only one axis, would be very great.

The secondary shoots are large and complex, but have an evident aquatic habit and structure; the vascular tissue is reduced and central, and there is great development of green assimilating tissue by means of the formation of the ramuli.

With regard to the absence of intercellular spaces, Goebel (13, p. 354) has already given what I am inclined to think is the true explanation or near to it, that the Podostemaceæ, living in well aerated water, do not need, like plants whose lower parts are in mud or in stagnant water, large intercellular spaces to serve as oxygen carriers to the lower parts for their respiration. I do not think that the very common explanation of the large spaces, that they serve to float the plants up in the water, is a sufficient one, though this may be part of their function. Tristicha floats freely enough with the current, though it has no such spaces, and is actually, like all the other Podostemaceæ that I have examined, so heavy that it sinks in still water. In general the development of large spaces seems to go with absence of oxygen in the lower part of the medium surrounding the plants, and with still water, both of which conditions are absent in the case of Tristicha.

The great number of flowers produced, and their development all at one season, is another noteworthy feature as compared with plants of still waters ; the production of the flowers at the time when the water leaves the plant stranded may be compared with the development of the sexual organs in Riccia fluitans when it is stranded by the drying of the pool in which it has been floating.

Lastly, the power of rejuvenescence of the thallus, which is well-marked here, and much more so in species to be considered later, is evidently a very great advantage to a plant exposed to the risks attending the temporary fall of water-level that are liable to occur.

In Tristicha and Weddellina, then, we seem to have plants still very like ordinary water plants, but with certain new features correlated with their new conditions of life, such as the development of creeping roots and haptera as fastening organs, the multiplication of the shoots by the exaggeration of the not elsewhere unknown phenomenon of development of shoots from the roots, great powers of rejuvenescence, development of flowers all at one season, and absence of intercellular spaces; the plant is finally destroyed by exposure to the air, leaving only the seeds and perhaps a few submerged thalli to tide it over the dry season.

LAWIA.

[(TERNIOLA), Tul.; Willis, Rev. Podost. Ind., Ann. Perad. I., p. 209.]

This peculiar little genus is confined to Ceylon and Western India, where it is extremely common in suitable localities. In Hooker's flora seven species are recognized on Weddell's authority; of these, I have transferred L. ramosissima to the genus Tristicha, while of the remaining six, three proved to be completely identical with forms described under other names, thus reducing the genus to Tulasne's original three species, zeylanica, pulchella, and longipes. I hardly consider these latter two separable, as the length of leaves and pedicels are, as we shall see below, extremely variable characters; I have therefore united them, and have also united the Indian forms to the Ceylon ones to form the one species L. zeylanica, of which there are many varieties and sub-varieties. As a temporary measure, pending detailed knowledge of material from many sources, I have divided the species into two Ceylon and two Indian varieties, Gardneriana, Parkiniana, malabarica, and konkanica, respectively.

The morphology of the vegetative organs has not been accurately described in this genus. The accounts of Gardner (12), who first discovered it, and of Tulasne, though accurate as far as they go, are very little more than descriptions of the flowers. The thallus adheres so closely to the rock that it is very difficult to detach more than minute fragments for herbarium specimens, and as the flowers are usually most numerous on the older parts, it so happens that practically none of the existing specimens show the growing points or the mode of growth of the thallus. Tulasne, indeed, noticed that not all the leaves were in the rosettes that are the most conspicuous feature of the upper surface, and Trimen describes the flabelliform apices, though he did not notice their leaves. Warming's account of this species (42, IV.), though correct enough in its description of the facts observed, suffers from this lack of complete material ; he had only the central flowering part of a thallus to deal with. Upon this there are no leaves borne directly, and hence Warming writes "le thalle ne porte pas directement de feuilles, ce qui indique que c'est une racine étalée en forme de thalle crustace." Roots of this form are not uncommon in the order, *e.g.*, in Hydrobryum, and there is almost literally nothing to distinguish the central part of the thallus of Lawia from a "root" thallus. Warming's account does not deal with the life-history or with the growth and development of the thallus. In the same paper he also deals with a specimen of L. longipes or foliosa collected at Khandala in the Bhor Ghat by Goebel (13), who has himself also described it. Here the incompleteness of the description is in the other direction ; only the growing point was examined, and not the older parts of the plant, and it was at once evident that the thallus was of stem nature. In reality both thalli are to all intents alike, but the difference between the apical and the central parts is so great that it is impossible to understand the morphology of the plant without seeing a complete specimen. In his sixth paper Prof. Warming has suggested that the L. zeylanica forms should be generically separated from the L. foliosa forms on the ground of their thallus morphology, but it will be seen below that this proposal rests on incomplete knowledge of the entire plants.

Lawia zeylanica, Tul.

(Plates IX.–XIII.)

My studies of this species have been made at Hakinda and other places in Ceylon, and at Igatpuri and Khandala in the Bombay Ghats, while I am also indebted to Mr. C. A. Barber for much valuable material from many places in

South India. The detailed description given below refers in general to the common Hakinda form, Gardner's original type of the species, which I have described as L. zeylanica Gardneriana, but the points of difference and of interest found in the other forms are also described.

Habitat.—The Ceylon forms of this species grow at elevations from 1,000 to 2,000 feet. It is found on smooth rocks in places where, during the vegetative season at least, the flow of water is very swift, but as a rule not in places where it is also very much broken. Most often the plants cover the rock to the exclusion of other species, but they are frequently mixed with Hydrobryum olivaceum, less often with Farmeria metzgerioides, and occasionally (usually at junctions of eddies with the main stream) with Podostemon subulatus or Dicræa stylosa, var. fucoides, all of which are also very dwarf forms, or forms which lie very low upon the rocks. The habitats of the Indian forms are, so far as I can judge from their dry season appearance, very similar. I have found them mixed in many places with Hydrobryum lichenoides, and some of Mr. Barber's specimens are mixed with Griffithella Hookeriana.

Dry Season Appearance.—The plant is exposed to the air early in the year (*e.g.*, I found it in flower at Hakinda on 9th January, 1898, 8th January, 1899, and 17th December, 1899), flowers as soon as exposed, and very quickly ripens and sheds its seeds. It is at this period that all the existing herbarium material has been collected. Large expanses of dry smooth rock, often many yards across, may be seen covered with a brown coating of thalli, thickly studded with ripe fruits, while close to the water's edge may be seen flowers in all stages from opening buds to nearly ripe fruits. Several pieces of rock are shown in Pl. X. As a common rule there is little form or structure to be seen in a hasty glance, but often such a specimen as the large one there figured may be found, in which it is evident that the thallus is branched on a definite system, and is not a continuous sheet, as it seems to be in the other figures. Closer examination shows that it is really branched in an irregular manner, so that any small portion of it consists of ribbon-shaped strips, rarely more than 1 cm. wide. The actual growing apices, which at this season may still often be found just below the water surface, are more or less fan-shaped. Closer inspection with a lens reveals the rosettes of small linear leaves which are scattered among the floral shoots and usually arranged in more or less regular longitudinal rows along the strips of thallus. The floral shoots themselves will be found to be at the edges and tips of the thallus branches ; each has one flower which emerges on a short pedicel from a small bristly cupule. In herbarium specimens the leaf-rosettes and even the cupules are often represented by scars or little pits. In the large specimen in Pl. X. the cupules can be clearly seen, the fruit stalks having fallen out.

Germination and Life History.—The seeds are shed upon the rocks and upon the dead surface of the old thallus, where they remain until the water rises to cover them. The epidermal layer of cells of the testa swells up when wetted, like that of the seeds of Linum, &c. This has often been described as an adaptation to fasten the seeds to the rocks for germination. It is true that when it dries after wetting the seed is very firmly fastened to the rock, but the next wetting washes the seed off once more, and it does not seem probable that this mucilaginous coat can have anything to do with preparation for germination ; it seems rather to enable the seeds to be carried away by the feet of wading birds. These may often be seen walking on the thalli in the dry weather, and some of the minute sticky seeds must be carried away by them. In fact, this is almost the only conceivable method in which these plants can be carried from one river to another. The number of seeds produced is very large, each flower, as a rule, setting a full complement of about 200–250, and the whole rock being covered with fruits, but of all this multitude very few ever come to anything. Many are washed away by the water, and only those which are retained by a crack or crevice in the rock or the old thallus seem to have any chance of germinating where they fall. Once carried off by the stream, there is little chance of a seed reaching a place where it can grow. It must have a rocky substratum, in a rapid stream of water, and it has no adaptation of its own, other than small size, to enable it to retain a position in such a place.

Germination, as a rule, occurs when the water rises with the rains of the little monsoon ; I have found seedlings in the period of low water in May between the little and big monsoons. In India the germination must evidently be later the further north the locality.

The early stages are extremely hard to find in this species and I have only been successful in getting a very few. It is no easy matter in working with these plants to determine which seedlings belong to which species, and two consecutive years of observation were needed to settle these points. The seedlings are excessively small, and can only be obtained when the water-level is low, an unusual occurrence at the time of year when germination occurs, except just for a short period between the two monsoons. I have frequently obtained them, however, by groping in deep water for capsules which I knew to be those of the species sought; every now and then a seed will be found to have germinated inside the persistent capsule-valve. The seed is exalbuminous ; the hypocotyl is short and stout, and the cotyledons are flat when expanded, but crumpled in the embryo (Pl. IX., 4). When wetted the seed presently swells and bursts the testa, the hypocotyl bends down at once to the rock, and immediately becomes attached to it by a copious development of rhizoids from the superficial cells (IX., 4); these organs are unicellular, and flatten themselves out at the tips against the rock, just like those of the thallus of Tristicha. At this stage the seedling is extremely small, about 0.5 mm. high. The base of the hypocotyl now begins to expand and forms a larger surface of attachment, fastened by more rhizoids.

No haptera were ever observed to form. The next stages are shown in Pl. IX., figs. 5, 6. Here the hypocotyl has formed a kind of tuber, on the upper surface of which a few leaves have developed. There is no elongation of the epicotyl in the ordinary way. The order in which the early leaves appear is very difficult to make out; only a small quantity of material in very few stages was at my disposal, and the plants are exceedingly small and delicate. I am inclined to think that the order is no very definite one; sometimes, and perhaps most often, the first two leaves are more or less at right angles to the cotyledons, which are themselves either opposite or approximately so, but I have found cases in which the first two leaves were approximately parallel to the cotyledons. Sometimes there seems to be an indication of an approximate tristichous arrangement of the leaves, but it is not very close, and is probably accidental. The phyllotaxy is probably a complex many-ranked one (very likely the same as in Tristicha), and sufficient leaves are not formed to enable one to recognize it. In a very short time it is evident that the growth of the seedling is taking place in a lateral direction, that a marked dorsiventrality is appearing, and that there is no more development of leaves in the vertical direction at all. The direction of growth is nearly always at right angles to the plane of the cotyledons, and horizontal along the rock. All the newly-formed leaves are now seen to lean in one direction, that in which the apex is growing. Pl. IX., fig. 7, shows a seedling with seven leaves besides the cotyledons, in which this growth is already becoming indicated, and in fig. 9 it is clearly evident. In this specimen, which is seen a little obliquely from above, one of the cotyledons is absent; there are four larger lateral leaves somewhat divergent, and a considerable number of small linear leaves all pointing nearly in the same forward direction, while the tuberous hypocotyl is also evidently elongating. The same stage is shown in side view in fig. 8, and shows this growth of the hypocotyl into the "shoot" thallus.

Once formed, the growing point extends itself along the rock pretty rapidly. I have never been able to find that the hypocotyl gives rise to more than one growing point, but in the absence of large quantities of material it would be rash to dogmatize. It will be well to point out at this stage one of the many traps into which one is liable to fall in working at these plants. Frequently I have obtained what I thought to be seedlings, but which on thorough investigation on the spot proved to be rejuvenescences of old exposed portions of thallus, which, as we shall see, are very common. The new growing points formed from these old thalli are exactly like seedlings, and still more so when, as soon happens, the old thallus from which they sprang shrivels away and is washed off by the current.

The next stage that I have found is one about half way to that figured in Pl. IX., fig. 12, in which owing to branching the seedling now has seven growing points. It will be observed that the dimorphism of the leaves, which was beginning to show itself even in the minute seedling of fig. 9, is now very distinct; there are large ovate leaves on the edges and smaller linear ones on the upper surface of the growing tip, the former in a single row on each side, the latter in a dense irregular crowd. This is well shown in Pl. IX., fig. 10, which represents a particularly distinct case sometimes found. The marginal leaves are parallel to each other, each with its lower and anterior edge overlapped by the upper and posterior edge of the next younger leaf. At the very tip the lateral leaves are more or less upcurved, to some extent covering the apex.

Pl. XI., fig. 5, which is slightly diagrammatic, shows a longitudinal section through a growing point in October. The "apex," or perhaps rather growing margin, of the thallus is asymmetrical, the youngest cells being a little short of, and above, the extreme tip, as shown at *m*. On the under side of this tip there is a layer of collenchymatous cells (*col.*), which (in the flabelliform thalli, at any rate) split off as the growing point expands, and thus appear to behave like a root-cap, especially like the cap we shall presently describe in Podostemon, Hydrobryum, &c. The leaves can be seen forming, in large numbers on the upper side, and in small on the lower.

There is no very definite arrangement, so far as I have observed, in the meristem, but the peculiar structure of this growing point requires further detailed investigation. The meristem is small-celled, the cells near the growing point being approximately isodiametric, while further back they are elongated in the direction of growth of the thallus. A desmogen strand of very narrow cells makes its appearance in the middle of the thallus at a very little distance from the tip. The dermatogen layer is fairly well indicated nearly to the very apex. Rhizoid formation begins a little way back from the tip, at the region where growth and movement are probably completed or nearly so, by the outgrowth of the epidermal cells in the usual way. Most of the rhizoids are sloped a little forward in many specimens, as if there had been a slight growth after they had become affixed to the rock. Looking at a growing apex in surface view the square shape of the cells near the apex is easily seen, and the elongated shape of those further back is very prettily indicated by the shape of their contained silica bodies. These bodies are abundant in the surface layers of the thallus, and have already been described in Tristicha (and *cf.* Pl. XI., figs. 1, 3). Their presence makes section cutting very troublesome.

To return to the large seedling mentioned (Pl. IX., fig. 12). Its growing points are all of the pattern described above, and have pretty evidently all sprung from the single original one by branching. The branching of the thalli is so near the tip, and the two branches are so nearly alike, that it looks like a dichotomy ; but though I have not been able to definitely decide this point, I think it is really a case of lateral branching. The growing point itself is the centre of a cushion of tissue thinning off towards the edges. When a branching takes place, the two new growing points soon have a sort of valley formed between them, the tissue there being thin, like that at the edges of the original growing thallus. This thin tissue soon ceases to grow in thickness or length, and presently breaks, leaving an irregular gap between the two growing points. The seedling figured shows various phases of this process. It will be evident that the breaking away is not a very definite process, being sometimes very marked, sometimes hardly at all, as is indicated by the persistence of the large marginal leaves along the greater part of the gap. The cells of this thin tissue do not elongate so much as those in the main course of the thallus, though they develop the silica bodies.

In Pl. IX., fig. 11, a specimen is shown in which the branching is clearly visible at the tip, and it can be seen that there is one of the large marginal leaves exactly central between the branches, overlapped on each side by their marginal leaves.

From this stage onwards the growth is evidently of the same type, and in August and September, by which time it is again possible to get material, the plants have reached a considerable size; several such plants are shown in the photograph reproduced in Pl. XII. The irregular but still definite manner in which the thallus has grown to this size is clearly evident. Several plants, it will be noticed, are growing side by side, and are already commencing to interfere with one another and to overlap, so that in the dry weather a few months later it will be very difficult to disentangle their mode of growth. It will also be noticed that as the plants get larger their apical portions get broader and more fan-like in shape. This is the expression of the fact that the branching or formation of new apices becomes more and more rapid in proportion to the rate at which by the elongation of the thallus these apices become separated each on its own piece of thallus. Along the edge of each of these fans there is a very large number of growing points, as shown in Pl. XI., fig. 2, which represents a portion of the edge of the thallus of the common Ceylon form at the season when the flowers develop. This figure also shows the course of the vascular bundles in the thallus. It will be observed that there is one to each growing point, and that they unite as they pass backwards. The small linear upper sets of leaves of each growing point run backwards for some distance along the course of the bundles, but at a distance of about 10 mm. from the tip they have usually mostly fallen off, though I have occasionally found specimens with leaves still visible at 50–75 mm. from the tip. Their somewhat fugacious nature, and their small size, is probably the reason why they have never been noticed by any one but Tulasne. They do not go far enough back to be among the older flowering parts which are those usually gathered by collectors.

The flabelliform type of margin or apex, which has just been described for the common Ceylon form (L. z. Gardneriana), is not the only one to be found. The other Ceylon variety (Parkiniana) has ribbon-like apices, with one or few growing points upon them, as figured in Pl. IX., figs. 13, 14. Among the Indian material both types also occur. Bearing in mind the form of the apices of the seedling, we shall perhaps be justified in regarding this second type as the more primitive ; the figure in Pl. XII. perhaps represents not only the ontogeny of the individual flabelliform tip, but also its phylogeny. The tip of a growing point in material from Khandala has been figured by Goebel (13, p. 169) and Warming (42, IV., p. 160), and I have verified their observations upon material collected by myself. The general size of the growing points is somewhat larger, and especially the leaves, which, instead of the 2–6 mm. of the Ceylon forms, may have a length of 8–15 mm., but the arrangement of the parts is similar. Very commonly in these northern forms the growing point is turned up clear of the rock, at least at the time that it begins to form the flowers, for the young stages have not been seen. This phenomenon may be simply due to the crowding of the apices together ; very often two large lobes of thallus are separated by a kind of hedge of leaves due to the erectness of the growing points along the two closely approximated margins. This is faintly indicated even in the Ceylon plant figured in Pl. XII., where in the second plant from the top the "hedges" can be seen as white lines through the large fan-like lobe.

The leaves require but little notice. They have been figured and described by Warming (42, IV., pp. 160, 163). They vary much in size in different forms, as well as on the upper surface and sides of the same growing point, but they are always moss-like leaves of very delicate texture, like the leaves on the ramuli of Tristicha ramosissima. They vary according to position on the thallus from linear to ovate or almost triangular, and in the lower part of each is a white mesial line showing very clearly in the living leaf ; the line has the corresponding linear or triangular shape to the leaf in which it occurs. Microscopic observation shows that the line represents a strand of narrow cells running up the middle of the leaf, and probably having some vascular function (Pl. XI., fig. 3), while cross section of the leaf shows that in this central part the leaf is several cells thick, though the margin is only one cell thick (XI., 4). Silica bodies are common in the angles of the leaf-cells (Pl. XI., fig. 3).

The thallus itself has a simple structure as seen in cross section (Pl. XI., fig. 1). On the upper surface is a well-marked more or less columnar epidermis, and under this, forming the body of the thallus, is a large-celled parenchyma. Many of its cells contain large silica bodies, more especially those of the two uppermost layers. On the lower surface is a less conspicuous epidermis, bearing the rhizoids. The cells contain chlorophyll, and large quantities of starch. A little below the middle the vascular bundles take their course, which has already been described as seen in surface view (Pl. XI., fig. 2). The structure of the bundle is simple ; it consists of a few small cells, of which the upper are apparently of phlcem nature, the lower xylem. I have not yet investigated the development of the bundle in detail.

We have next to consider the development of the peculiar rosettes of leaves, which are found upon the older thalli, and which Warming showed to be endogenously formed. These soon begin to make their appearance. The first but not the only place in which they appear is commonly in the angles between the branches of the thalli, as shown in Pl. XI., fig. 2. They appear in this position without any actual separation or splitting of the thallus taking place. They also very commonly spring from the thin marginal portions of the thallus or its branches. They appear at first as little swellings of the upper surface of the thallus, formed, as Warming has described, by an endogenous growth under about two layers of cells, and soon burst out through the upper epidermis. The diagrammatic sections in Pl. XI., figs. 6, 7, show how the growing point is formed by transverse divisions of the parenchyma cells between two vascular bundles ; the appearance of the tissue under the rosette is not unlike that under the cups of an Æcidium. The growing apex itself does not come above the surface of the thallus, but the leaves burst through and spread themselves out in a symmetrical rosette. They are usually linear or lanceolate in form, and have the same structure as the leaves at the growing point of the thallus itself. Beyond what has been described, no order seems to be followed in the development of these secondary shoots upon the thallus, new ones often appearing among the old. On the whole, however, they appear in longitudinal rows down the centre of the strips of thallus ; in the narrow forms only one or two rows may be found (XI., 9), in the more flabelliform several (XI., 2).

When these endogenous shoots appear upon the upper surface of the thallus, but not actually at the edge of it, they show radial symmetry, as just described, but when, as in rejuvenescence especially is not infrequently the case, they form upon the margin of the thallus, they show a distinct dorsiventrality from the very first. Pl. XI., fig. 8, shows such a shoot soon after its appearance. It rapidly develops into a growing point exactly like that at the tip of the main thallus, and may commence at once to form new branches of the thallus, or to form a flower, according to the time of year.

We have now brought the life-history down to the time when the dry September weather allows of the study of the morphology of the young plants after the high water level of the earlier part of the monsoon. At this season they have usually reached a considerable size, like the specimens figured in Pl. XII., often 10–20 cm. in diameter, with well-grown fan apices and with numerous rosettes of leaves upon the older parts; only on one occasion have I seen any sign of flowers, and then I found a few ready to open; but as a rule the development of the flowers begins much later in Ceylon, for I have found no sign of it in material gathered so late as the first week in November. Owing to the shorter wet season in India it is evident that the development must begin earlier there. Now, unfortunately, the high water of the other monsoon sets in, and it is impossible to get material, and when the water-level once more sinks the development of the flowers is already finished, so that this stage of the life-history must at present be left to supposition. It is not difficult, however, by a comparison of the growing tips at the two periods, to infer with some probability in what manner the development of the cupule, at any rate, takes place.

The flowers are almost always marginal or apical, formed from the characteristic apical growing points with their dimorphic leaves; only very rarely indeed, is a flower found on the pper surface of the thallus, when it may possibly have been formed from the growing point of a leaf rosette. Very commonly, as indicated in Pl. XI., fig. 2, each growing point in the large fan forms a flower, and almost all the more lateral apices form flowers in nearly all cases. Each apex forms one flower only, which stands more or less erect on a pedicel emerging from a horizontal or ascending cupule, which is covered with slender bristle-like leaves closely packed together on the upper side, has a membranous leafless nearly flat under surface, and a few larger leaves on the two lower margins, showing in fact the same general dimorphism and arrangement of the leaves as the original vegetative apex.

The upper side of the cupule is thicker than the lower. The pedicel starts from the base of the internal leafless hollow.

There is much variation among the different forms in regard to the form and depth of the cupule and the length of the leaves on it. Pl. XIII., fig. 5, shows the typical cupule of the common Ceylon form, just before it is exposed to the air by the fall of the water-level. In this form, and also in the other Ceylon form (Parkiniana, Pl. XI., fig. 9), the cupule, as a rule, remains closed over the tip of the flower until exposure to air, but the opening at the apex is not completely impervious. When cut in transverse section this cupule shows the general appearance of the diagrammatic sketch in Pl. XIII., fig 9. This shows the thick upper and thin under sides, the two lateral vascular bundles, the leaves on the upper wall and margins, and the general orientation of the enclosed flower. Pl. XIII., fig. 8, shows the same in longitudinal section, and shows that the pedicel in this form does not elongate till the emergence of the flower.

Examining the forms from the Bombay districts (L. z. konkanica) we find the cupule in what may perhaps be regarded as a more primitive condition ; it is thinner, less obtrusively axial in nature, and opens sooner, while the flowers are still submerged. Such a cupule with a nearly ripe fruit is shown in Pl. XIII., fig. 1, and in section in fig. 2. What appears to be the case, so far as I have been able to observe, in these plants is this. The cupule forms simultaneously with the flower, but not so rapidly as in the Ceylon forms, so that it never really shuts in the flower at the apex, and even after the flower has emerged to some extent the cupule continues to grow. Hence it comes that those who have examined only young buds have often supposed this plant to have no cupule ; in this stage the cupule is often all but evanescent, and sometimes the flower may ripen its fruit with the cupule in this condition. Other growing points on the same plant, again, may have very long cupules indeed. Non-observance of these differences (which were correctly noticed by Tulasne) has led to several errors in the descriptions of these plants. Thus Wight divided Law's material into two species (pedunculosa and foliosa) on the differences of the apices of one plant, and Warming has described as L. foliosa material collected by Goebel at Khandala, in which I have found the majority of the apices to have well-developed cupules. Hence, as I have already mentioned in a preceding paper, the species L. foliosa (Wight), Wmg., is quite untenable.

The more southern Indian forms (L. z. malabarica), collected by Mr. Barber, show very similar cupules, on the whole deeper and more like those of the Ceylon forms (Pl. XIII., fig. 3).

Looking back to the structure of the vegetative growing point already described, it is easy to see how these cupules may have arisen by an invagination of the apical point during the formation of the flower. The flower, in Ceylon, only emerges from the cupule after the fall of the water has exposed it to the air, but in India I commonly found the flowers growing upwards through shallow water, and in one case at least I found flowers which being submerged at some depth in a pot-hole could not grow stalks long enough to bring them into the air, and had become fertilized under water, though not perhaps strictly cleistogamously, as the perianth segments had separated. Many ripe fruits had been formed in the pot-hole. True cleistogamic flowers occur in Podostemon Barberi, as will be described below.

The flower emerges—in the Indian forms often with a nodding stalk—on a pedicel, which at anthesis is about 2–5 mm. long, usually erect, whatever may be the slope of the rock, and which has a clear pellucid cortex through which the central vascular bundle is visible (Pl. XIII., fig. 3). At the base the pedicel is continuous with the thallus tissue.

Although the thallus and the cupule are so very dorsiventral, and though the dorsiventrality of the thallus appears at so early an age, yet the flower itself shows radial symmetry, in spite of its having developed in a more or less horizontal position. Its structure is simple, and has been sufficiently described by previous authors. It has a sepaloid perianth, which is divided part of its height into three segments. This at anthesis stands up closely round the essential organs and holds the three slightly exserted stamens with their introrse anthers very close to the stigmas, so that autogamy is the rule (Pl. XIII., fig. 3). The flower is very small and inconspicuous, and the loose powdery pollen is easily blown about by wind, and as the stigmas are receptive a little time before the dehiscence of the anthers, and the flowers are very close together on the rocks, there is a slight chance of an occasional cross, but in general the fertilization is from the pollen of the same flower. Every flower, as a rule, sets a full complement of seed. The ovary is trilocular (Pl. XIII., 10), with a thick central placenta and very many minute ovules, and crowned by three short papillose stigmas. The ovule shows a simple structure like that described by Warming for Tristicha hypnoides.

The ripening of the seed is very rapid, and in about a week or ten days after the opening of the flower the capsules have generally shed their seeds. The ovary wall in the flower is smooth, and the ovary triangular, with three bundles visible in the wall of each carpel. After fertilization these thicken and lignify into stout ribs, as Warming has described. No dehiscence ribs form at the junction of the carpelsin this form, as is the case in the Dicræas, &c., to be described below. The capsule (Pl. XIII., fig. 7) has nine well-marked ribs, with the thin wall depressed between them. At the same time the tissue round the vascular bundle in the centre of the pedicel (Pl. XIII., fig. 4) becomes strongly lignified as in Tristicha, while the pellucid outer cortex falls away, leaving the fruit on a rather longer pedicel than the flower, but on a slender and very elastic one, as compared with the stout non-elastic stalk of the flower. The lignification of the outer part of the vascular bundle usually proceeds some little distance back into the tissue of the thallus itself.

The length of the pedicel of the fruit is very variable, especially in the more northern forms ; *e.g.*, I have found pedicels from 6 to 25 mm. long on one plant. What determines the length I cannot say, but incline to think that it is partly the rate of fall of the water-level, this again partly depending on slope of rock, &c. In determining varietal distinctions, the average length of a large number of fruit stalks should be taken. A half-ripe fruit also may ripen after gathering without lengthening its stalk.

Rejuvenescence.—One of the most important features in the general life-history of this, as of other species of the order, is its almost infinite capacity for rejuvenescence of its thallus from any part thereof which remains alive. So long as any portion, however small, of the thallus is alive, it seems capable, if submerged in favourable conditions, of forming a new growing point and re-commencing its growth. The new apex forms near the edge of the old or damaged portion of thallus, and begins at once to grow outwards horizontally, showing the same structure and development as the growing points previously described. An example of such a new growing point is shown in Pl. XI., fig. 8. The importance of this capacity to the plant is very great. The ordinary growing points soon die if exposed to air by the fall of the water, and are also liable to damage from larvæ of insects and in other ways. The damage to the plant is, however, only temporary, as new apices are at once formed and the growth goes on again. It is largely owing to the extensive formation of these secondary growing points that the morphology of the mature thallus is so complex and difficult to unravel. The secondary growing apices may form flowers, just like the primary ones.

Owing to this capacity for rejuvenescence, the plant can hardly be called strictly annual. As the water falls in the dry season, the bulk of the plant, or all of it in some cases if the fall be very rapid or the rock horizontal, becomes exposed to the air, and if it so remain for more than perhaps a week or ten days, it often or usually dies, having in the meanwhile opened its flowers and ripened its seeds. Any growing point, however, that lies near the lower side of the plant will now tend to grow downwards along the rock, and may succeed in growing downwards faster than the water falls, so that the plant may thus survive the dry season with its original growing points. Oftener, perhaps, this survival is by means of new apices, formed from exposed thallus at a time when a shower has caused a temporary rise of the water and so covered again part of the old thallus. Especially may this be seen in April, when the water reaches its lowest and then rises again with the rains of the little monsoon. Great numbers of young plants may then be seen, which are easily mistaken for seedlings. Closer examination, however, shows them to be formed from the old thalli rejuvenescing in the newly submerged portions.* Often new growing points may be seen on portions of thallus bearing ripe fruits. Later in the season these young plants are still more like seedlings, as the dead portions of the thallus are now decayed and removed, so that nothing remains but the star-like plant formed by the branching of the new growing point, and closely resembling a seedling.

Physiology.—A few notes on certain physiological features exhibited by these plants must now be given. A general discussion of the physiology of the group will be given later.

The chief necessary conditions of life for Lawia zeylanica seem to be a rigid substratum on which to grow, preferably smooth rock, though it will grow on logs of wood or twigs fixed among the rocks ; (2) rapidly running water covering the plant ; (3) sufficient light. Like most of the other members of the order, it will not grow well, and in nature is very rarely found, in shady places on the rivers ; usually it occurs in spots which for part of the day at any rate are fully illuminated by the sun.

The cultivation of this species is very difficult. I have succeeded in keeping it alive for some weeks in running

* *E.g.*, on 28th April, 1898, I found such specimens 2–4 cm. long.

water on the verandah of the laboratory, but not in getting it to continue its apical growth in such circumstances.

The sensitiveness of the thallus to contact with the substratum is very marked, and the thallus follows every irregularity of the rock on which it grows. As, on the whole, the growing points tend more to grow upwards than to grow in other directions, it may be perhaps concluded that they have a certain sensitiveness to light or gravity. The growing point itself shows a marked dorsiventral structure, but the flower which terminates it does not, though it is developed in a more or less horizontal position. Corresponding to its radial symmetry of structure, it no sooner escapes from the cupule than it turns upwards, and assumes a nearly erect position.

Though adhering very closely to the rock, the plant does not seem dependent on its root-hairs for food, and it is doubtful if it absorb much from the rock, unless it obtains from it the great quantity of silica with which its cells are filled. The use of this silica is questionable, but probably it has some secondary value in preventing the too rapid drying up of the thallus when exposed to the air. Assimilation probably goes on in both leaves and thallus, and the relative areas would indicate that there is more in the latter. At an early period in the life-history, the thallus contains a very large quantity of starch, and later in the year, when the flowering shoots are developing, the amount stored up at their bases and in their tissues is enormous. To this is to be ascribed the very great rapidity with which the plant is able to open its flowers and to ripen its seeds.

The deep red colour of the majority of the plants is very striking, and when the water is low and the sun shining brightly, it is not infrequent to see spots where Weddell's metaphor is not exaggerated, "le fleuve semble, si l'on me pardon l'expression, rouler sur un tapis de roses." The universality of this colour in the plants of this order, as in the deep-growing Florideæ, seems to point to a definite physiological meaning of the colour.

The exceedingly dwarf habit of the species, and its wonderful capacity for rejuvenescence, are rather biological than physiological features.

The classification of the Lawias is rendered exceedingly difficult by the variability of many of the characters, such as the length of leaves and pedicels, and the size or depth of the cupules. Seven species have been recognized. Of these, L. ramosissima is more allied to Tristicha, to which I have transferred it. Historical evidence and comparison of forms showed that L. pedunculosa was a synonym of L. longipes and L. Lawii of L. pulchella. The evidence on which the species L. foliosa was based has been demolished above. Tulasne's two Indian species are based on differences in length of leaves and pedicels, but as I have found these characters to vary enormously on the same plant, with depth of water, age of plant, and other things, these two forms must be united, and as further investigation shows that their differences from the Ceylon forms are probably not enough to be specific, we are thus reduced to a single species, L. zeylanica, Tul.

In Lawia we have evidently a highly modified plant to deal with, and it is also evidently adapted to more peculiar conditions than is Tristicha. At the same time it represents distinctly a side line in the evolution of the Podostemaceæ, and is the only plant with a shoot thallus in the highest group, the Tristicheæ.

The thallus, or at any rate its upper side, is here pretty evidently of "shoot" nature, and is without either roots or haptera; it is of the most extreme dorsiventrality, and lies closely down upon the rock. It is thus well suited to conditions which, as pointed out above, must have had an important influence in the evolution of the Podostemaceæ; no conceivable force of current, apart from scour, can detach it from the rock, and it can also, owing to its exceedingly dwarf habit, survive so long as there is the least trickle of water flowing over it. The actual distribution of this plant seems to point to the fact that this character is of great importance, and may be regarded perhaps as a direct adaptation to life in shallow water, or water liable to become shallow very rapidly. In Ceylon the species is distinctly infrequent, and it becomes more and more common proceeding further and further northwards through Western India, *i.e.*, in going into regions in which the season of deep water becomes shorter and shorter. In the Khandala district the plant is enormously abundant, and is found in little brooks up to points quite near to their sources. In this district the rainy season is very short, but there is a trickle of water in the streams for some time, and the plants live in this. This reasoning is supported by the further fact that the other species of this district, Hydrobryum lichenoides, is also extremely dwarf. We shall return to the matter below.

The great capacity of rejuvenescence possessed by this plant must also be of great advantage to it. It has an obvious advantage over Tristicha in the matter of the risks caused by fall of water-level at a non-floriferous period; exposure only kills a small part of it, instead of perhaps several large and complicated shoots, and owing to the fact that the thallus can bud out again from any part, growth is at once resumed, without the plant having suffered any serious loss. The thallus itself, too, is more or less amphibious, and can form new growing points even after considerable exposure.

The endogenous secondary shoots are an interesting feature, but are of course not to be regarded as homologous with those of the root thalli of preceding genera.

The mature characters of the plant appear very early indeed in the life-history, the dorsiventrality appearing almost immediately after germination. On the other hand, though the plant is so dorsiventral in its morphology and anatomy, the flower shows no sign of this character.

PODOSTEMON.

[Michx.; Willis, Rev. Podost. Ind., Ann. Perad., I., p. 228.]

As already explained in the preceding paper, the Indian flora contains no representatives of the systematic groups which intervene between the Tristicheæ and the Eupodostemeæ, with the latter of which we have now to deal for the rest of this paper. In the systematic order there followed Podostemon comes after Dicræa, but for morphological purposes it is perhaps simpler to take the former first, as in it the secondary shoots are still of considerable size, and take the chief part in assimilation, whereas in Dicræa and nearly all the following genera they are very much reduced as compared with the thallus.

As elsewhere explained, I have excluded from the genus most of the species placed in it by Bentham, who is followed by Hooker in his Flora of British India; these species are considered under Dicræa, Hydrobryum, Griffithella, and Willisia. There can be little doubt that Bentham's fusion of all these went either too far or not far enough, for if these be united with Podostemon there is no valid reason for keeping either Mniopsis, Oserya, Devillea, or Ceratolacis separate from it, whereas in the Indian species which he did unite with Podostemon there is very great morphological variety, as we shall see.

The genus, as now defined, is confined to America and India, so far as our present knowledge goes, and includes in India and Ceylon two very isolated forms, P. subulatus, Gardn., and P. Barberi, Willis, to which perhaps should also be added Polypleurum Schmidtianum, Warming, lately discovered in Siam.

Our knowledge of the morphology of this genus is comparatively good and complete, thanks to the labours of Prof. Warming, who has described the thallus, secondary shoots, and flowers, in many different species from America, and in P. subulatus from Ceylon material collected by Trimen. The American species mostly show a creeping thread-like thallus of root nature, very similar to that of Tristicha ramosissima, attached to the rock by hairs and haptera, and with endogenous branching and a root-cap. From this are given off, often more or less paired, the secondary shoots, which grow upwards to a greater or less height, bear distichous leaves, branch more or less often, and bear several or many flowers. The early stages in the life-history, even of such comparatively accessible forms as the Ohio P. Ceratophyllum, are however completely unknown.

Podostemon subulatus, Gardn.

(Plates XIV.-XVI.)

I have investigated this species chiefly at Hakinda, where it is abundant, and I have also found a variety of it in the Anamalai mountains. The latter is characterized by smaller habit and longer pedicels, and may perhaps ultimately prove specifically different.

Habitat.—In Ceylon the plant occurs in the Mahaweliganga and its tributaries, between 1,500 and 2,000 feet. At Hakinda it is common, and presents a very striking appearance, especially when seen in the height of the vegetative season in September. It grows like the rest only on a rock substratum, and is rarely found in rapidly moving or broken water, but occurs in great masses in the more quiet bays in the rocks among the rapids, where the eddy keeps the water in constant slow movement past the plants, waving the long red or green leaves to and fro, like Algæ on the rocks of a quiet seabeach. Like the rest it is never found on unstable substrata or in stagnant water. It is very often mixed with Dicræa elongata, more rarely with D. stylosa, vars. laciniata or fucoides, or with Farmeria metzgerioides, and occasionally, at places where an eddy returns into the main rush of the stream, it occurs mixed with Lawia zeylanica or Hydrobryum olivaceum. Its habitat in the one place where I found it in the Anamalais was very similar ; it was not mixed with any other species, but close to it, at the edge of the eddy in which it grew, were Willisia selaginoides and a Hydrobryum.

Dry Season Appearance.—The left-hand figure in Pl. XIV. shows a stone covered with this species in the condition in which it is found when the water has fallen away from it and the fruit is ripe. The rock is covered with a little forest of small fruit-bearing stems, 1–3 cm. high, marked with the scars of fallen leaves (Pl. XVI., fig. 11). The fruits are shortly stalked, and when open have lost one valve. Often the thallus may still be seen as a thin thread on the rocks between the stems. An examination of material taken at this time from below the water (such as was studied by Prof. Warming) shows that the shoots bear long subulate leaves, in the lower axils of some of which the floral shoots arise. These leaves shrivel and drop off at once on exposure to the air. The structure of the shoots at this period has been very fully described by Warming, and the following account will deal mainly with the earlier parts of the life-history.

Germination and Life History.—The seed is like that of the species already described, but has a slightly different embryo, the cotyledons being short and subulate, instead of thin and crumpled. There is a mucilaginous layer in the seed coat, as usual. When wetted the seed swells ; the hypocotyl emerges and bends downwards, and becomes at once attached to the substratum by rhizoids, as in Lawia ; it then becomes slightly tuberous, and the cotyledons expand. They are opposite to one another, and grow to a length of about 4 mm. The upper surface is slightly channelled at the lower part, but is not distinctly sheathing like the mature leaves. The cotyledons are not hairy, though the ordinary leaves are so.

The primary axis develops only to a very slight degree ; it remains more or less erect, but the cotyledons and leaves usually bend over towards one side. The leaves soon appear (Pl. XVI., fig. 1), the first two being markedly alternate, and approximately in the same plane as the cotyledons. The second leaf, as seen in the figures, develops within the sheath of the first. About six is the greatest number of leaves that I have observed to develop upon any primary axis that I have seen, and the leaves are comparatively small. All the leaves appear in one plane, *i.e.*, are distichous, with the cotyledons forming the lowest member of each rank. The leaves are hairy on the upper surfaces, and are usually, especially when young, of a deep reddish colour from the presence of anthocyan in the epidermal cells.

The thallus appears almost at once (Pl. XVI., fig. 2) growing out along the surface of the rock as a little papilla emerging from the basal portion of the hypocotyl, usually at right angles to the plane of the cotyledons. Its development is endogenous. Once formed, its growth is rapid; it becomes attached to the rock by rhizoids and occasionally by haptera. Its growing point shows a peculiar structure, details of which must be reserved for future description. It has no deciduous root-cap whatever, but the extreme tip is formed by a collenchymatous layer beyond the initial meristem, similar to, but less marked than, that which we shall subsequently find in Hydrobryum and Farmeria. The "epidermal" tissue (if such it be) of the maturer parts of the thallus can be distinctly traced in surface view round the actual apex, being there continued by the collenchyma. The extreme apical zone shows cells dividing in all directions; then follows a zone of mainly transverse division, and then one of elongation.

Very soon the thallus begins to branch. This it does very close indeed to the apex, and as might perhaps be expected from the construction of the latter, it branches exogenously. In Pl. XVI., figs. 4, 5, the tip of a thallus is shown which has just branched, and other figures on the same plate also illustrate the branching. The branch forms close to the apex, so closely indeed at times that until it is observed that the endogenous shoot is also forming between it and the apex, it looks almost as if formed by an actual dichotomy; in reality, however, the branching appears to be lateral. The shoot seems to be considerably developed before the branching begins. One arm of the two thus formed usually grows much more rapidly than the other. At the next branching this is repeated on the other side, and so on. The shorter branch of the two, as a rule, does not grow out very far, and often remains very short, as in the portion of a young plant figured in Pl. XVI., fig. 6, where two of the three branches shown have simply formed short projections, fastened to the rock in the usual way. The similarity of this figure to that of the alga Bostrychia Moritziana as figured by Goebel (Flora, 83, 1897, p. 436) is of the most striking description. The alga, it is worth noting here, and the subject will be considered again below, occurs in the same place with Oenone Imthurni, one of the Podostemaceæ of British Guiana. The frequently recurring similarity of the Podostemaceæ with the Algæ of moving water can scarcely be altogether "accidental."

When one of the lateral branches thus formed branches again, the first secondary branch is always upon the basiscopic side of the primary. The thallus becomes more or less zigzag in its construction, the two branches diverging at every node. In transverse section (Pl. XVI., fig. 7) it shows an almost cylindrical shape, flattened on the lower side, upon which is a kind of continuous foot, formed by the mass of root-hairs or rhizoids. In the central portion, but a little towards the lower side, is a vascular bundle of very simple construction, described by Warming, who states that there are sometimes two xylem groups towards the lower side, characterized by spiral vessels.

Leafy secondary shoots are also developed upon the thallus, and soon form, as in Tristicha, the most important part of the plant. One shoot forms at each branching of the thallus. Pl. XVI., fig. 3, shows the first leafy shoot appearing very early in the life of the thallus, and fig. 4 shows it more clearly, with its endogenous origin. The first leaf that breaks through is usually towards the basiscopic side, as there shown, and the other leaves follow in distichous order. The first leaves are small, but the shoot grows rapidly, and very soon leaves of 3–4 cm. long are produced, and after a few months, in August or September, leaves may be commonly found of as much as 30 cm. long. The shoot in the Ceylon form usually grows more or less erectly, while in the Anamalai form it is more prostrate, but otherwise the two are very similar. Each shoot exhibits a certain amount of dorsiventrality, the side next to the fork of the thallus being the upper and slightly concave, while the other side is lower and convex; the basal portion of the shoot flattens out into a sort of foot, figured by Warming, who has described these shoots in detail. The dorsiventrality shows itself in other ways also. Pl. XVI., fig. 8, shows a section of the top of a shoot through the leaves, and shows the slight concavity of the upper side; the vascular bundles form a curved line, concave upwards, and the leaves themselves show a distinct dorsiventrality, which resembles that of the cupules of Lawia, in that the upper sides of the sheaths are thicker than the lower. The lower sides, while thinner, are also larger in surface than the upper. We shall find these characters much more pronounced in the leaves at the bases of the flowers in Dicræa and other subsequent genera.

Occasionally in the Ceylon, and usually in the Anamalai form, the stem branches at the base, but more commonly there is no branching in the former until it has reached a height of 0·5–2 cm. and is ready to flower. When fully grown, one of these shoots may have a height of as much as 3 cm. and bear as many as 20 leaves, each 20–30 cm. long. The stems are produced near together upon the thallus, so that when a plant is well-grown in September it may have 30 or 40 such stems, and the great mass of reddish-green leaves waving in the water like seaweeds upon the rocks of the coast, forms a very striking sight. A portion of such a plant is figured in Pl. XV.; the separate shoots on the left show their construction and the thallus joining them. The leaves themselves have been described by Warming; it may be noted that the very young ones are redder than the fully grown leaves, that the upper surfaces are hairy, and that when taken from the water the leaves are very slimy, like those of many other water plants. This particular species is practically free from silica, and consequently shrivels rapidly when taken out of the water, all but the stout erect stems; the leaves fall, and the thallus withers to a thread.

As the stems grow upwards the leaves fall off below, leaving well-marked scars. Up to the beginning of the high water of the north-east monsoon the stems (at Hakinda) are mostly unbranched, and the leaves monothecous (*i.e.*, with sheath on the upper side only). Subsequently branching occurs from the lower axils of dithecous leaves (with sheaths on both upper and lower sides, *cf.* Warming), and a terminal flower is developed on each branch. I have, as with the other species, been unable to get material showing the development of the flower. When the water falls in December the flowers may be seen fully developed in their spathes, the latter not, however, opening until exposed by the fall of the water. At this period the leaves are usually a good deal smaller than in the earlier part of the vegetative season. Except that the spathe is shorter and stouter, the general appearance is very like that figured in Pl. XVII., fig. 1, for Podostemon Barberi. The transverse section of the group of leaves in Pl. XVI., fig. 8, includes the section of the pedicel of the flower, and an enlargement of this is shown in fig. 9. It is nearly circular in section, has a small central vascular bundle, a large cortex, and a columnar epidermis, especially well marked on the "upper" side, so that even in the pedicel there is a degree of dorsiventrality.

As soon as the water-level sinks sufficiently to expose the plants, the leaves shrivel and drop away, and the spathes open to allow the escape of the flowers. Pl. XVI., fig. 10, shows a flower fully open. It is without perianth, unless the thread-like organs at either side of the common stalk of the stamens be regarded as perianth; it stands on a short stout pedicel, nearly erect. On the lower side, *i.e.*, the convex side of the shoot, is the andrœceum, consisting of two stamens on short partial filaments united upon a longer common filament. The ovary is of two carpels, bilocular, with a stout axile placenta, thin septa, numerous ovules, and two stigmas. In cross section it is very like that of P. Barberi (Pl. XVII., fig. 6), but the outer margin of the deciduous tissue is not undulate, so that the ovary is not winged as in that species. In all other respects it is the same, and the description given below will suffice for both.

The stamens stand away from the stigmas, so that self-pollination is not absolutely inevitable, though it seems by far more common than a cross. The flower is anemophilous, and produces large quantities of loose powdery pollen. Practically all the flowers appear to set a full complement of seed. The seeds are very small and soon ripe.

The development of the fruit is of particular interest, and as it is very similar in all the following genera, it will save repetition to describe this one in full. As in most of these plants, the seed is practically no larger than the ovule, and the fruit than the ovary, as is shown in Pl. XVI., figs. 10, 12, and 13, which are all on the same scale. The pedicel, as already described, has a thick cortex, which, as in Lawia, is deciduous, leaving the now woody central tissue as a slender but much more elastic stalk to the ripe fruit. With this deciduous tissue there falls away also the outer tissue of the ovary, as indicated for P. Barberi in Pl. XVII., figs. 6 and 9, leaving to the ripe fruit only the vascular tissues, which become strongly lignified and form the ribs, and the innermost two layers of cells, already cutinized in the ovary, which form the wall of the ripe fruit, and are very smooth and shiny within, but rougher on the external surface where the other cells have fallen away. The outer layer of the two also becomes strongly lignified. The ripe fruit is thus, if anything, rather smaller than the ovary, but with clearly marked ribs.

The distinction between the genera Podostemon and Dicræa is partly based on the mode of dehiscence. In the former the two lobes are unequal, and one falls away leaving the other on the stalk, while in the latter both are equal and persist on the stalk. The figure shows the construction of the typical Podostemon fruit. As the cross section of that of P. Barberi shows, there are eight ribs, of which the septal ribs are double ; dehiscence occurs by their splitting and the falling away of the septa. In Podostemon the ribs on the one half of the fruit run down into the pedicel (XVI., 12), while those of the other and deciduous half do not. The halves of the dehiscence rib unite with the rib next to them on each lobe. The process will be easily understood by a reference to the figures, which may be compared with those of Dicræa.

The capsules open as soon as ripe if the air be dry, and the plant now presents the usual dry season appearance figured in Pl. XIV., fig. 1, in which the persistent lobes of the open fruits can be clearly seen.

Rejuvenescence.—Like Lawia, this species exhibits a great power of rejuvenescence, forming new shoots with great rapidity if any necessity arise, as through injury. When, as not infrequently happens in August or September, the water falls rather low during the vegetative season, many of the leafy shoots and parts of the thallus become exposed to the air and die. As soon as the water rises again, however, the tip of the thallus forms a new growing point, growth is resumed, and is soon as free as ever. This process also goes on in the dry season of February and March, when the bulk of the plant is killed by exposure ; branches of the thallus are formed and grow downwards over the rocks more rapidly than the water falls, so that the whole of the plant is not killed. It is rather hard, consequently, to say whether this plant, or indeed any of these plants, should be strictly termed annual. The new shoots formed in the dry weather of the early part of the year do not flower till the following dry season.

This species is fairly well represented in herbaria : most of the specimens show leaves *in situ* on the stems, but only rarely show the thallus.

Ecology.—In general this is much the same as in Lawia. The plant is larger and less firmly fastened to the rock, and affects less rapid water. Its habit is less dwarf, and among the Indian Eupodostemeæ it is perhaps the one which approaches nearest to Tristicha in general habit of thallus and shoot, but it shows an advance on that genus in the greater dwarfing of the shoots, and makes up for great number of leaves by larger size of the few that occur ; it is thus able to live in shallow water with perhaps greater safety than Tristicha ramosissima. It still shows, what is rare in the succeeding genera, the assimilation chiefly performed by the leaves and not by the thallus. Vast quantities of starch are, as usual, accumulated in the thallus, the shoots, and the pedicel and placentæ of the flower.

Podostemon Barberi, Willis.

(Plate XVII.)

This very interesting new species, more closely allied to the preceding than to any other known species of the genus, but differing in its flat thallus and its single-staminate cleistogamic flower, as well as in a few other points, was discovered at Beltangadi in S. Kanara by my friend Mr. C. A. Barber, after whom I have named it.

Habitat.—It occurs in a rapid, but not violent stream, and is mixed with Griffithella Hookeriana, var. Willisiana.

Dry Season Appearance.—The plant in the fruiting condition has some similarity to P. subulatus, but the fruits have much longer stalks, and the secondary shoots are very short. The flowers are easily seen to be cleistogamic, the spathes not opening until the fruits are nearly ripe and often hanging in wisps about the pedicels.

Mature Structure.—The germination and early life-history of this plant have yet to be studied ; the only existing material is that collected by Mr. Barber at the end of the season. Probably, however, the general features of the life-history are much the same as in the preceding species.

The thallus, however, is very different ; instead of being nearly cylindrical, it is flat, narrowly elliptical in section, about 1 mm. thick in the middle, and tapering off to the sides (Pl. XVII., figs. 1, 3). Its breadth is usually about 3 mm., but in one or two cases the thallus is broader, and almost seems as if it tended to become crustaceous, like that of some of the Hydrobryums. It is frequently branched, the branching being all in the horizontal plane and exogenous. Along the middle of the lower side runs what may almost be called a continuous foot, composed of root-hairs closely matted and mixed with a gummy excretion as already described for Tristicha.

In the middle of the thallus, as seen in cross section (Pl. XVII., fig. 3), is a vascular bundle like that of the preceding species, while the wings or sides of the thallus, as seen in fig. 4, are composed of large-celled parenchymatous tissue, with epidermis above and below. I have not seen in this species any sign of the tangential division of the cortex of the thallus that is so marked a feature in the very similar thallus of some of the Dicræas. Nor do the margins of the thallus seem to fall away here as in some of the latter.

The secondary shoots arise on the upper margins of the thallus, in the angles of the branching, just as in P. subulatus. They differ from the latter chiefly in the smaller size of the leaves (*i.e.*, so far as can be judged from specimens taken at the end of the year ; during the purely vegetative season they may quite well be much larger), and in the fact that the lower leaves do not fall away to expose a scar-covered axis. The leaves in the specimens that I have seen rarely exceed 5 cm. in length. In structure and arrangement on the stem they are like those of the preceding species, and the branching takes place as there from the lower axils of dithecous leaves.

Flowering occurs, as usual, at the beginning of the dry season ; this species shows what one is surprised not to find more commonly in the order, cleistogamic flowers, fertilized under water. What is the stimulus causing maturity in the flower has yet to be determined, whether greater exposure to light, more dissolved air in the water, reduced water-pressure, or other cause. The spathe (Pl. XVII., figs. 2, 5) is adnate below to the pedicel, is long and narrow, and encloses the flower until after fertilization. There is only one stamen, which stands closely up against the stigmas. Germination of the pollen takes place within the anther, but I have not been able to make out how the tubes pass to the stigmas. The ovary soon expands into the fruit after fertilization, and the spathe, which for a time lengthens with the pedicel, ultimately splits and falls away.

The six main ribs of the ovary, but not the two dehiscence ribs, are provided with stout wings of delicate translucent tissue, a feature of specific distinction between this species and P. subulatus. Pl. XVII., fig. 6, shows a cross section of the ovary, and fig. 9 of the resulting fruit. These show, as has already been partly described under P. subulatus, the way in which the ribs of the fruit are formed. In cross section the ovary shows a stout placenta, two thin septa, and six wings, each with a vascular bundle. There are also vascular bundles in the place where the dehiscence ribs are to form. The inner epidermis in section shows a bright yellow colour ; it consists (fig. 8) of long narrow cells with very stout outer cutinized walls. Under it is a layer of smaller somewhat thick-walled cells, and beneath this again, *i.e.*, towards the outer side of the ovary, is large-celled parenchyma tissue. As the fruit ripens, this parenchyma falls away, and the vascular bundles and the inner epidermis and layer of cells under it alone persist. The inner layer of cells and the outer parts of the bundles become lignified, while the inner epidermis forms a smooth shiny inner layer to the fruit wall. By the fall of the parenchymatous wings, the two dehiscence ribs become almost as prominent as the other six, and the two sides of each bundle become woody, but not the central line, in which dehiscence takes place. As seen in fig. 7 the stout inner epidermis also ends on either side of the line of dehiscence. The septa of the fruit break away, and the dehiscence ribs split down the middle. As in the preceding species, one valve of the fruit falls away, the other persisting with its ribs decurrent into the pedicel.

The genus Podostemon, from a morpho-ecological standpoint, evidently falls into line with Tristicha, and it will be of interest to consider its peculiarities as compared with that genus, in connection with the difference in the general conditions of life. On the whole, so far as can be judged, Podostemon lives in very similar localities to those inhabited by Tristicha, but the water is perhaps a little swifter. Exposure to light, &c., and the other conditions considered in the introduction seem much the same for both. Morphologically, the chief feature in which Podostemon differs from Tristicha is the great reduction of the secondary (and probably the primary) shoots. The thallus is very similar, though the root-cap is almost absent (as perhaps in Tristicha hypnoides), and it is exogenously branched. The secondary shoots, however, are much dwarfed, making up for the reduction of the axis by the development of very large and flexible leaves; the number of flowers borne on them is also much smaller. Thus, on the whole, probably the plants are better able to take the risks of temporary fall of water-level, and do not have to pay so dearly for exposure, and can better stand shallow water. They also probably offer less resistance to the current, and so can stand swifter water. The extension of leaf surface, obtained in Tristicha by the delicate moss-like leaves of the ramuli, is here increased by the formation of hairs on the surface of the leaves.

Dorsiventrality is considerable, and shows very markedly in the flower, but less so in the vegetative parts than in Lawia, and there is hardly any trace of it in the seedling.

The great development of the secondary shoots is accompanied in this plant by the curious feature common among the Eupodostemeæ, that the primary axis has become insignificant, and takes no part in the bearing of flowers.

P. Barberi shows the first sign we have yet met with of that flattening of the thallus which is so marked in some of the subsequent genera.

DICRÆA.

[(Du Pet. Th.) Tul.; Willis, Rev. Pod. Ind., Ann. Perad., I., p. 216.]

I employ this genus, as already explained, in Tulasne's sense. It is very abundant in all the districts of India and Ceylon where Podostemaceæ have been found, except the more northern on each side of the continent. The species are variable and polymorphic, and much detailed study is needed to finally determine the specific limits; by using very broad distinctions I have included all my material under five species, one of which is not, I think, really separable from the rest.

This genus is characterized by the possession of very remarkable root-thalli, two forms of which have already been described by Prof. Warming, viz., those of D. elongata and of D. stylosa, var. fucoides (D. algæformis, Trim., Wmg.), both from material collected in Ceylon by Trimen at the beginning of the dry season. These accounts are very full and accurate, but a few corrections must be made in them, and they do not deal with any of the early stages of the life-history.

Dicræa elongata, Tul.

(Plates XIV., and XVIII.-XX.)

Our knowledge of this species is mainly due to Warming, who has described material collected at Hakinda by Trimen in the dry season. My account is therefore chiefly confined to the general life-history and the earlier stages, and to the correction of a few errors in previous descriptions. I have investigated the species at Hakinda, where it is very abundant.

Habitat.—This species is apparently confined to Ceylon, where it occurs from the lowest slopes of the hills up to

2,000 feet, especially in the Mahaweli and Kelani rivers. It grows, as a rule, in rapidly running broken water, but not in such violent streams as does Lawia. Its size and its manner of drifting out with the current cause it to afford a much greater hold for the water to pull upon. It is most often found growing by itself, like most of these plants, but is commonly found mixed with Podostemon subulatus or Dicræa stylosa, var. laciniata, less often with var. fucoides, or with Hydrobryum olivaceum. It is usually one of the first to emerge as the water-level falls.

Dry Season Appearance.—As found in January or February upon dry rocks the plant consists of numerous more or less upright or projecting woody stalks, reaching to a length of about 10–15 cm., with distichous stalked fruits borne at intervals of about 1 cm. on each side. Along the rock, and firmly attached to it, are woody creeping thalli, from which the erect ones spring. The erect stalks are also thalli, while the lateral stalks borne upon them are the secondary shoots, endogenously formed from them and bearing each one fruit (Pl. XIX.). Usually some plants may be found which are still submerged, and then it can be seen that the erect woody thalli are only the lower ends of very long thalli, which drift out in the water to a length of as much as 50 cm., bearing little fascicles of leaves towards the outer end, and floral shoots on the lower parts (Pl. XIX., and *cf.* figs. in Tulasne and Warming).

Germination and Life History.—The seed has the usual structure, with a mucilaginous outer coat, and the germination takes place as in those species already described. The cotyledons spread out approximately in the same plane, but sometimes with a tendency to approach one another on one side and thus give the embryo an asymmetrical structure. Almost at once the leaves of the primary axis appear. The first and second are usually, but apparently not always, nearly at right angles to the plane of the cotyledons (Pl. XVIII., fig. 1), and they are followed by a small number of other leaves, which are arranged in no very exact order or phyllotaxy that I have been able to discover. The primary axis is quite insignificant, and never reaches any size.

The thallus appears almost at once. The base of the seedling axis forms a sort of tuber, as usual, which is fastened to the rock by root-hairs and by the formation at a very early stage of one or more exogenous haptera. The thallus appears to be endogenous, but in some cases that I have examined I was not able to satisfy myself that it was not exogenous. Great care has to be taken not to confuse thallus and hapteron in young seedlings; the latter is always exogenous and is usually larger-celled. Pl. XVIII., fig. 1, shows a young seedling with the thallus beginning to form. In fig. 3 a rather later stage is shown on a larger scale to indicate the endogeny of the thallus, and the exogenous hapteron with its larger cells, which are now apparently more or less fully grown. A still later stage is shown in fig. 2. Here the primary axis has reached almost its maximum development, consisting of a few leaves on a very reduced stem. As soon as the thallus is well established the primary axis becomes quite an insignificant factor in the life of the plant, and in older plants cannot usually be found at all. The thallus grows along the rock, attached by root-hairs and by haptera for a distance of one or two millimetres, then checks in its growth and forms a branch on the upper side, as seen in figs. 2, 4. This branch is the commencement of a floating or rather drifting thallus, which extends upwards into the water and does not, as a rule, become attached to the rock at any other point than its basal end. Usually the drifting thallus seems to start from the creeping one at a gentle forward slope or angle, as in fig. 2, but sometimes, as in fig. 4, it starts at right angles. These drifting thalli form the chief part of the mature plant, and being, like the creeping thallus, green, do a large part, if not the bulk, of the work of assimilation. The thallus grows rapidly by an apical growing point (Pl. XVIII., fig. 5), already described by Warming, with a small terminal root-cap. A single vascular strand runs up the thallus to near the tip, and from it branches run to the endogenous secondary shoots, which are produced in acropetal succession upon the thallus, usually alternately, but often sub-oppositely. The endogenous shoots have been fully described by Warming. In contradistinction to what we have seen in Tristicha and Podostemon, they are very much reduced ; the axis does not, so long as the shoot remains vegetative, come above the thallus surface at all, but remains almost evanescent, and the only part appearing above the thallus is the leaves, of which there is a small fascicle, about 4–8 in number, simple, subulate, hairy on the upper surface, and not often more than 5–10 mm. long. The secondary shoots appear very near to the tip, and are usually about 5–10 mm. apart; they are distichously arranged along the two sides of the cylindrical thallus, *i.e.*, on the sides which were lateral as the thallus started from the creeping part.

The thallus branches freely upon or near to the rock, but only rarely do the upper parts of the drifting thalli branch; when this occurs, the branches are like the drifting part, and lie more or less parallel with it. The branching, as a rule, is exogenous, except when branches are formed on old parts of the thalli, when they are commonly endogenous. When a branch is formed, it usually creeps along the rock for a short distance, and then gives rise, just like the primary thallus of the seedling, to a drifting thallus. Thus ultimately the plant forms a large number of drifting thalli and a confused tangle of creeping thalli upon the rock. The branching is less regular in this species than in most of the others with which we have to deal ; the branches appear more or less anywhere, instead of being in strict acropetal succession along the thallus. By the end of September the plant has reached its full vegetative growth, and is even more striking as seen in shallow water than Podostemon subulatus. Pl. XIX. shows such a plant ; there are many long drifting thalli of lengths up to 50 or even 60 cm., waving out in the water as the swift current passes by, but firmly held by the creeping thalli at the base. The colour is green or red.

To turn for a moment to the internal structure of the thallus at this stage, we find several features of interest, details of which must as usual be postponed for a later paper. In transverse section the thallus (Pl. XVIII., fig. 6) is approximately circular or elliptical, with a single vascular strand towards the lower side, surrounded by a cortex whose cells are collenchymatous towards the centre, and with walls thinner towards the epidermis. The vascular strand is elongated in the horizontal plane (fig. 8), and near the tip of the thallus is only two or three cells thick. At the ends may be seen two small-celled groups, which may perhaps represent primary xylem, and the rest of the tissue is parenchymatous or phloem-like, especially on the upper side, where the cells are narrower, and seem to represent primary phloem; no sign of any characteristic xylem markings or of lignification is present. Further down in the thallus meristematic activity is evident in the vascular strand. The rather larger lower cells of the strand are found to be dividing, chiefly at first in the horizontal plane, but later also in the vertical or irregularly. A commencement of this process is shown in fig. 9, and two cells, with their resulting products, are shown in fig. 10 at a stage when the process is nearly complete, and when the bundle has reached the stage figured by Warming from January material. Besides this growth in thickness in the bundle, there is also a corresponding growth in the cortex. As shown in fig. 7, it begins in the outer layers and on the upper side, and is at first tangential, but very soon most of the cortex begins to divide both tangentially and radially. Even at this stage, though the bundle has reached some size, there seems to be no lignification, nor any characteristic xylem elements, though these may be seen later in the lower parts of the bundle.

The heavy rains of the north-east monsoon now begin, and by December, when the plant is again in shallow water, the development of the flowers is practically complete, though there is no sign of it in October. As might be expected, the floral shoots are simply metamorphosed vegetative shoots, and there is no dimorphism in the sense ordinarily employed in reference to this plant. Only on extremely rare occasions does the whole number of the secondary shoots become floriferous; as a rule, about one-third or a half of them is the maximum so metamorphosed. The non-floriferous shoots are always towards the tip of the thallus, the floriferous at the lower end, and not infrequently some of the creeping thallus becomes floriferous also. During this period of submergence the thallus has continued to grow in thickness, mainly by meristematic activity in the cortex, and it may now be as much as 4 mm. in thickness near the base, tapering away to a mere thread towards the tip. The leaves of the shoots towards the base usually drop as the thallus grows longer, and presently the floral shoots are formed at these points. What determines the number of shoots that are to become floriferous, unless it be the available amount of nutrition, is hard to say; the boundary between the flowering and non-flowering parts of the thallus is very sharply marked. In the former the inner collenchymatous cortex becomes very thick-walled, while the thin-walled outer cortex shrivels, though it does not fall altogether away, as in other Dicræas to be considered below. The lower part of the vascular bundle now also exhibits the characteristic xylem elements, in the form of annular and spiral vessels, while the upper part is phloem tissue. Until this time there has of course been no use for water-conducting tissue or xylem of any kind, but now the floriferous part of the thallus is to come above the water. No lignification, however, seems to take place, or at least, the walls, though thickened, give no reaction with aniline chloride or phloroglucin. Beyond the floriferous part the thickening of the walls of the cortical collenchyma and of the vascular strand does not take place.

The formation of the floral shoots in this genus shows an advance on that in the preceding genera with root-thalli, in that the whole shoot is floral only, is very short, and bears one flower instead of many. The axis, hitherto evanescent, comes above the surface of the thallus, and developes more leaves. These differ from the previous vegetative leaves, in that the sheathing base is larger and the blade smaller. The axis rarely exceeds a few millimetres in length, exclusive of the flower-stalk. The tips of the leaves shrivel away, and very soon only the sheathing lower parts are left. There are usually about four of these "bracts" below the flower, the two upper being larger than the two lower; their shape is usually long and narrow, but sometimes shows an approximation to the cowl or helmet form characteristic of D. stylosa, &c. The upper side of the bract is thicker than the lower, just as in the unaltered leaves of Podostemon subulatus. At the end of the axis is the solitary flower, enclosed as yet in its spathe, the latter being very like that of Podostemon. Pl. XVIII., fig. 11, shows a section at this period through the thallus and secondary shoot, and shows the shrivelled cortex and the vascular bundle branching to the secondary shoot.

The spathe remains closed until exposure to the air, with the flower inside it quite ready for expansion. Presently, with the stiffening of the tissues the flowering part of the thallus becomes fairly rigid, only the non-floriferous tip still undulating in the water; very often the flowering part becomes more or less erect upon the rock. Soon after, with the continual fall of the water-level, the flower-spathes begin to be exposed to the air, and as this happens they split and the flowers emerge. Thus, as all the flowers are ready for immediate expansion, it happens that the actual order in which they ultimately open is determined, not by any morphological construction of the plant itself, but by the orientation of the floriferous thallus with regard to the water-level. As very often the thallus is nearly erect, it happens that the order of opening is a descending one, so commonly in fact that this plant is often quoted in the text books as one in which an apparent raceme is really centrifugal. If the thallus happen to lie out horizontally, and be a little twisted, so that one side is nearer the surface of the water than the other, then the flowers on this side will all open before those on the other side, and may even have ripened their fruits, while the flowers on the under side of the thallus are still in the bud.

The flower is described and figured by Warming; in general it is very like that of Podostemon subulatus, already described and figured above. It appears to be chiefly self-pollinated, like the other Ceylon forms, and practically all flowers set seed freely. The pedicel has the usual deciduous cortex.

The fruit is very similar in structure to that of Podostemon, but has equal lobes. Pl. XVIII., fig. 12, shows the ovary in cross section; it has the same wall structure and other features as in Podostemon, already considered, but on looking at the fruit in Pl. XX., fig. 2, the essential difference between the two genera can be easily seen. In Dicræa the ribs are symmetrical on both lobes of the fruit, and from each lobe three ribs run down into the pedicel. The dehiscence rib is also symmetrically arranged, and the fruit splits accurately down the middle line into two equal lobes, which persists for some time on the stalk. As soon as exposed to the air, the non-floriferous parts of the thalli usually wither up and drop off, leaving the short woody fruiting stalks shown on the left hand in Pl. XIX.

Rejuvenescence.—Like the rest this species has a large capacity for regeneration of injured growing points and the production of new ones from almost any part of the thallus so long as submerged. The creeping thallus is able to stand considerable exposure without dying, and may revive and form new growing points. The process of regeneration of broken or injured tips has been described by Warming; the new tip forms in the thallus a little way back from the injury, and growth is resumed. The creeping thallus also very readily gives rise to new growing points by endogenous formation; these grow along horizontally for a short distance, and then give rise to vertical branches, exactly as the primary thallus does. Pl. XX., fig. 1, shows a piece of rejuvenescent thallus from a plant which had been submerged by a rise of water in the flowering season before it was actually dead. As the water falls in the dry weather, the lower parts of the plants usually exhibit a large amount of this sort of rejuvenescence, and towards the end of the dry weather there is usually quite a large crop of plants with floating roots from 5 to 8 inches long growing upon the rocks. These roots show no sign of transforming their leafy shoots to floral shoots the same year.

This species is well represented in the herbaria, but the leaves of the shoots at the outer end of the thallus are very brittle when dry, and have very often disappeared, sometimes even the whole of the foliiferous portion of the thallus is missing. When this is the case it is perhaps usually due to the fact that the specimens were gathered when the fruit was ripe, by which time the terminal portion of the thallus has usually disappeared, having withered up and broken off. The leafy tips of the bracts, too, fall away to a large extent. The size of all parts varies greatly. *E.g.*, the pedicel of the ripe fruit, described as 1/5 inch long by Trimen, 6–8 mm. by Weddell, 8 mm. by Tulasne, varies in the specimens in the Peradeniya herbarium from 3 to 9 mm.; perhaps 6-7 is the most usual length. The flower bud varies much in bulk, and also the fruit, which varies from a length and breadth of 2·2 and 1·25 mm. to 1·5 and ·75 mm.; the largest fruits are thus four times the bulk of the small. Some specimens recently found in the Bambarabotuwa river, a tributary of the Kalu-ganga, in Ceylon, by Mr. H. F. Macmillan, show a smaller habit altogether. The floral shoots in many of the specimens are only monostichous. The bracts also vary in the direction of the more cowl-shaped form of those of P. algæformis.

Dicræa dichotoma, Tul.

(Plates XIV., XX.)

This species, as explained in the preceding paper, includes the four forms, D. dichotoma, Wightii, rigida, longifolia, originally described by Gardner and Wight, but which I do not think are deserving of even varietal rank, depending apparently on differences due to the different depths from which the material was taken. I have carefully examined the herbarium material, and have also collected for myself in the Paikara river, and though further examination on the spot is required, I do not think there is any good evidence at present for separation of the forms named.

Habitat.—Like D. elongata, this species grows in rather rapid and broken water. In the Paikara river it is frequently mixed with Hydrobryum olivaceum, var. griseum, the only other form that occurs in that locality.

Dry Season Appearance.—A stone covered with fruiting material is shown in Pl. XIV. (top, right). Brown withered thalli about 5-8 cm. long, thin, ribbon-like, more or less zigzag, may be seen attached to the rocks for at least the greater part of their length, though the ends are usually more or less free. Standing vertically upon these are the fruiting shoots, very like those of D. elongata, in fact it is not always easy to tell which is which when, as sometimes happens, only the lower part of the thallus of the latter bears fruits. Under water plants may be found in January at any rate, which illustrate the mature structure sufficiently well, but it is desirable that the life-history should be fully worked out.

Mature Structure.—As seen at the end of December, the thalli are about 10–15 cm. long or more, lying very closely down upon the rock, and with much less marked difference between the creeping and drifting parts than in D. elongata. Usually the basal 3–5 cm. are attached to the rock, and the rest free, but in a line with the creeping part, and often attached at one or two points by haptera. The haptera are often very large—to 1 cm. long—and much branched in this species. The drifting part is usually fairly frequently branched, the branches also drifting and repeating the structure of the original thallus ; the creeping part is less often branched.

The thallus is flattened, but not so much so as in the species to be considered below ; at the base it may be as much as 4 mm. wide and 3 mm. thick, and tapers to the tip. It is not unlike the thallus of Podostemon Barberi, but longer and narrower, and in the older parts it grows in thickness like the thallus of D. elongata, more especially in the central part, while the marginal portions shrivel (Pl. XX., fig. 4). The vascular strand and the general anatomy of the thallus are much as in the preceding species. The secondary shoots are about the same distance apart, and the thallus is often more or less zigzag, small lateral projections being formed under each secondary shoot (Pl. XX., figs. 3, 5).

The general structure and history of the secondary shoots is the same in all essential features as in D. elongata, and the basal third or even half, or more, of the thallus becomes ultimately floriferous. The formation of the bracts by the metamorphosis of the leaves is clearer in this species than in the last, and requires a little explanation, as the method of formation is common to other genera of the order, and the examination of herbarium material in various stages of the metamorphosis has led to many errors and much confusion. The figures in Pl. XX. show the process clearly. In fig. 6 the secondary shoot is beginning to develop a flower ; it still has several long leaves with sheathing bases. The bases enlarge, especially those of the two uppermost leaves, and the tips of the leaves begin to shrivel as in fig. 7. Then follows the stage shown in fig. 8, where the tips have mostly fallen away, and finally the process reaches the stage shown in fig. 9, where the flower is open, with its spathe split into several teeth at the tip ; at the base of the spathe are two large more or less cowl-shaped bracts with no tips, and below these two or more leaves, which are only little enlarged, but which are usually considerably stretched by the growth of the outermost bracts and the flower. Many specific characterizations have been chiefly based on differences in the form of the tips of the bracts, while in reality these differences simply express different stages of the process above explained, and until it is complete it is not safe to base any diagnosis on the form of the tip or keel of the bracts.

As mentioned in the preceding paper, several species have been made from the Paikara material, the separation characters chosen being chiefly the length and number of the bracts; D. Wightii, for instance, depends for its character simply on the fact of its having been taken from deeper water, before the long tips of the leaves had fallen. I examined all the plants I could at Paikara, and came to the conclusion that the forms mentioned could not be regarded as anything but phases.

The flower of this species is very similar in all points to that of D. elongata, and the fruit is the same, but with broader dehiscence ribs (Pl. XX., fig. 10).

Rejuvenescence by the formation of new growing points on broken or resubmerged thalli appears to take place to a considerable extent.

The herbarium material of D. dichotoma is on the whole good, apart from the confusion caused over the development of the bracts, which has led to its being divided into many species.

Dicræa Wallichii, Tul.

(Plates XX.-XXI.)

As explained in the preceding paper, I include Weddell's D. pterophylla in this species, it having been separated from it simply on account of misconception of the process of bract development; Weddell examined spirit material collected by Sir J. D. Hooker, while Tulasne and Griffith used dry material, in which the keel was more disintegrated. I divide the species into two varieties; of the second, D. Wallichii striata, the Burma form, I have only seen herbarium material, and probably enough when good material is available it may prove specifically distinct. The following remarks refer only to the Khasia mountain form, D. Wallichii Khasiana, which I have myself studied at Cherrapunji, the district in which the plant was originally collected. I have also examined the herbarium material.

Habitat.—The plant grows in very similar situations to D. elongata, on rocky substratum in rapidly flowing water. Owing to the enormous rainfall of Cherrapunji, there must be considerable depth and force of water during the vegetative season. I found it in one or two places growing slightly intermingled with Hydrobryum lichenoides.

Dry Season Appearance.—A number of specimens are figured in Pl. XXI. As usually seen at Cherra, the plant consists at this time of brown thalli, a few millimetres wide and almost as thick, attached at the base by a sort of foot, and running outwards from it, usually down stream, in a branched laciniate form, to perhaps 5–10 cm. long. On the ends of the laciniate arms the fruits are borne, usually one on each, on a stalk of about 8 mm. long.

Mature Structure.—The most of the dried material in the herbaria gives little clue to the mature structure of the living plant, which is really very like that of D. stylosa, comparatively little branched, and with broad lobes, not with laciniæ. In most essential points the structure is that of the latter species, to which reference may be made for details. The thallus is usually attached at the base only, or at the base and a few outer points, only rarely at all points. At the base, where the primary axis formerly stood, there is a sort of stout cup-shaped foot, seen from below in Pl. XX., fig. 14. From this the thallus spreads out, chiefly in one direction, that of the prevailing current, so far as I have been able to observe. In general it has the habit and construction of a Fucus, with broad crisp undulated lobes just as described below for D. stylosa, var. fucoides. Plate XXI. shows a series of specimens from above and below the water, and with the explanation that accompanies it is sufficient to clear up the somewhat confusing appearance of the various existing specimens of this species and its synonym.

The thallus grows by a broad growing point like that described below in D. stylosa fucoides, with exogenous branching; it forms endogenous secondary shoots on the upper edges, to which run branches of the central vascular bundle (Pl. XX., fig. 11). Probably when in full vegetative growth in September the plant is very like D. stylosa fucoides as shown in Pl. XXII., fig. 3, but towards the end of the season the tips of the thallus lobes are commonly found to have fallen away or to be breaking off, so that the general form is commonly like that shown in fig. 12, Pl. XX. In this specimen the vascular bundles are shown, leading to the marginal secondary shoots (themselves not shown). Ultimately, as usual, some but rarely all of the secondary shoots become floriferous, and here a peculiarity of this species shows itself, in that instead of the flowers being concentrated on one part of the thallus, they are scattered over the whole or most of it, in each lobe some of the shoots becoming floriferous, the rest remaining sterile. Round the vascular bundles leading to the developing flower the tissue as usual becomes thick-walled and brown, while the bundles leading to the sterile shoots are not so surrounded. The former bundles show clearly as brown bands through the living thallus (fig. 13). As the flowers develop the intermediate tissues become disorganized and begin to break away, so that finally nothing is left but the brown bands of thick-walled tissue containing the vascular bundles leading to the flowers. Thus the remarkable differences seen in the different collected material are easily explained. The process is not usually complete till the plant is fully exposed on the rock, and I am inclined to think, but cannot be sure, that the flowers emerge from the water as soon as it gets shallow. Griffith's material mostly shows the thallus with the thin marginal parts between the bundles still present, though the fruits are ripe. Other material has been gathered from dry rocks, and has completely fimbriate thalli without thin margins. Others again have been collected quite early, and show the process only in its early stages, and so on.

The floral shoot develops from the vegetative, as in D. dichotoma or elongata, but does not become so much lengthened. The basal sheathing parts of the leaves, which form the scaly bracts, are proportionately much shorter and broader, helmet-shaped in fact. The spathe does not show at first between the two outer bracts, and the floral bud is consequently as broad as long and closely sessile on the thallus. The open flower itself (Pl. XX., fig. 15) is very similar to that of the preceding species.

Rejuvenescence.—I found this process going on at Cherrapunji in many plants which still remained submerged; the process was exactly like that in D. stylosa, var. fucoides, to be described below.

Dicræa stylosa, Wight.

(Plates XXII.—XXIV.)

As explained in the preceding paper, I include under this name several Ceylon and South Indian forms, which will probably ultimately prove to be specifically distinct, but to which, pending detailed knowledge of all forms from many localities, I have only given varietal rank. We shall deal with the forms in order. Warming has described the Ceylon form D. stylosa fucoides from Hakinda dry season material sent by Trimen, and there is comparatively little to add to his description, except for the earlier stages of the life-history.

D. stylosa laciniata, Willis.

Habitat.—This form is common in the Kandy District, Ceylon; it is often confused with D. elongata, to which it has considerable resemblance, and with which it is often mixed. It also occurs with D. stylosa fucoides, and less often with Podostemon subulatus or Hydrobryum olivaceum, very rarely with Lawia zeylanica. It grows in rapid water which when shallow is liable to be broken, and lives at a rather greater average depth than some of the other forms.

Dry Season Appearance.—In general this is almost exactly like that of D. dichotoma, flat, narrow, prostrate thalli, with erect fruit stalks.

Life History and Mature Structure.—In consequence of the infrequent flowering of this species, and the somewhat awkward places which it mostly affects at Hakinda, I have not been able to obtain seedlings; probably the early stages are like those of D. elongata, which the plant resembles very closely in habit. When fully grown it is about the same size as D. elongata, with prostrate creeping thalli upon the rocks, giving off long drifting thalli, often as much as 50 cm. long, and sparingly branched. The chief distinction in habit from D. elongata is that the thalli are flattened, like very narrow ribbons, just like those of D. dichotoma; they are, however, much longer than those of the latter species.

The thallus has a growing point like that of D. elongata, but flattened and broader (Pl. XXII., fig. 1), with the secondary shoots developing on the upper sides of the margins in the usual way. The upper side, near to the tip, is very convex, the lower approximately flat with a slight convexity over the central part, in which the vascular strand is situated. The internal structure is much like that of the species already described. Subsequently the thallus grows in thickness, much as in var. fucoides, described below, by meristematic activity in the central part above, and still more below, the vascular bundle, while the marginal portions do not grow to correspond. In this way the centre becomes a stout rib, very prominent on the lower side. The vascular bundle is like that of D. elongata, but sometimes it is divided into two by a band of collenchymatous cells at right angles to the substratum. The thallus grows rapidly in length, and occasionally branches exogenously, the branches lying parallel to the thallus from which they sprang.

The secondary shoots are like those of the other Dicræas, and ultimately the lower end of the thallus, rarely more than about one-third of it, becomes floriferous, just as in D. elongata. The floral shoots form in the way described above for D. dichotoma, but the bracts are broader in proportion to their length, just as in D. Wallichii, and when the tips have fallen away, are almost helmet-shaped. The flower emerges as soon as the tip of the spathe is exposed to the air, and is wind-fertilized, probably, as usual, mainly by its own pollen. The non-flowering part of the thallus does not become woody, and falls away on exposure, just as in D. elongata.

Rejuvenescence takes place just as in D. elongata, and is very common.

D. stylosa fucoides, Willis.

Habitat.—In general this is the same as that affected by the preceding form, with which it is commonly found associated; it is less often found mixed with D. elongata, Lawia zeylanica, or Hydrobryum olivaceum. Both this form and the last may be seen in perfection, forming a very striking sight, at the confluence of the Guru-oya with the Hulu-ganga, near Teldeniya, a little below the ford over the former; the water is clear, not muddy like that of the Mahaweli-ganga, and the plants can be seen to some depth.

Dry Season Appearance.—When in fruit the thalli are almost exactly like those of the preceding, but a trifle broader.

Germination and Life History.—The seedlings are very hard to find, and I have only been able to get two of them, both at the stage shown in Pl. XXII., fig. 2. The primary axis is like that of D. elongata, short and stout, with a hapterous base and endogenous thallus arising nearly opposite the hapteron. The growing apex is broken off in both my specimens, but is probably like that of the mature plant. The thallus broadens out at once much more than in D. elongata, rapidly becoming nearly circular in outline, and is slightly upcurved at the edges. On the lower side haptera and rhizoids are formed in the usual way. The next stage is seen in August and September, when plants are found like that shown in Pl. XXII., fig. 3, a few inches across, starting at the base from a stout hapterous foot like that of D. Wallichii, and shown in section in fig. 4. From this the thallus grows outwards and usually slightly upwards, and is perhaps most often only attached at the foot, but very commonly also at one or more outer points, usually by haptera, but sometimes it is found touching the rock and fastened by root-hairs. Sometimes the thallus is entirely prostrate and creeping, attached to the rock at all points, and then looks just like that of Griffithella, shown in Pl. XXV., fig. 1. I have not been able to determine satisfactorily what causes one form or habit to be assumed rather than another, but it seems fairly clear that the fully creeping form is rare, except when there is ample space available. When the plants are crowded they tend to grow more upwards, attached only by the feet. When they grow near the edge of a rock the plants tend to give off streaming thalli like those of D. stylosa laciniata, but broader. When fully grown the plant may reach 20 cm. or more, with the thalli frequently branched or lobed; the lobes are exogenously formed and are often as much as 7–10 mm. wide. At the same time they are also commonly more or less undulate in form, with margins curved up and down, and the whole plant, with its red or olive colour, has an extraordinary resemblance to a Fucus or similar alga, especially when a large mass of the form attached only by the foot is found growing together.

The growing point is rounded and rather upcurved at the tip, on which is a root-cap almost completely on the upper side, as already described by Warming for this species (*cf.* Pl. XXII., fig. 6). As seen in section (fig. 5) this develops from the meristem at the apex in the usual way, and the same meristem gives rise to the general tissues of the thallus. Details need not be given here. At the sides of the growing apex, which very rapidly widens to its full size, the endogenous secondary shoots may be seen developing, with a branch of the central vascular strand going to each. The apex is continually branching, so that the thallus assumes the general form shown in Pl. XXII., fig. 3.

In cross section the thallus when in young vegetative condition shows a slightly thickened rib in the middle, and long thin lateral wings turned down at the extreme margin (Pl. XXII., fig. 7). The vascular strand is rather below the centre, as usual. It is shown on a larger scale in fig. 8, and has two well-marked groups of tissue, as described by Warming, more or less separated by prosenchymatous tissue between. Its subsequent growth, and the meristematic activity that goes on, are closely similar to what occurs in D. elongata, and have been described in part by Warming, whose accounts of the peculiar bundles of the very dorsiventral types of Podostemaceæ appear to have been somewhat overlooked by anatomists.

Growth in thickness also goes on in the thallus itself outside the bundle. Instead of being, as in D. elongata, almost equal throughout the thallus tissues, it is practically confined to the tissue above and below the bundles, and in these there are more tangential than vertical divisions, especially on the upper side. Pl. XXII., fig. 9, shows a transverse section at an early stage, a little to the right of the bundle. The upper cells are mainly dividing tangentially, while the lower are also dividing vertically, the result being an upcurving of the thallus. It is in this way that the shape of the foot arises and similar causes produce the curvatures and irregularities which are so marked in these Fucus-like thalli. The lateral wings of the thallus do not take part in this growth in thickness, and thus a stout central rib is gradually formed, just as in Fucus itself. In transverse section near the base of an old thallus the result of this continual tangential division is often very striking, as shown in Warming's figure (42, II., Pl. XI., fig. 22), where there are long, vertical, parallel rows of cells not unlike a very deep palisade layer of a leaf. Whether this development has any functional object like that of the palisade layer must be left for future determination ; it seems a little improbable in view of the fact that the younger parts of the thallus, which probably do most of the assimilatory work, are without it. As the development proceeds, the thin marginal parts of the thallus commonly shrivel up, and often fall away altogether, leaving only the stout rib, so that a piece of the base of the thallus of this form is indistinguishable from that of var. laciniata, though the early stages of the two are so utterly different.

The secondary shoots in the vegetative condition are just like those of the other Dicræas (Pl. XXII., fig. 3). Ultimately the lower ones, usually for about a quarter of the length of the thallus, but sometimes more, become floriferous in the usual way by growing out from the thallus, enlarging the sheaths of a few leaves and losing their tips, thus giving rise to broadly helmet-shaped bracts. The spathe is enclosed in the upper bracts till a later period than in D. elongata, and frequently the bracts do not even separate till the air touches them. Although the vegetative shoots are erect, the flowering ones usually lie more or less prostrate until the curving upwards of the spathe is accompanied by more or less curvature of the bracts. The spathe is broadly funnel-shaped (Pl. XXIV., fig. 1). The flower is of the usual Dicræa type, on a short stalk, with short stigmas and stamens. It is wind-fertilized and usually autogamous, and practically all flowers appear to set seed. This form at Hakinda, however, lives so deeply submerged that it does not always set very many flowers. The fruit stands on a pedicel about 6 mm. long which becomes thin and elastic in the usual way by dropping its cortical tissues.

Rejuvenescence.—This species exhibits very extensive production of new growing points in case of any injury to the thallus, such as the breaking off of a portion of it, or injury to the tip caused by exposure to air. New growing points form in the usual way, endogenously, behind the old one, or perhaps anywhere in the tissue, and soon grow out into new thalli. The older basal parts of the thalli can survive a long exposure, and may be found rejuvenescing at any time of temporary rise of the water in the dry season.

D. stylosa Bourdillonii, Willis.

This form, which is the original type of the species, is common in herbaria. My spirit material was collected at Mundakayam in Travancore by Mr. Bourdillon.

The dry season appearance is very similar to that of the last form, but the plant is larger in all respects, and much longer, while the non-floriferous parts of the thalli not uncommonly seem to persist, though they lose their leaves. The thallus is large, often to as much as 30 cm. long, broadly ribbon-like, and much branched, the width of the branches decreasing towards the outer ends. It is attached by a foot, and very often by one or more outer points. The lower part becomes floriferous as usual, with closely crowded shoots, just as in fucoides. The vascular bundles show large and brown where they lead to flowers, just as in D. Wallichii, and the marginal parts of the thalli break away more decidedly than in fucoides; they often show thin and membranous in herbarium specimens.

The flowers (Pl. XXIV., fig. 2) are as in the preceding form, but larger, with longer stamens and with stigmas often as long as the ovary, but varying considerably in length. The stigmatic character is that on which Wight based the species, but is too inconstant to be taken by itself. The fruit is borne on a long stalk with the usual deciduous cortex.

D. stylosa algæformis, Willis.

This is Beddome's D. algæformis (not Trimen's), from the Anamalais, figured by him (3), but in some points incorrectly, as explained in my first paper. I obtained material in the Anamalais, where it grew in a rapid stream, sharing its habitat only with Hydrobryum lichenoides. It agrees in all essential points with the form last described, but has shorter stigmas on the whole, and the stamens do not greatly exceed the ovary as in that form. In some of Mr. Barber's material, parts of the thallus are very broad (to 2 cm.), and there are a considerable number of secondary shoots on the upper surface as well as at the margins. This simply implies, of course, a greater proportionate growth of the marginal parts, as compared with the central part and vascular bundles.

D. stylosa kanarensis, Willis.

The material which I have examined was collected by Mr. Barber in rapids in S. Kanara, where its habitat was shared with Griffithella Hookeriana and Lawia zeylanica.

The habit of the plant is practically the same as that of the form fucoides, and the plants are of about the same size. Two chief points of difference must be noted. As in D. Wallichii, the floriferous secondary shoots are not all together, but are divided from one another by non-floriferous (Pl. XXIV., fig. 3). The vascular bundles leading to the floriferous shoots become surrounded by the usual dark brown woody layer, while the others remain thin and indistinct. Presumably the thin parts of the thalli ultimately shrivel and perhaps drop off, but I have no material collected at a late enough stage to be sure of this. The bracts are also peculiar ; when young they are long and rather incurved, and they develop the cowl-like sheathing bases in the usual way, The tips, however, do not break off or shrivel close to the sheath, as in other Dicræas, but some distance above, so that a more or less persistent acuminate tip is left, even after drying. The fruit commonly stands on a very long pedicel, but sometimes on a much shorter one.

Dicræa minor, Wedd.

(Plate XXIV.)

As mentioned in the preceding paper, the autonomy of the species is very doubtful, and further investigation on the spot where it grows is required. Griffith's dry material looks distinct, on account of the very short fruit stalk (Pl. XXIV., fig. 6), but the spirit material collected at Nongkhlaw by Sir J. D. Hooker, and named by Weddell, looks to me very like D. Wallichii, though of course, having been collected in a different locality from the typical D. Wallichii, it will probably prove different in detail. A specimen is figured in Pl. XXIV., fig. 4, and a flower bud (secondary shoot) in fig. 5. In view of this uncertainty there is no need to describe it further.

Comparing Dicræa with Tristicha and Podostemon, it is evident that at least one line of evolution which was pointed at by a comparison of those genera between themselves has here been carried out much further, viz., the dwarfing and reduction of the size of the individual secondary shoots. In Dicræa they are very small, with no appreciable axis until they flower, and the number of flowers on each is still further reduced than even in Podostemon, each shoot bearing one only. The number of shoots, on the other hand, is so greatly increased that, though only part of them flower, the number of flowers is probably about as large as in Tristicha or Podostemon. The advantages gained by the reduction of the size of the shoots are evident ; the plant is able to live in shallower water, and it suffers less from exposure resulting in the death of the exposed shoots ; instead of losing a large and complex shoot as happens in Tristicha and to a less extent in Podostemon, it loses only a few leaves, and the small portion of thallus on which they stand or which may be exposed ; at the same time this thallus retains its vitality for a considerable period, and may revive and form new growing points if again submerged. On the other hand, the reduction of the shoots to little tufts of leaves is attended with a corresponding loss of assimilatory capacity, but this is made up by the remarkable development of the thallus into a leaf-like structure, so that the mature plant is not unlike the large leafy Podostemaceæ of South America, though in the latter the leaves are of the ordinary kind. The thallus of Dicræa is still pretty evidently homologous with the root-thalli of the preceding genera, but regarded simply as a "root," it is one of the most remarkable structures that can be imagined under that category—endogenously developed from the main primary axis, it is true, and with a semblance of a root-cap, but exogenously branched, usually not attached to the rock, except at the base and perhaps elsewhere, but drifting freely in the water, and performing the chief functions of assimilation, besides bearing the floriferous shoots.

Probably the drifting form of thallus should be regarded as derived from the creeping, and there is evidently as yet no very marked separation of the two types, except in D. elongata ; in the more algal types of Dicræa there is a good deal of polymorphism, and the thallus may assume almost any form, whether creeping or drifting. D. stylosa fucoides in particular is of interest in this way, and shows the first signs of the remarkable polymorphism which we shall see carried to extreme in Griffithella.

The dorsiventrality of Dicræa is extreme, and shows itself in many features, such as the growth in thickness of the thallus, the structure of the vascular tissue, &c. It is noticeable, however, that it is not appreciably exhibited in the secondary shoots in their vegetative stage, though it is shown in the corresponding stages of Tristicha and Podostemon. Here we have perhaps a case in which the evolution has been through dorsiventrality back to radial symmetry. As soon as the secondary shoots become floriferous, they become dorsiventral once more, though not so markedly so as those of Hydrobryum, &c. The flower itself, with its symmetrical ovary, is less dorsiventral than that of Podostemon, and comes nearer to the floral types of the less highly modified groups of Podostemaceæ.

GRIFFITHELLA.

[Warming; Willis, Rev. Podost. Ind., Ann. Perad., I., p. 231.]

Under this genus I include the curious species first found by Law, described as a Mniopsis by Tulasne on account of its smooth fruit, and placed in Podostemon by Weddell, Bentham, and others. On the whole, perhaps, as explained in the preceding paper, it comes nearest to Mniopsis, but on account of its peculiar thallus morphology, its reduced secondary shoots, and the different stigmas, I am inclined, though with some diffidence, to regard it for the present as generically distinct. Warming (42, VI., p. 13) has described a second species, G. Willisiana, from herbarium material, but I am hardly inclined to regard this as a separate species until further material has been examined from Kanara, and I have therefore included it as a variety in G. Hookeriana. The genus also seems, as Warming points out, to have relationships to the Javanese Cladopus.

In general we may say that the genus, as at present known, has the morphology of Dicræa in the vegetative parts, and of Mniopsis in the floral.

Griffithella Hookeriana, Warming.

(Plates XXIV.-XXVI.)

For material of this extremely interesting plant I am indebted to my friend Mr. Barber, who collected the remarkable series of forms figured in Plates XXV. and XXVI. (left), and to Mr. R. K. Bhide, who collected some (Plate XXVI., right) at Atgaon, west of Poona. I sought for it in vain on my own visit to the Bombay Ghats.

Habitat.—The plant appears to grow in moderately rapid water, such as is affected by the Dicræas. I have found it mixed in my material with Lawia zeylanica, Podostemon Barberi, Dicræa stylosa kanarensis, and Tristicha ramosissima.

Dry Season Appearance.—The general appearance of the plants at the end of the year is shown in the three smaller rocks in Plate XXV., where also may be seen the first indication of the very remarkable polymorphism, which is characteristic of this species. On the large lower stone is a large plant just exposed and flowering. This has a closely attached creeping branched thallus, with marginal flowers. A similar and larger plant, still in the vegetative condition, is shown on the large rock figured on the left. On the smaller stones above are thalli in fruit, evidently, though shrivelled, of the most various shapes, and much smaller than the creeping one below. Examination with a lens shows that some of them are flat upon the rock and branched, others cup-like, some like discs or cups on stalks, &c. The fruit is smooth, almost spherical, with one smaller valve splitting off obliquely from a larger persistent one. The seeds are shed upon the rocks in the usual way, and the early stages of the life are no doubt similar to those in the rest of the group. It is very much to be desired that this plant should be followed throughout its life-history. The material at my disposal was all collected at the end of the life, and contains no stages that show the primary axis or the development of the peculiar forms assumed by the thalli.

Mature Structure.—The chief interest in this species centres in the thallus and its extraordinary polymorphism. In general it has the morphology of that of Dicræa. The growing point in all my specimens was more or less shrivelled, and I was not able to definitely make out its construction, but on the whole it seems to be like that of Dicræa stylosa, var. fucoides, broadly obtuse in shape ; whether there is a properly developed root-cap or not I was not able to decide.

The thallus in the creeping form, with which we shall first deal, is like that of Dicræa stylosa in transverse section, and grows in the same way by tangential divisions of its cortical cells. It may be as much as 1 cm. wide, and creeps along the rock, closely attached to it by root-hairs and occasional hapterous outgrowths, branching exogenously, till at last a large plant like that figured in the left hand of Pl. XXV. may arise. At intervals of a few millimetres along the upper side of the margins the secondary shoots arise as seen in the figures, and endogenously as usual; their first appearance is extremely close to the growing apex. These shoots are very like those of a Dicræa, but are often rather more prostrate, with distichous sheathing leaves to about 5 mm. long. As the figure indicates, these leaves probably only perform a small portion of the work of assimilation, being small, as in Dicræa, in proportion to the area of the thallus. Vascular bundles lead from the main bundle of the thallus to the leafy shoots, in the ordinary way, and the thallus grows in thickness like that of Dicræa by tangential division of the cortex.

We may now go on to deal with the extraordinary series of forms shown in Pls. XXV. and XXVI. All in XXV. and the left-hand half of XXVI. are the var. Willisiana collected by Mr. Barber, while the rest are some forms collected near Atgaon. These are not the only Atgaon forms, but are those not well represented in the Kanara material. The cup and disc forms are frequent at Atgaon, but not the simple creeping form.

Not infrequently, as in some of the plants on XXV., 2, and in XXVI., 5, 6, the creeping form, instead of growing to a large size, remains short,* and more or less discoid or lobed. When the growth of the actual apices is not much faster than that of the tissue between, the form approximates to a

* I am inclined to think that the large creeping form may perhaps be varietally distinct from the small one, though they agree very closely indeed in all other points than size; the question can only be settled by detailed study on the spot where they grow.

disc, but when the apical growth is rapid, it is lobed or branched. When the disc form grows old, it is usually stout, and with the margins slightly turned up. The upward curve seems to be brought about as in Dicræa stylosa fucoides by greater meristematic activity and growth near to the edges.

Accentuation of the growth of the sides of the base of the thallus results in a form like a bowl or cup, lobed or not, according to the relative rate of growth of the apices. When once the corner is turned, so to speak, the thallus continues to grow away from the rock in an ascending direction, and so the cup may reach a considerable size, as in several of the examples figured in Pl. XXVI.

The simplicity of the cup form may be complicated by further irregularity of growth in length and thickness at different parts, resulting in the very involved forms seen on the right in Pl. XXVI. In all but the last two of these the foot or disc from which the plant starts may be seen.

If the development of the thalli be very uniform, and the growing points do not outrun the tissue between, the cup or bowl may be very symmetrical, as in XXVI., 1 and 4. Sometimes one side grows faster than the other (this is the case especially when the plant is on a sloping rock, the lower side growing the faster), and a scuttle-shaped thallus is formed like that in Pl. XXVI., fig. 3.

Not infrequently the foot grows vertically by division and elongation of its cells, and thus forms a shorter or longer solid stalk (narrower than the actual foot, which usually forms a disc like that of Tristicha ramosissima), carrying up the disc or bowl upon its summit, as in Pl. XXVI., figs. 1, 2, 3, 10. The first-mentioned figure represents a most symmetrical stalked cup, like the basal cup of the alga Himanthalia lorea. It is particularly interesting to see in these plants how many of the forms of the algæ of moving water they reproduce.

The remarkable polymorphism of the thalli in this plant is thus very simply explained anatomically, and forms an extremely interesting illustration of how plastic the form of the plant may be when once it has got over the difficulties presented in most plants above the mosses by the presence of a more or less rigid skeletal tissue and by the absence of merismatic activity in all parts. Here the form is determined before the bundles become stiffened in the flowering season, and the capacity for renewed merismatic activity possessed by nearly all the cells enables a great variety of form to be produced, chiefly by simple irregularities or differences in the rate of growth of the different parts or cells. Almost incredible though it seems at first glance, the various forms in Pl. XXV. and the left-hand part of Pl. XXVI. are all forms of one plant, not even varietally distinct from one another, unless the large creeping form be distinct from the small creeping one. Detailed work on the spot with living plants is required to determine with certainty whether there is any heredity of the form of any individual, but so far as Mr. Barber's observations go, and they confirm what I have mentioned above as occurring in Dicræa stylosa fucoides, the particular form of any individual seems mainly, if not entirely, in a direct correlation with the environment. Plants on the top of the rock, when crowded, tend apparently to the nearly symmetrical cup or disc form, and those on the sides of the rock to the form in which the lower side is produced to a greater length than the upper, while when there is plenty of room the creeping form seems more common. This last form, however, seems quite absent in the Atgaon material.

The secondary shoots are very closely similar to those of Dicræa, and some or all of them ultimately become floriferous, while the tissues leading to them become woody in the usual way. The bracts form just as in Dicræa, with broad sheathing bases and deciduous tips (Pl. XXIV., fig. 8). The solitary terminal flower emerges from a spathe as usual, and stands erect; it is anemophilous, as in all the other Indian forms. The general floral structure is like that of Podostemon, with a dorsiventral ovary which ripens to anisolobous fruit with one deciduous valve. The stigmas in the Atgaon form are generally subulate, but in the var. Willisiana are very often ovate or almost cordate, notched or even fimbriate or divided into two, like the stigmas of the Hydrobryums to be considered below. The ovary wall shows no vascular bundles, and the fruit consequently no ribs (Pl. XXIV., fig. 9), but, as fig. 10 shows, it has a stout cutinized inner epidermis like that in the preceding genera, then a layer of thick-walled cells (f), and outside that one or two layers of sclerenchyma, followed by the outer thin-walled epidermis and sometimes a thin-walled hypoderm. The thin-walled cells fall away from the ripening fruit, which has a smooth wall.

I have seen no evidence of rejuvenescence, but it probably occurs as in Dicræa.

Comparing this genus with the preceding ones, it is evident that it is very similar to Dicræa, so far as morphological adaptation to its mode of life is concerned ; it has the same algoid form of thallus and reduced secondary shoots. Its chief interest is in the great polymorphism, probably the most extreme known among the higher plants, and in the fact that this carries out to its highest development what we saw begun in Dicræa. Strange though the forms of the various thalli are, regarded only as structures in flowering plants, they are parallel to the similar forms that may be found among the algæ of moving water, just as is the case with nearly all the other forms assumed by the Podostemaceæ.

WILLISIA.

[Warming ; Willis, Rev. Pod. Ind., Ann. Perad., I., p. 233.]

This very peculiar genus, so far as at present known, is confined to the Anamalais and Burma ; I have collected material in the former locality, and Mr. Barber has since obtained some for me from the same place at an earlier time of year. Willisia selaginoides, the species there found, was first described and figured by Beddome (3), and has hitherto remained almost unknown. It is a very remarkable form, with no very evident near relationships among the other Indian forms.

Willisia selaginoides, Wmg.

(Plates XXVIII.-XXX.)

Habitat.—I have only seen this plant at one place, in the Sholai-aar near Monica estate in the Anamalais, at a height of 3,500 feet above sea-level. It was growing in a steep rocky gully, somewhat out of the main rush of the water, but with a rapid current flowing in it. It was there accompanied, as Pl. XXVIII. shows, by Hydrobryum lichenoides Fentonii.

Dry Season Appearance.—This is sufficiently well shown by Pls. XXVIII., XXIX., and is very different from that of all the other forms with which we have to deal. The rocks are covered with little tufts of stems 2–7 cm. high, each tuft often being composed of one plant only; they stand stiffly erect, have four rows of scaly leaves each, and are terminated each by a solitary fruit, typically half concealed among the uppermost leaves, but often on a long stalk due to the falling away of the tissues. Many stalks in the older or longest exposed shoots have often lost the whole or nearly the whole of their cortical tissues and their leaves in this way. At the base of the shoots one can see indications of a small thallus, on which they are closely crowded. The fruit is smooth, with unequal valves, one remaining upon the pedicel after the fall of the other. Usually at this period some plants may also be found alive in the water, and it is on material thus obtained that the description here given is based. The shoots stand stiffly erect, and consequently the flowers are exposed to the air, open, and ripen their fruits long before the plant is actually killed by the exposure of its thallus (of course, in all probability the thallus, as in the most of the Ceylon forms, probably lives for a considerable period after being exposed, and probably may rejuvenesce). The plant grows in a very rapid current at the place where I studied it, and the erect shoots were in a state of constant and rapid quivering movement to and fro.

Mature Structure.—The germination and the early stages of the life-history of this plant should be of especial interest. The earliest stages that are as yet known are those in the material collected in November last by Mr. Barber, and these are almost as mature as those collected by myself in January, but show very well what I take to be the primary axis. One of these specimens is figured in Pl. XXX., fig. 2, and shows at the base the clump of little floriferous shoots just described, with two long shoots, one of which is broken off, of an entirely different type. These long shoots may be as much as 50 cm. long, and are provided with long loriform leaves reaching a length of as much as 15 cm. I feel almost certain that each of these long shoots is the primary axis of a single plant, but as I have found two on some of the specimens, chiefly in dry material, and have not been able to satisfy myself that there were also two thalli I must leave the question for future decision. The anatomy is quite different from that of the floriferous shoots, and very similar to that of the primary axis of Hydrobryum olivaceum.

This apparently primary axis, whose upper parts I only know from the herbarium material, is non-floriferous as a rule, though I have seen it with lateral tetrastichous floriferous branches. By the beginning of January, to judge from the material collected by myself, it has usually died down, and is only represented by a more or less decayed stump at the base. This stump is often 5–8 mm. thick, and therefore much stouter than the floriferous shoots. The primary axis bears leaves in a complex phyllotaxy, which I have not been able to make out. It is evidently very flexible, and drifts out with the current like the shoots of Tristicha ramosissima In transverse section it shows a central vascular strand.

slightly asymmetrically placed as in Hydrobryum olivaceum, and the anatomy of the tissues is also very similar to that seen in the latter plant. There is a broad parenchymatous cortex, without any sheath of collenchyma round the bundle. The vascular strand itself is made up of groups of phloem-like tissue, divided by strands of long parenchymatous cells ; the groups are like those in the thallus of Dicræa, and probably arise in the same way.

At the base of this axis is the thallus, which is comparatively very small ; it is crustaceous, like that presently to be described in Hydrobryum, closely creeping, and attached to the rock at all points. It is very difficult to make out its mode of growth in the mature specimens, but it appears to resemble that of Hydrobryum, and the thallus is lobed like that of H. olivaceum. It bears (Pl. XXX., fig. 1) numerous closely crowded secondary endogenous shoots, which have already been mentioned as forming the most striking character of this plant. These may be seen in all stages, from very young ones just emerging from the thallus up to fully formed flowering or fruiting stalks.

I have been unable to make out in what order or arrangement the secondary shoots are developed upon the thallus. The lobes of the thallus are very irregular, and very commonly there is a single line of secondary shoots along each, but I am inclined to think that the original origin of the shoots is rather more marginal than central.

Beddome, who first described this plant, figures it as having two kinds of secondary shoots, the one such as we have described, and the other purely vegetative, with tetrastichous leaves without sheathing scales. Further investigation is very much required at early periods in the life-history to determine the exact phenomena, and whether all the secondary shoots are at first like the latter type. Towards the end of the season most of the still submerged secondary shoots bear scales on their whole length, but near the top, as Beddome has also figured, these scales bear long deciduous loriform green assimilating tips which drift out in the water. One is therefore tempted to suppose that the scales arise late in the season, as in Dicræa, by the enlargement of the bases of ordinary leaves and the fall of their long tips, and as some shoots are usually to be found (*cf.* Beddome's figure) with scales below and simple leaves above, this is not altogether improbable. The question must be left for future settlement on the spot.

It is, however, certain that when a young secondary shoot appears near the end of the season, as in Pl. XXX., fig. 1, it has scaly leaves from the first, and usually without any deciduous tips. This phenomenon is not infrequent also in Dicræa and Hydrobryum.

The anatomical features of the secondary axis are very different from those of the primary. It stands stiffly erect, at least in the flowering season, and this rigidity is given by a stout belt of lignified tissue surrounding the central strand. The structure of the latter, too, is quite different from that of the strand in the primary axis, but this point must be left for future description.

The scaly leaves fit together very closely, and the exposed parts are hard and almost brittle with silica. The long tips always drop off on exposure to the air.

At the top of the secondary axis is the spathe (Pl. XXX., fig. 3), usually of urceolate form, with two stiff teeth. It is half buried among the uppermost leaves, and the spathe is at right angles to the top pair of these. From this fact, together with its two teeth, one is tempted to regard it as a pair of leaves combined, but there is as yet no evidence of this being the true explanation beyond that just given. The exposed upper end is hard and stiff with silica, while the included part is very thin and delicate. In my taxonomic paper I have described the tip of the spathe as circumscissile, but this is hardly quite the correct expression, as there is no definite splitting layer of the spathe, but it splits round so as to separate the siliceous upper part from the non-siliceous lower. The upper part falls away as a cap and exposes the flower.

The flower opens as soon as exposed to the air, and thus, owing to the erectness of the secondary shoots, has generally ripened its fruit by the time the whole plant is exposed upon the dry rock. It is figured in Pl. XXX., fig. 4, and has the usual structure of the flowers of this group of Podostemaceæ, with stamens slightly exceeding the stigmas. It is anemophilous, and apparently largely self-fertilized. It is quite sessile among the upper leaves of the shoot. It ripens quickly into a comparatively large smooth fruit, which has a broad dehiscence rib only very faintly prominent on either side, and a stouter rib in the centre of each valve (fig. 5). One valve remains persistent on the stalk after dehiscence, while the smaller and the seeds fall away. The persistent valve often curves inwards as in fig. 6 in dry air. The wall of the fruit (fig. 7) shows a very similar structure to that of Griffithella, with stout sclerenchyma layers. The ripe fruit has a smooth exterior, from which the parenchymatous outer layers of the ovary wall have fallen away. It very commonly stands on a long or short pedicel, owing to the falling away of the upper leaves and the cortex of the stem. The upper part of the pedicel is usually bifid, consisting of the two vascular strands that formerly went to the ovary, with their woody sheaths.

Rejuvenescence.—I have not observed any evidence of the occurrence of this phenomenon, but in all probability it occurs as usual.

Comparing Willisia with preceding genera, it is evident that in some respects it is more on the level of Podostemon, in that it has large and complex secondary shoots. On the other hand, these bear each only one flower. The flowering takes place while the water is still comparatively deep, though the seeds are ultimately shed upon the rocks. In one species of Podostemon we had an indication of a crustaceous type of thallus, which, however, was more of the Dicræa type; in Willisia we get a crustaceous closely attached thallus, small it is true, but leading on to the type we shall now have to consider in Hydrobryum. The dorsiventrality of this genus is not very marked, other than in the thallus; the flowers, however, are very dorsiventral in structure, though the secondary axes stand erect; as yet, however, we only know the plant at its flowering season. It seems a plant ill-adapted to water that is, or is liable to be, shallow.

HYDROBRYUM.

[(Endl.) Tul.; Willis, Rev. Pod. Ind., Ann. Perad., I., p. 235.]

As explained in the preceding paper, I have defined this genus, which has undergone many changes, practically in the same sense as that of Tulasne. Its most interesting species is perhaps H. olivaceum, which has caused much confusion by its peculiar habit and mode of growth. It has been described by Warming (42, IV.) under its own name from Ceylon material, and in the same paper under the name Dicræa apicata from Nilgiri material; neither description is exhaustive, and there is much to add. I have been able to study most of the species in the living condition, with the exception of H. Johnsonii, of whose autonomy I feel doubtful, and H. sessile, a new species discovered by Mr. Barber, but of which he kindly sent me abundant spirit material. The genus is apparently confined to Asia, where it is common in suitable places.

Hydrobryum lichenoides, Kurz.

(Plates XXVIII., XXXI., XXXII.)

This species occurs in numerous forms, nearly all of which I have studied on living material, in Ceylon and India. The plant shows a most remarkable amount of variation in many of its characters, and these variations seem to be different at almost every locality, so that it probably may be divided into a great number of varieties, even if it be not necessary to split it ultimately into several species. For the purposes of the present paper, however, this variation does not matter much, being chiefly in features that need only be briefly touched upon.

Habitat.—The plant affects smooth rocks in rapid currents, but on the whole is not found in quite such violent water as H. olivaceum. It occurs very commonly in quite small streams, where the risk of shallow water is great, just as do the other Hydrobryums and Lawia zeylanica, and perhaps correlated with this is the fact that it occurs at much higher elevations than most of the Indian Podostemaceæ. In Ceylon it is rare, occurring only, so far as yet known, in one river, at a height of 3,500-4,000 feet. In this river there is not, so far as yet known, any other species of the family. In the Sholai-aar, in the Anamalai mountains, it is commoner, and is mixed with H. olivaceum, and also, as Pl. XXVIII. shows, with Willisia selaginoides. Mr. Barber found it in Kanara, and I myself found it in enormous quantities everywhere in the Khandala district, where it is most conspicuous, and accompanies Lawia zeylanica in almost every stream. It is difficult to understand how it has been overlooked in this district, but in the Museum at Kew I found some specimens from the Bombay Ghats collected by Law, and labelled as Lawia pulchella. It is also frequent in the Cherrapunji district at 4,500 feet, and often mixed with Dicræa Wallichii, and I found it at Shillong and in the foothills between Shillong and Gauhati.

Dry Season Appearance.—This is well shown in exposed plants in Pl. XXXI., and in plants from just below the water-level in Pl. XXVIII. Most of the plants in the first-mentioned plate are from the Khandala district, where this plant is to be seen in its greatest luxuriance and development. The rock is covered with creeping thalli, as closely and firmly attached as those of Lawia, a few millimetres broad, and tapering towards the tip, brown, gray, blackish, or nearly white, acccording to the form and the locality. They are very regularly branched, alternately or sub-oppositely, with little prostrate shoots in the forks of the thalli, from each of which arises one fruit, standing upon an erect axis emerging from the boat-shaped spathe, which is split along the upper side and usually lies nearly prostrate upon the rock. The fruit is ribbed, and is usually open, with the larger valve persistent upon the stalk, while the smaller has fallen off with the seeds. In specimens taken below the water, as in Pl. XXVIII., or in the upper right-hand figure of Pl. XXXI., the secondary shoots can be seen as little buds, prostrate on the thallus; those close to the tip are still often in the leafy vegetative condition.

Germination and Life History.—I have only been able to get two or three seedlings of this plant, at Hatton in Ceylon, and all were at the age of the one figured in Pl. XXXII., fig. 1. Evidently the germination takes place much as in Dicræa stylosa fucoides, giving rise to a short stout hypocotyledonary axis with a few leaves at the top on a condensed epicotyledonary stem, the leaves arranged according to some phyllotaxy which I have not been able to discover, but not at any rate distichous. At the base of the seedling the thallus emerges, and soon widens out at the tip and begins to branch. The branching is more fully shown in fig. 2; at first it is usually alternate, but later it is not infrequently sub-opposite, as the photographs show. The growing apex is like that of Dicræa, or like that of H. olivaceum described below (excepting that it is an apex, and not a margin, as in the latter), with a collenchymatous cap. The branching is close to the apex, exogenous, and lateral as in Podostemon subulatus, with a secondary shoot formed between the two lobes in each case, at a very early period. Vascular bundles are also developed leading to the branches of the thallus and to the secondary shoots. The thallus grows rapidly in size, and may reach a length of several inches during even the comparatively short vegetative period available in the Bombay Ghats. The lateral branches themselves branch again, the first branchlet being on the basiscopic side as usual. The secondary shoots are like those of Dicræa, mere tufts of small leaves emerging from little openings in the thallus.

Later on, as the flowering season approaches, the development of the flowers takes place, most of the secondary shoots producing each a single terminal flower. The axis elongates and becomes prostrate on the thallus (or nearly erect in some varieties), pointing in all cases towards the tip. The bracts, 2–8 in number, which form on each shoot, are developed just like those of Dicræa, by the enlargement of the sheathing bases of the leaves and the fall of the tips. The upper exposed side of the sheath is thick and siliceous, the lower thin and membranous. At the end of the shoot is the flower enclosed in the usually prostrate spathe (Pl. XXXII., fig. 3). When exposed to the air by the fall of the water (and thus, owing to the very dwarf habit, almost only at a time when the water is about to leave the plant altogether), the spathe splits in a more or less irregular way on the upper side, and the flower emerges on a short stalk and stands erect. Like all the other flowers we have described, it seems anemophilous and self-fertilized, with the chance of a cross at times owing to the nearness of the flowers to one another on the rock.

The structure of the flower has already been sufficiently described. The chief point of importance to be noted here. as bearing on the taxonomy, is the great variability to be found among the stigmas, of which a few instances are figured in Pl. XXXII., figs. 5, 6 (and *cf.* Pl. XXXVI., fig. 8). The average form perhaps is ovate, but every stage may be found from simple narrow subulate to broadly obcuneate with many teeth. As the latter form of stigma is the character on which Weddell chiefly bases his reduction of the genus Hydrobryum to the solitary species H. Griffithii, and we shall find the same variability in the stigmas of this species also, it is evident that this character is not generic.

The fruit soon ripens, and is anisolobous with one deciduous valve. It has eight ribs, well marked in most cases, but almost evanescent in some of the varieties. In some, too, the ribs are confluent some distance below the tip of the fruit, in others only at the tip.

Rejuvenescence.—This appears to be frequent in this species and to occur in the usual way, by formation of new thallus growing points.

Hydrobryum sessile, Willis.

(Plate XXXII.)

This species was discovered in S. Kanara by Mr. Barber, who kindly sent me a good supply of alcohol material. It is of interest as showing many transition features to characters which are well marked in other forms.

Habitat.—This appears to be very similar to that of the preceding form—smooth rocks in rapid or shallow streams.

Dry Season Appearance.—This is very like that of H. olivaceum, to be next described, but on closer examination it is easily seen that the rock is not covered, as at first sight appears to be the case, with a continuous coating of thallus, but that there are narrow slits dividing the branches of the thallus. The fruits are sessile among the dead bracts, and smooth.

Mature Structure.—In general construction and growth the plant is like H. lichenoides. The thallus, however, is very much broader, and the branches are so close together that it practically covers the entire surface of the rock on which it grows (Pl. XXXII., fig. 7). It thus forms a transition in this feature to the true lichen-like thalli of the succeeding species. The secondary shoots and the development of the floral buds are as usual. The flowers are sessile with long stamens and curved ovary (figs. 8, 9). The fruit is smooth and sessile, thus perhaps forming a transition to the fruit of Farmeria metzgerioides described below. Rejuvenescence probably takes place in the usual way.

Hydrobryum olivaceum (Gardn.), Tul.

(Plates XXXII.-XXXVI.)

As already mentioned, this very remarkable plant has been described under several different names, and I shall endeavour to explain below the origin of this confusion.

Habitat.—The species is very abundant at Hakinda, where most of my investigations have been made, and where it covers large areas of rock to the exclusion of other forms, though it is often found mixed with Lawia zeylanica, less often with Farmeria metzgerioides or Dicræa stylosa fucoides, and only rarely with Podostemon subulatus, Dicræa elongata, or D. stylosa laciniata. It affects on the whole the most violent and rapid water of all the species, and is often found on the edges of waterfalls and similar places of very strong current. In the Nilgiris I found the var. griseum in very similar places, and occasionally mixed with Dicræa dichotoma, while in the Anamalais I found the local variety mixed with Hydrobryum lichenoides, var. Fentonii. The intermingling of this species with the larger plants mentioned usually occurs mainly at places where there is considerable local variation in the condition of the water, as for instance at a place where an eddy rejoins the main rush of the stream.

This species, like the others with low-lying thalli, appears to be able to inhabit much smaller streams and shallower water than the large species, and is (consequently perhaps) found at higher levels. It goes far higher than any other species in Ceylon, except H. lichenoides, and is frequent from 1,500 to 5,000 feet, and in quite small streams.

At Paikara in the Nilgiris it reaches nearly to 6,000 feet, and in the Anamalais I found it at 3,500 feet, and probably enough it may be found at higher elevations. In Ceylon it occurs in very small streams, which easily run almost or quite dry, but the thallus lies so low upon the rocks, and the leaves of the secondary shoots form so good a sponge for catching any water that may be trickling over the plant, that it is able to live so long as there is any water, and it can even stand a considerable period of complete exposure and yet revive and form new growing points if once more submerged.

Dry Season Appearance.—The appearance of the plants when completely exposed and in ripe fruit is very well shown in Pl. XXXIII., but the plants there figured are unusually good examples of single plants, and show the general form and lobing of the thallus in a way that is very uncommon in most places, owing to the way in which the thalli grow over one another, and to the frequent formation of secondary growing points from broken or otherwise injured parts. The rocks are covered with an irregular crustaceous coating of dry easily-powdered thallus, gray to white in colour, and with numerous short-stalked ribbed fruits standing erect upon it, the stalks emerging from little prostrate shoots of scale leaves on the thallus. Each prostrate shoot has a terminal boat-shaped spathe, splitting along the upper margin, just as in the preceding species, and as can be clearly seen in the photograph. The thallus has an irregular lobed margin, towards which the secondary shoots point; they thus often, in very irregular portions, seem to point all ways, and many of the artists of this plant have consequently supposed the direction to be perfectly random, and have produced very misleading pictures. The plant in the lower left-hand corner of the plate shows clearly that the growth of the thallus must have been from a common centre as in Lawia.

If we examine at this period the plants which are still submerged, we shall find that the thallus is green, olive, or reddish in colour, with delicate margins, which are very often more or less decayed or disorganized, especially in the Indian forms. It is, as a rule, very hard to find specimens showing any such regularity as that exhibited by those in the figures, and this may account for the extreme inaccuracy and misunderstanding of most descriptions of this plant. The submerged thallus will be found to bear leaves, but these of course soon fall when exposed, and hence the herbarium specimens are leafless and the plant is described as such, even by those who have collected it alive. The leaves in falling leave the scars of the secondary shoot upon the thallus, as can be clearly seen in the photograph. Most of the secondary shoots, however, have formed floral buds by this time and the leaf tips have fallen.

In the Nilgiri form, and occasionally in the others, the simplicity of the construction is further masked by the curious way in which the thallus frequently crumples, as seen in the right-hand specimen in the plate, where the upper parts of the thallus are crumpled and ridged into a dense irregular mass.

The flowers open at once after exposure, and shed their seeds upon the rocks in the usual way, where they may be retained in crevices of the rock or of the old thallus.

Germination and Life History.—Germination takes place in April and May, when the water-level rises during the little monsoon. The first stage is much the same as in the species already described. The seed swells and bursts its coat, the hypocotyl emerging and bending downwards to touch the substratum, where it promptly becomes fastened by means of the usual rhizoids developed from its superficial cells. The basal portion usually enlarges slightly, and from it are almost immediately developed outgrowths—the thallus and haptera. The early stages of development are extremely interesting, and I much regret that I have not been able to obtain sufficient material to follow out all the details. The seedlings are very minute, and grow in places where it is very hard to find them, and I have to consider myself very fortunate in having got so many as I have actually obtained.

Pl. XXXII., fig. 11, shows the earliest stage that I have seen, the seedling being about $2\frac{1}{2}$ mm. high, with two cotyledons developed, an erect hypocotyledonary axis as long as the cotyledons, and two small outgrowths at the base. In the specimen here shown one of these, the left-hand one, was certainly exogenous, the other, on the right, endogenous. It is often extremely difficult in these seedlings to make out whether a particular organ is exo- or endo-genous. Those cases where the organ is certainly exogenous are easy, for by aid of the microscope the surface cells can be traced from the stem to the lateral organ, cell fitting on to cell with no break of continuity; there are, however, many cases where this cannot satisfactorily be done, and sometimes it cannot be decided what is the true state of affairs. Sometimes, however, the endogeny can be made out by tracing the cells, and at the junction of the two organs a few remains of cell-walls or a break of continuity in size or mutual interweaving of the cells may be seen. The endogeny, when it occurs, is usually only under one or two layers of cells, and as soon as the organ emerges, its surface cells come to the same level as those of the organ from which it springs, obliterating almost completely the proofs of endogeny.

To return to the case in hand. The exogenous outgrowth is a hapteron, the endogenous the first appearance of the thallus. In about half of the few cases I have studied, there was always one endogenous outgrowth, which could be recognized as thallus by the structure of its growing margin. In the remaining cases, the organ which could be definitely stated to be thallus arose without doubt in an exogenous manner. We have therefore in this plant a transition case, the thallus sometimes forming exo-, sometimes endo-genously.

The seedling thus forms a thallus and one or more haptera at the very earliest stage. Some of the figures show other seedlings with more than one hapteron, but none of the few cases that I was able to examine showed a formation of more than one thallus, though I suspect that this does at times occur.

The cotyledons are opposite to one another, with slightly channelled upper sides, and are awl-shaped. They continue to grow in size for a little while, as the various figures show. The upper side is very hairy, with long unicellular hairs. This is an interesting case of adaptation appearing in the actual embryo, for the mature leaves of this, as of many other species of this family, have hairy upper surfaces. Between the cotyledons is visible a very minute plumule. The figures above mentioned show several stages a little more advanced. The seedlings shown are all, it will be noticed, upon old capsules, for it was only in such positions, as a rule, that I was able to find them under the water. All show a thallus more or less developed, and one or more haptera. Where the thallus has developed exogenously from the hypocotyl, it is only to be distinguished from the haptera, so long as it remains small, by the structure of its apex or rather margin, which is on the whole broader, and more evidently meristematic, the cells being smaller and more numerous. The thallus nearly always starts in a downward direction. It seems most frequently to arise at right angles to the plane of the cotyledons, as the figures show.

By means of the haptera and the thallus, both of which follow all irregularities of the substratum and develop rhizoids on the lower side, the seedling is very firmly fastened to its support, and cannot be washed away by any force of the water. The haptera seem usually to remain small, whereas the thallus soon reaches a considerable size, and by the end of the year may be a foot in diameter. The primary axis is usually bent down by the force of the water, and the cotyledons also often twist round to such an extent that the hairy upper surfaces face downwards.

The first two leaves soon appear between the cotyledons, in a plane at right angles to that of the latter, or nearly so (fig. 13). They appear in alternate order, but very nearly at the same time (fig. 12). The next two are approximately at right angles to the first (fig. 13). The primary axis continues to grow in length and thickness while this is taking place. The leaves continue to appear at the apex for some considerable time, and the axis to increase in size to correspond (Pl. XXXIV., fig. 3), till at last, towards the end of September, it may be as much as 5 cm. high and 3 mm. thick with a large number of leaves at its apex, which themselves may be 10 cm. long (Pl. XXXIV., fig. 4). When a number of leaves have been formed, the phyllotaxy seems to be of the $\frac{3}{8}$ or $\frac{5}{13}$ type, but I have not been able to make this out in a satisfactory way from want of material, and I do not think the point of very great importance. Pl. XXXII., figs. 15, 16, shows a young plant with its leaf arrangement. In a short time the original growing point at the apex of the stem becomes replaced by three or more, as in figure 17, which has three, and as time goes on there may be a large number of growing points present. The branches thus formed, however, never elongate, and the stem always remains as a simple axis, crowned by a tuft of leaves.

The first formed leaves are very small, not more as a rule than 5–10 mm. long. As the stem grows the successive new leaves are larger and larger, till the last formed ones may reach 10 cm. in length and 1 mm. in diameter. The leaves are hairy on the upper side, as in other species of this genus, and exactly resemble those borne on the endogenous shoots of the thallus, to be described below. They are perfectly simple, long, and very narrow, flat or slightly hollow on the upper side, convex upon the lower, needle-shaped with very acute apex, and slightly sheathing at the base.

In transverse section the structure agrees with that described by Warming (Dicræa apicata, 42, IV., p. 155, and fig. 24). The leaf has a small vascular bundle in the centre, apparently consisting only of phloem tissue.

It is worthy of note that though the primary axis of the plant in this species thus becomes of considerable importance, more so than in most of the other species that have been studied, it still consists, throughout its life, practically only of the hypocotyl. The appearance of the primary axis when fully grown is shown by Pl. XXXIV., fig. 4, which is a modified reproduction of the original drawing of Podostemon Gardneri, Harvey.

These leafy primary shoots are the most important assimilatory organs of the plant up to the end of August or September, when the thallus begins to be very large (Pl. XXXV. shows an entire plant at this stage). About this time they usually begin to suffer from the water pressure, and from the accumulation of rubbish which usually clings to them, and they often get broken off or flattened down upon the surface of the rock or the thallus, and the leaves tend to break off. When bent down they frequently become obliterated by a piece of thallus growing over them. They may still be commonly seen at the end of October, and traces may be found even in January, so that we may say that they survive through the whole life of the plant.

The internal anatomy of the stem can only be briefly touched upon; it has already been described by Warming (Dicræa apicata, *l. c.*). Towards the middle of the cross section, but a little excentrically, is a vascular bundle. This is not very clearly marked off from the surrounding tissues, and shows a somewhat simple structure, like that of the primary axis of Willisia, consisting when mature of a number of irregularly arranged groups of phloem tissue with thicker walled cells between the groups. Details must be left for subsequent description.

To return to the thallus. It grows outwards in close contact with the rock, to which it becomes attached by the usual rhizoids, or in the Nilgiri form and occasionally in the others by haptera also. Only the extreme marginal portion, for about 2 mm. or perhaps at times 5 mm. from the edge, is actually growing and expanding, so that the attachment can soon be made without risk of severance by further growth. In a very short time the thallus shows a scallop-shell form (Pl. XXXII., fig. 14). When cut in longitudinal section (Pl. XXXIV., fig. 2), the edge of the thallus shows a meristem like that of Dicræa, with a collenchymatous root-cap at the outer part, which is derived from a more or less regular transverse meristem that on the inner side gives rise to the thallus tissues. The root-cap is usually slightly raised above the rock, and hardly seems to perform any protective function in preserving the meristem from contact with the substratum, though it must be of a certain protective value when the thallus collides with another thallus or with a projecting portion of rock or other obstacle. It is possible also that it may have a stiffening function like the rim of bundles along the margin of a dicotyledonous leaf. The presence of this tissue is almost the only constant "root" character, whether physiological or morphological, that remains to the thallus of this species, though a series may be easily traced back to the root-thalli of such forms as Tristicha. As seen in transverse section, the thallus shows very similar features to those of most of the other genera with flat thalli that we have already examined. It has (Pl. XXXIV., fig. 5) a well-marked epidermis and parenchymatous cortical tissues, in the lower part of which the vascular bundles are to be found, showing the usual structure, but very small. The course of the vascular bundles in the thallus and their relation to the growing margins is very complex, and I have not been able to make out satisfactorily any general principle. Each secondary shoot of course has a vascular bundle to it.

The thallus does not grow in thickness like that of a Dicræa or a Griffithella, though it becomes a little stouter behind the margin by the increase in size of the cortical cells. It is very sensitive to contact or to light or gravity, and follows out every irregularity of the substratum.

Before its diameter has reached more than a few millimetres the thallus begins to branch ; this process seems to take place by a slowing of the growth in certain spots, and the thallus becomes lobed. When growing on smooth rock the thallus usually assumes a sort of trefoil shape in a short time, but very commonly there is no recognizable symmetry about it, as it grows to fit the more or less irregular substratum, and usually comes into contact with other plants. Each lobe as formed continues to grow in the same manner, and so does the tissue at the base of the fork between the lobes, so that, though these forks are at first quite close to the primary axis, later in the year there are none within several inches of it. The primary axis at first is at one side of the plant, but very often the thallus overlaps round it, or in many cases the tissue at the base of the stem grows out like the thallus, so that the stem stands more or less in the centre of a thallus. The lobes as they grow in size go on branching in the same way as at first, so that at last the appearance of a plant growing in an isolated position upon a large piece of smooth rock (Pl. XXXV.) is like that of a large more or less circular piece of lichen, lobed along the margin, the lobes being rarely more than an inch deep, and the division between them almost obliterated by the fact that the thallus in its growth does not diverge at the bases of the divisions, but if anything tends to converge, so that the lobes oftener than not overlap each other. The diameter of the thallus reaches 15–18 cm. (6–7 in.) by the end of August (Pl. XXXV.), and by January, when its growth finally ceases, often as much as 30–36 cm. (12–15 in.). The growing edge of the thallus is usually of a more or less deep red colour, while the mature part is perhaps most often of an olive green, but in dry weather, when the water falls so as to expose it to more intense light, it very often assumes, like all the other species, a reddish colour all over, due to the presence of anthocyan in the epidermal cells. As a rule, these plants have to grow on very irregular surfaces of rock, and so the thallus becomes equally irregular in shape. Often, too, a number of seedlings commence close together upon a rock, and as they grow they collide with one another, and one grows over another ; when this is the case the lower thallus soon dies. Insect larvæ of various sorts feed largely upon the thalli, which contain enormous quantities of starch, and thus help to destroy their symmetry. If the water falls, as is not infrequently the case in the drier end of the south-west monsoon, in August and September, so as to expose the thallus, the exposed parts soon die, especially the growing margins, and when this is the case, the symmetry may be almost wholly lost; the growth is recommenced when the water rises again, in any part of the thallus that has not been killed, by a process of rejuvenescence described below, but the former symmetry is so far gone that little remains to show the principle of growth of the thallus. Hence, when the water finally exposes the plant in January, the principle of growth cannot be clearly made out at all, except by good fortune in finding plants that have not suffered any of the accidents we have described, and it is not surprising therefore that under the circumstances it should be described as having no definite form.

Not only does this plant bear a large number of big leaves on its primary axis, but it also produces a great number of leafy secondary shoots upon the thallus, so that it could hardly be more incorrectly described than has hitherto been done. Before it has reached a diameter of more than one centimetre, it begins to produce these leafy shoots, two of which are shown in Pl. XXXIV., fig. 1, upon a very young seedling. The seedling shown in the figure is clasping an old capsule, and has already become lobed. The primary axis had become broken off very early, and this no doubt accounts for the large size of these leafy shoots upon so small a thallus, for, as a rule, they have hardly begun to make their appearance above the surface in a thallus of this size (*cf.* fig. 3). Their first appearance is seen in Pl. XXXVI., fig. 3 (*an.*). They appear in the zone of growth close to the margin of the thallus, as little round markings on the upper surface. A trifling distance further back they pass into the region of elongation of cells, and become elliptical. The centre of the mark is usually green, but the cells round it as a rule show a deep red colour, like those of the margin of the thallus. Soon afterwards the first leaf of the shoot breaks through the superficial cells and appears above the surface of the thallus, so that in this species, as in all the others, the leafy shoots borne upon the roots are endogenous. A second leaf soon follows the first, and the plane of the two leaves is at right angles to the margin of the thallus. More leaves soon appear, till the shoot, when fully grown (Pl. XXXIV., fig. 4), may consist of leaves as much as 5 cm. long, and five, six, or more in number. These leaves exhibit the same structure and appearance, though usually on a smaller scale, as the leaves of the primary shoot. The growing point of the shoot does not at first elongate or appear above the surface of the thallus, and there is, perhaps in consequence of this fact, no appreciable dorsiventrality in the shoots at this period of the life-history. They remain in this condition till a little while before the beginning of the north-east monsoon in October, when they mostly become transformed into flowering shoots during the rainy weather which lasts through the remaining part of the year, till when the water falls in January only those near the margin of the thallus still retain their leafy condition. The flowering shoot consists only, as a rule, of a terminal flower with a few bracts below it, and lies horizontally upon the thallus, thus showing a dorsiventrality, which is absent in the younger stages. The growing points, too, are then above the surface of the thallus. Pl. XXXIV., fig. 6, shows stages in the transformation of leafy to floral shoots, which is very similar to that already described in Dicræa. The floral shoot, as was mentioned in describing the dry season appearance of the plants, points towards the edge of the thallus. The sheathing bases of the leaves now produced enlarge and become fleshy, and presently the tips wither and fall off, leaving the swollen basal parts of the leaves, which then form the scales or bracts of the floral shoot. These scales show a distinct dorsiventrality, in that they are very much thicker in the exposed portions upon the upper than upon the lower side; the latter is quite thin and membranous, while the former is thick and fleshy. This difference is much less in species like Dicræa elongata, where, though the shoots have an upper and a lower side, both are freely exposed in the water.

At the tip of the floral shoot the flower develops, enclosed in its spathe, and it is fully formed in all its parts early in the north-east monsoon, though, perhaps for want of the necessary food supply from the thallus, it seems incapable of further development and anthesis in the event of the water-level falling prematurely before December.

Should the fall of the water be somewhat early, specimens may frequently be found in the condition shown in Pl. XXXIV., fig. 6, with the long green tips still persistent upon some of the bract-scales, and in the specimens of Podostemon Gardneri preserved in the herbaria this state of things is frequent (see also Prof. Warming's figures and descriptions of Dicræa apicata, which is really the species we are now considering, as is elsewhere explained). As a rule, however, before January, the season when the plants are normally exposed to the air, all these tips have fallen, and the buds present the appearance described in systematic works, and shown in Pl. XXXVI., fig. 1, which represents one bud with the flower just exposed by the longitudinal splitting of the upper surface of the spathe. At this period also, as has been already mentioned, the primary axes are mostly more or less completely disorganized, and the thalli themselves have lost their simplicity of form to a very large extent, so that when the final stage in the life-history is reached, the plant presents very few salient features giving any clue to the somewhat complex development through which it has gone, and a description of it from specimens collected at this time is almost certain to err in many points, and to give no idea of the real appearance of the plant when actually in the course of its growth.

The spathes split on contact with the air, and in a few hours the flowers have emerged and are standing erect on short stalks, ready for fertilization (Pl. XXXVI., fig. 2). Like those of the preceding forms, they are wind-fertilized, and apparently largely autogamous; the pollen is loose and powdery, and may be seen blowing out of the anthers in every gust of wind.

The fruit ripens rapidly, and in about a week after fertilization the seeds may be shed. The thallus appears to be able to live exposed to the air for a considerable time, but ultimately dies if not again submerged.

Before leaving the consideration of this plant, a brief description must be given of the very curious monstrosity figured in Pl. XXXVI., fig. 5. This was found on 20th July, 1898, among some seedlings. The primary axis has been bent down, to show the rest clearly. The thallus is rather thick, folded up into a kind of V shape, and with a large number of growing points round the margin, which in the two cases marked *g*, *g* have grown outwards to some distance. From near one end there springs the trumpet-shaped organ *t*, which is flattened out at the end, and appears to have been attached to the rock (the specimen was obtained in the usual way by groping in deep water); its margin is like that of a normal thallus and appears to have grown in a similar way. On the far side are four pitcher-like organs, *a*, *b*, *c*, *d*, springing from the margin, in different stages of development, and on them endogenous shoots (*s.s.*) are forming, somewhat as in Dicræa elongata. These pitchers are hollow at the outer ends for some depth. The whole is of interest as showing once again the almost unlimited plasticity of the thallus in these plants.

Rejuvenescence.—As in most of the other species, so here, the thallus, so long as alive, seems to have an almost unlimited capacity for the production of new growing points and the renewal of growth after exposure to air or other injury. The new growing point is formed endogenously behind the injured portion, and grows out from it in the usual scallop-shell form (Pl. XXXVI., figs. 3, 4). Exactly how long the thallus can stand exposure without losing all capacity for regeneration is uncertain, but I have found several cases in this as in other species, where it appeared to have survived several months after being exposed by the fall of the water in January. When the flowers are ready to open the thallus and stalks are crammed with reserves, especially starch, and hence the ripening of the fruit is very rapidly carried out after fertilization; but all the starch is not thus used up, and by means of what is left the plant is able to regenerate its thallus if placed under water once more.

With regard to *Podostemon Gardneri*, Harv. MS., a few notes must be made. Thwaites' original description is as follows: "caule simplici, terete, glabro, foliis plurimis capillaceis coronato. C. P. 2,989. Hab. on the membranaceous rhizomes of Hydrobryum olivaceum, Tul. In a rapid mountain stream at Ramboda, October, 1853, Dr. W. H. Harvey." He suggests that it may be an early stage of growth of H. olivaceum. No doubt can remain that it is simply the primary axis of the form just described, but to make quite sure I have myself examined the spot where it was found, and verified that the stream is inhabited only by Hydrobryum olivaceum. I have also examined the herbarium material at Peradeniya, Kew, and Paris, and in each case found the thallus attached to the base of the primary axis, leaving no possible doubt as to identity.

With regard to the Anamalai form, it need only be remarked that it agrees in all essential respects with the description of the Ceylon form given above, but the lobing of the thallus is usually much deeper, more like that of the Nilgiri variety.

The Nilgiri form, Podostemon griseus of Gardner, shows considerable differences from the Ceylon form. The primary axis is larger and stouter, and sometimes bears flowers either on the hypocotyledonary portion, or among the leaves. Owing to the decayed condition of my material, I am uncertain whether these flowers are borne directly upon the axis, or, as in one or two cases seems to be the truth, upon very small thalli formed upon the axis. The question should be settled on living material in the latter part of the vegetative season. The thallus itself has a curious gray colour in January, instead of the olive green of the Ceylon form, and at this period it is usually found to be more or less decayed and worn away, except just round the bases of the shoots. It is, as the specimens in Pl. XXXIII. show, much more deeply lobed, as a rule, than the Ceylon form. Its primary axis was described by Tulasne as Dicræa apicata, whose identity I have verified as with Podostemon Gardneri.

Hydrobryum Johnsonii (Wight), Willis.

As mentioned in the preceding paper, the autonomy of this species is very doubtful. I am inclined to think that it will ultimately prove to be the same as that already described as H. lichenoides, Kurz, in which case of course the latter name must become a synonym. In view of this uncertainty there is no need to deal further with it here.

Hydrobryum Griffithii (Wall. MS.), Tul.

(Plate XXXVI., figs. 6–8.)

This species is the only representative of Tulasne's subgenus Euhydrobryum, subsequently raised to generic rank by Weddell, and characterized from its twelve-ribbed isolobous fruit and fan-like stigmas.

Habitat.—I found it growing on rocks on the bank of the Kalapani in the Khasia mountains, over which a slight trickle of water was running, but which from their extreme steepness would probably have a very rapid current in the rains, though perhaps not a very deep one. The habitat was almost exactly similar to those in which I have often found H. lichenoides and H. olivaceum.

Dry Season Appearance.—This is very similar to that of H. olivaceum, but the thallus is in general smaller, the buds or shoots upon it are arranged in a more regular way, evidently radiating from a common centre, and the isolobous fruits are nearly prostrate, instead of being, as one might expect from their symmetry, erect.

Mature Structure.—This is almost exactly like that of H. olivaceum in all important points. The thallus is similar in form to that of the Nilgiri variety of the latter, with deep sinuses between the lobes, and with the same curious growing margin. The secondary shoots are similar to those of H. olivaceum, and the flower emerges in the same way. The spathe shows a tendency to be bifid at the tip like that of Willisia, and the exposed part of it is very siliceous, as in that species, and seems sometimes to break off in a similar way. The structure of the flower shows little of special interest, excepting in the stigmas, which exhibit much variety, parallelling that of H. lichenoides, and completely destroying the generic value of the stigmatic characters. In Pl. XXXVI., fig. 8, a few examples are shown, selected almost at random from the few flowers at my disposal, and showing all forms from simple subulate to the obcuneate and deltoid toothed forms like those of the American Lophogyne.

The fruit is almost, but not quite, isolobous, and has usually twelve, but often more, ribs. The extra four ribs, as compared with the fruits of the other species, are intercalated, and often do not run up to the top of the fruit, much as is the case in the extra ribs often found in the Burmese form of Dicræa Wallichii. This difference alone is certainly not sufficient to allow of this species being generically separated from the other Hydrobryums, with which it agrees so closely in thallus morphology, spathe, and other floral characters.

The genus Hydrobryum thus contains some of the most peculiar of the many peculiar plants that we have described. If only the species last described, H. olivaceum and H. Griffithii, were known, we might be somewhat puzzled to know what to make of them, but the intermediate steps afforded by H. sessile and H. lichenoides lead back without any serious discontinuity to the thalli in the forms already dealt with.

The dwarfing of the secondary shoots, and the enlargement of the thallus to do the work of assimilation or to produce more secondary shoots for that purpose, which we have already seen in Dicræa, &c., is carried to an extreme in this genus, and we get here forms as dwarf in every respect as Lawia itself. Probably directly correlated with this is the fact that the two genera have very similar habitats, and that the species are very often mixed with one another. Both inhabit water that is liable to become shallow very quickly, and consequently perhaps are the genera which are found at the greatest elevations, *i.e.*, on the whole in the smallest streams, and in the most northern localities, *i.e.*, in the rivers which most rapidly run dry. During the early part of the vegetative season the water is usually deep enough, and we find in H. olivaceum, and perhaps in others, a comparatively large primary axis at this period. By the time the risk of shallow water becomes great, the thallus is fully established and the plant can do without the large axis. We cannot regard the thallus as merely an adaptation for attachment to the rock, for the primary axis is able to hold on in the swiftest current if all the thallus be removed, except the part immediately at its base.

In H. lichenoides we see the stage that would be reached by a simple dwarfing of the secondary shoots of Podostemon subulatus or better of P. Barberi. In H. sessile we get a further stage in the broadening of the thallus, so that it covers practically the entire surface of the rock included in its outer outline. In this species the sinuses at times tend to be obliterated by growth of their bases, and if this process be carried a stage further, we get the deeply lobed thallus of H. Griffithii and H. olivaceum griseum, and finally the shallowly lobed H. olivaceum zeylanicum, in which growth is no longer apical but marginal, and the root-cap is continuous round the whole outer edge of the plant. This thallus shares with that of Dicræa the distinction of being probably the most remarkable organ yet described under the general morphological category of "roots," and were there not the series of stages connecting it to that of Tristicha and Podostemon, it might easily be looked upon as an organ of an entirely peculiar class. We shall return to this subject in the general summing up.

FARMERIA.

[Willis, Rev. Pod. Ind., Ann. Perad., I., p. 246.]

This genus, though evidently closely allied to Hydrobryum, and resembling that in many points of structure, yet differs in certain very marked peculiarities, and is of particular interest. It is confined, so far as yet known, to Ceylon and the extreme south of India, in each of which there is a single species. The Ceylon species was described by Dr. Trimen, but incompletely, as he overlooked the presence of the fruit in his material ; it is buried among the bracts, and is indehiscent, two almost unique features in this order. Large quantities of fruit may be found in the material distributed by him. Of the Indian species, I have only very incomplete material at my disposal.

Farmeria metzgerioides (Trimen), Willis.

(Plates XXXVI.–XXXVIII.)

Habitat.—This plant is extremely abundant at Hakinda, where it grows on smooth rocks in eddies and rapids, as a rule not affecting such swiftly moving water as does Hydrobryum olivaceum. As usual, it is most often found alone, but it is frequently mixed with Lawia zeylanica, Hydrobryum olivaceum, and rarely with Podostemon subulatus or others. It also grows in more shady places than the other species; I have found it in quantity along the shady right bank of the river below the corner at Hakinda, where the water is overhung by Pandani, Fici, &c., and where the sun only shines for a few hours in the morning.

Dry Season Appearance.—This is shown in Pl. XXXVIII. on the two stones in the middle. There is a narrow ribbon-like thallus, upcurved at the edges, like that of Hydrobryum lichenoides in most respects, branched right and left, but more sparingly and not so close to the apex, and with secondary shoots along the edges, these consisting of a few little bracts like those of Hydrobryum, and with the fruit concealed among them. Where a branching occurs, the secondary shoot is behind, not in the axil of, the branch.

Germination and Life History.—When the water-level falls at the beginning of the dry season, the plant may be found in flower, *e.g.*, I noticed it in flower at Hakinda in 9th January, 1898, 8th January, 1899, and 17th December, 1899. The flowers are sessile, and ripen into sessile fruits, each containing two seeds only, which are larger than those of most of the order. The fruit does not dehisce, but remains tightly held down within the hard persistent bracts, and the seeds germinate *in situ* and break through the thin membranous fruit wall. The embryo (Pl. XXXVI., fig. 9) is short, straight, and thick, and from 0·5 to 0·75 mm. long, of which length the cotyledons form two-thirds.

The germination is fairly rapid. The hypocotyl emerges from the testa and bends downwards to the substratum, becoming attached in the usual way, while its base becomes somewhat flattened or tuberous (Pl. XXXVI., fig. 10). Haptera are rare; one case was found with haptera at the base of the foot formed by the hypocotyl. Fig. 14 shows two seedlings emerging from a capsule more or less embedded in the remains of the old thallus, bracts, &c.

The cotyledons spread out at once; they are not opposite to one another in this species, but stand at an angle of about 135°, so soon as they are open. Thus the dorsiventrality of the mature plant shows itself in the very earliest stages of its life. The notch between the cotyledon-bases runs lower down, *i.e.*, nearer to the foot of the hypocotyl, on the anterior than on the posterior side of the expanded embryo, but I am not able to make out whether the same is the case in the ripe embryo in the seed. The wider angle between the cotyledons is usually upwards, the backs of the cotyledons being almost appressed to the substratum. The cotyledons are wider and stouter in proportion than ordinary leaves, and are not hairy. The apex is acute, and the base vertically thickened as may be seen in the figures; the upper side is very slightly concave.

Figure 10 shows a very young seedling; the cotyledons are spread out with their lower sides almost against the ground, and in the larger angle between them the thallus is emerging, slightly above the base of the flattened "foot." The direction of starting does not, as one might expect, bisect the large angle between the cotyledons, but lies as a rule in a line with and opposite to one of the cotyledons, as may be seen in several of the figures, especially well in fig. 11. In some cases two thalli are formed from one hypocotyl, as seen in figures 13, 15, 16. The second thallus is usually in the smaller angle between the cotyledons. In one case three thalli were observed. The development of the thallus is endogenous, but as usual this was a matter of difficulty to observe, and in one or two examples it was impossible to make definitely sure. The endogeny seems to be only under one or two layers of cells. As soon as the thallus emerges the line of demarcation becomes very indistinct, the cells at the edge of the thallus coming into the same level as those of the hypocotyl.

Leaves soon develop above the cotyledons. The first usually appears in the larger angle between them, and the second in the smaller, but apparently the reverse is sometimes the case. Both cases are seen in the two seedlings of figure 14. Subsequent leaves are arranged in an approximately distichous way upon the stem, the third leaf being approximately over the first. The leaves are subulate, and have sheathing bases, and bear hairs upon their upper surfaces, like so many in this family. The growth of the primary stem is not long continued ; it rarely forms more than 6–8 leaves, of about 5–7 mm. in length. This primary axis can hardly therefore be of very much use to the plant after the thallus has become of appreciable size, and indeed the primary axes, so far as could be found, seem to disappear after the first two or three months.

To return to the growth of the thallus. When it first emerges from the hypocotyl, it has a narrow apex, but it soon widens into an ovate form, as in figure 11, and this form of the apex remains essentially unchanged throughout the life of the plant.

Examination of the apex of the thallus shows that the extreme tip bears, or rather is composed of, thick-walled collenchymatous cells, much as in Hydrobryum olivaceum, much larger than the small and thin-walled and densely protoplasmic cells immediately behind the tip. The latter are meristematic, and the collenchymatous tissue represents a root-cap, though it does not seem to be of much practical value to the thallus in that respect. The cells of this tissue, as they approach the edge, become longitudinally stretched (*i.e.*, tangentially to the surface of the growing point), and now and then thin layers of them may be seen splitting off from the end of the thallus, just like an ordinary root-cap.

The growth of the thallus is fairly rapid. As soon as it has grown a few millimetres out from the hypocotyl, it becomes attached by rhizoids to the substratum, and the endogenous leafy shoots begin to appear. Pl. XXXVI., fig. 12, shows this stage: on the left side of the thallus, near the edge, a leafy shoot is just emerging, while a little nearer to the apex on the right-hand side is the swelling indicating the formation of a second younger one. The shoots appear with great regularity in this alternate and acropetal succession, when not interfered with by any obstacles, but when the substratum is very irregular, or there are many plants competing for space, the regularity may be lost. The next stage is exhibited in Pl. XXXVII., fig. 1. The primary axis shows the cotyledons and four leaves, while the thallus, springing in a line with one of the cotyledons, has grown out to a considerable distance from the hypocotyl, and has developed several leafy shoots. At each node it is wider and also somewhat thicker than at the intervening part. This specimen also shows the branching of the thallus itself. The leafy shoots appear first, and are often, but not always, followed at the nodes by branching of the thallus. The shoots appear under two or three layers of cells at a very early stage. The appearance of the branches of the root-thallus is later, and it is often hard to determine whether they are really endogenous. Their development in the meristem remains to be worked out. They appear on the under side of the thallus, near to but not quite at the edge, just in front of the leafy shoot at the same node, as seen in Pl. XXXVII., fig. 3. They are endogenous under a few layers of cells. The branch thallus repeats the structure of the main thallus, and does not as a rule stop short in its growth like that of Podostemon subulatus, though it often becomes stopped by obstacles.

The thallus in cross section is convex above, and shows a general construction like that of Hydrobryum lichenoides or H. olivaceum. The leafy shoot developes a few small leaves, rarely more than five or six, of about 5 to 10 mm. in length, and hairy above.

The growth of the seedling plants is fairly rapid. For example, on 21st May, 1898, the seeds were just germinating, and on 19th July the rocks were thickly carpeted with plants, many of which were from two to three inches long and much branched. During the next four or five months the plants seem to be purely vegetative. The flowers, when they begin to form, develop very rapidly. The usual period for this process appears to be December. Nearly all of the leafy shoots then form flowers. By this time the plants have grown to great lengths, and form a dense interwoven felt-work upon the rocks, as may be seen in hitherto existing herbarium specimens, which as distributed consist of fragments of very many different plants inextricably mixed.

Pl. XXXVII., fig. 2, shows a thallus, which is just forming flowering shoots in the middle of December. The apex is still growing, and forming leafy shoots as usual, while a little further back the flowering shoots occur in various stages of development. At the tip of a root the flower shoot apparently develops as figured here, without any long period during which the axis is purely vegetative, while further back on the thallus the old vegetative shoots may be seen changing to flowering shoots. In either case, however, the process is essentially the same. While the shoot is only leafy, the growing point lies below the surface of the thallus, but now it begins to elongate and come above it. The leaves, hitherto thin and comparatively simple, grow out at their bases, changing function and form like those of a lily bulb; the sheathing part of the leaf thus becomes much enlarged. The axis remains in the horizontal position, or rather the position parallel to the substratum, which in this species it occupies from the very beginning. The upper side of each sheath becomes fleshy, whereas the lower remains thin and membranous. Bracts are thus formed as in Hydrobryum. In that genus the free blade of the leaf usually falls off early, so that it can rarely be found in January, but in Farmeria this is not, as a rule, the case, and the bracts have leafy ends until the water falls so low as to expose them to the air, when the free ends wither and fall off. In the centre of the bud thus formed by the bracts the flower gradually develops within its spathe. By the end of the wet season in December or January it is ready to open as soon as exposed by the fall of the water.

The flower is quite prostrate, as in Hydrobryum sessile, only the stigmas and the long stamen emerging and bending upwards out of the spathe, which splits like that of Hydrobryum on the upper side. The stigmas are very long and subulate. The stamen is single, as is occasionally the case in Hydrobryum (Pl. XXXVII., fig. 4). The chief interest of the flower is in the ovary, which is quite different from that of the rest of the order, so far as yet known. It is bilocular, but much more dorsiventral than any other, the lower loculus being more or less abortive, without ovules, and displaced towards the stylar end in the ovary (Pl. XXXVII., fig. 9). From the base of the ovary springs a short stalk, which bears a large swollen placenta filling the distal end of the upper loculus of the ovary, the septa being on its lower side and converging towards the stalk. The basal end of the placenta is flattened (figs. 5, 6), and bears two large ovules filling up the basal end of the loculus, themselves flattened against the placenta (fig. 7). The tissues of the placenta are closely packed with starch, and there is thus an abundant supply of food ready for the ripening of the seed, as the bulk of the placenta is quite as great as that of the two ovules or the seeds which result from them.

The flower is as usual anemophilous. The ovary ripens to a fruit of about the same size as itself (fig. 8) with two large seeds, borne on the rather shrivelled placenta. The pericarp is thin and membranous, and does not dehisce. As the fruit is quite enclosed in the persistent hard scaly bracts, the seeds are thus firmly held against the rock, and ultimately germinate in that position, as we have already seen. This species is consequently one in which there is no great difficulty in obtaining numbers of seedlings if the water-level be only sufficiently low.

Farmeria metzgerioides is thus, so far as we as yet know, the solitary case among the Podostemaceæ of the possession of an adaptation to ensure the anchorage of the seeds in a position suitable for their germination and growth. The species is, perhaps in consequence of this, extremely abundant at Hakinda, perhaps the most abundant of all. On the other hand, the chance of distribution to a distance is probably very much diminished. However, Farmerias in vegetative condition, which appear to be specifically identical with the Hakinda form, have been found at other localities in Ceylon, some at a great distance, so that, unless we suppose the species to have evolved separately at each locality, we must assume that distribution to a distance is at times effected.

Farmeria indica, Willis.

(Plates XXXVII., XXXVIII.)

Of this species, I have only material collected in the dry season, on exposed rocks, and can only mention the most interesting points of difference from F. metzgerioides. As Pl. XXXVIII. shows, it is a very small plant, with an extremely slender creeping thallus, branched in the same way as in the preceding species, but differing from it in being attached to the rock by flat membranous feet, like those of Tristicha ramosissima (Pl. XXXVII., fig. 10). Sometimes these feet project under the thallus, while sometimes they appear to be formed by a widening of the whole thallus; both cases are shown. I have not seen the flower. The fruit is slightly stalked, and is dehiscent, with a larger upper lobe. Very commonly the latter has two or more extra ribs, so that the fruit, which is otherwise like that of Hydrobryum lichenoides, becomes ten- to twelve-ribbed, and not unlike the fruit of H. Griffithii. The internal structure of the fruit is like that of F. metzgerioides, but the large placenta bears four (or perhaps at times three or five) seeds instead of two.

In general, therefore, the genus may be looked upon as closely similar to Hydrobryum. Its most interesting special features are the endogenous branching and the reduction of the number and increase of size of the seeds, and their germination *in situ* in one species.

GENERAL SUMMARY AND DISCUSSION.

Having described the more important features of the general morphology and life-history of the Indian forms, we may go on to discuss them in connection with the general conditions of life which were considered in the introduction, and to consider their bearing on some of the general questions of morphology, ecology, evolution, &c.*

We have already briefly outlined (p. 277) the way in which the general life-history of these plants is connected with the seasonal distribution of the rainfall, describing the way in which the seeds germinate at the beginning of the rains, giving rise to small primary axes from which the thalli, which form the most important morphological feature of the order, bud out. In all but Lawia the thallus is of "root" nature, with endogenous secondary leafy shoots which ultimately become floriferous, the flowers opening with the fall of the water in the early part of the next dry season, and shedding the seeds upon the rocks. All these features will now be dealt with in a general way. The most interesting general morphological points are perhaps the

* Summaries of the chief features of general importance are given after each genus described above ; *cf.* pp. 303, 325, 339, 362, 369, 374, 395, 404.

extraordinary plasticity of the skeleton-less root, and the parallel dorsiventrality of the vegetative and floral organs, the latter point in particular leading to important deductions bearing on the importance of correlation in evolution.

The Primary Axis.*

We now know the construction of this organ in Lawia, some Dicræas, Podostemon subulatus, Hydrobryum lichenoides, H. olivaceum, Farmeria metzgerioides, and probably Willisia selaginoides, while it is not improbable that the tall floriferous shoot of Sphærothylax, as described by Warming (42, IV.), is also a primary axis. It is very much to be desired that the primary axis should be investigated in the other Podostemaceæ, especially in some of the Tristicheæ, as we may hope from it to get some light on the difficult problem of the phylogeny of these plants. Looking at such cases as the probable primary axis in Willisia and Sphærothylax, and the well grown hypocotyledonary shoot of Hydrobryum olivaceum, it would seem probable that the order at first consisted of forms with well grown primary axes, which in all likelihood were floriferous. From this stage the evolution would appear to have proceeded in the direction of a gradual reduction of the primary axis, as the secondaries, and afterwards the thallus also, took over its functions of assimilation and flower-bearing. The primary axis in Hydrobryum lichenoides, and still more in Dicræa and Farmeria, is reduced to a very insignificant object, and after germination is over, and the thallus established, it appears to be of no further value in the economy, and does not bear flowers.

The phyllotaxy of the primary shoot is usually complex, but in Podostemon subulatus it is approximately distichous like that of the secondary shoots. The leaves are usually almost exactly like those of the secondaries, and are of very simple construction, as in most water plants. The anatomy

* And *cf.* preceding paper, p. 190.

of the stem is like that of other highly adapted water plants, but requires study in detail.

The primary axis in most forms shows little sign of dorsiventrality, unless in the excentricity of the bundles. In Lawia the curious lateral growth, of or from the primary axis, resulting in the formation of the thallus, requires further investigation. In Podostemon subulatus the primary shoot shows a certain unequal symmetry in the way it forms an upper side by the curving over of the leaves, while in Farmeria metzgerioides there seems to be an actual dorsiventrality in the very cotyledons, which are diverted a little towards the lower side, and slightly unequal. None of the Podostemaceæ as yet investigated have any developed primary root, as indeed is only to be expected from their mode of life.

The Thallus and Secondary Shoots.

These organs are best considered together, as they are essentially connected in the general ecology and morphological construction of these plants, and not infrequently also, as in Lophogyne, the secondary shoots themselves are developed in thalloid forms, making what we may perhaps call secondary thalli. Under the general term thallus or primary thallus we may include the creeping dorsiventral organ which is developed from the primary axis and itself bears endogenous secondary shoots. These, in the Indian forms, are not themselves thalloid in structure, but are simple leaf-bearing axes, ultimately floriferous in all but Lawia. Phylogenetically considered, the thalli found in the different genera of the order are of different morphological value. It is evident that the thallus of Lawia is not homologous with the other Indian thalli, and it is doubtful if it is exactly equivalent to any of the other thalli found in the order. It is evidently of shoot nature, if we judge only by the upper side, which bears leaves, and whose growing points end in flowers, but, on the other hand, we have to note the curious growing point with its root-cap-like lower edge, and the peculiar method of formation of the whole thallus by a lateral outgrowth apparently of the entire primary axis, so that there is a possibility, though probably a very unlikely one, that we should regard the thallus as "combined" root and shoot, and perhaps the endogenous shoots as representations of its "root" element. The whole question, however, must be left for detailed developmental investigation. Castelnavia princeps has a shoot thallus, apparently derived from the primary axis, but in this there seems to be a combination of stem and leaf, which is not the case, so far as we can see, in Lawia. In Lophogyne arculifera the root-thallus bears secondary shoot-thalli, of similar morphological construction to the thallus of Castelnavia princeps.

The other seven Indian genera all possess some kind of "root" thallus, and this is also the case with most of the American genera. Taking first the Tristicheæ, we find in Tristicha ramosissima and Weddellina squamulosa a thallus to which, without any serious stretching of the common meaning of the term, the name of root may well be applied. It is a thin thread-like organ, which is probably endogenously developed from the base of the primary axis just as in Podostemon subulatus, in which a similar organ occurs. It is endogenously branched, at least in Tristicha, and the structure of the vascular cylinder, though slightly dorsi-ventral, as might be expected, is not markedly different from that of an ordinary root; the tip is covered by a root-cap of the ordinary kind. The only marked feature in which these roots are peculiar is the regular development upon them, in acropetal succession, of the endogenous leafy shoots, and this, though carried here to a high degree of perfection, is by no means uncommon in other roots. These secondary shoots reach a high degree of development and complexity, but are not otherwise remarkable among water plants. In Tristicha hypnoides, according to Cario (8), there is no root-cap, but otherwise it seems to resemble the other Tristicheæ.

Passing on to the more modified forms in the order, we find the thread-like root-thallus in nearly all the other

American forms,* without much difference from what has been described in Tristicha, excepting a reduction of the size and complexity of the secondary shoots.

In the Indian Eupodostemeæ we find the most remarkable types of thallus in the order. In Podostemon subulatus the thallus arises endogenously from the base of the hypocotyl, but is itself exogenously branched, and has a very curious collenchymatous and non-deciduous root-cap; it is still thread-like, but is perhaps rather more dorsiventral than that of the American Podostemons, and its secondary shoots are much smaller. In P. Barberi the dorsiventrality is more marked, the thallus being broad and almost leaf-like, though it is still attached to the rock in the middle line.

In the remaining Indian genera, there are several types of thallus structure. Thus in Dicræa and Griffithella we find the very remarkable alga-like forms above described, some of which, *e.g.*, the creeping closely-attached forms of D. stylosa fucoides and G. Hookeriana Willisiana, are not very different from the thallus of Podostemon Barberi; they are endogenously developed from the base of the hypocotyl, have very reduced secondary shoots, are exogenously branched, markedly dorsiventral in their external and internal structure, and have the collenchymatous root-cap. From this form it is an easy stage to the more or less freely drifting type of thallus found in the same varieties, and to the somewhat more modified and slightly dimorphic thalli of D. elongata and D. dichotoma or D. stylosa laciniata. Even the extraordinary forms found in Griffithella, such as the stalked goblet in Pl. XXVI., fig. 1, are led up to by easy stages through intermediate forms.

In this connection attention may be specially drawn to the remarkable polymorphism exhibited by these thalli, and which is well shown in the figures of Plates XXI.–XXVI. The thalli of many of the other genera are very variable, but none approach the wide range of form seen in the thalli

* *Cf.* 42, under Ligea, Apinagia, Mourera, Lonchostephus, Marathrum, Podostemon, Mniopsis, &c.

of the Dicræas and Griffithellas. The reason perhaps lies in the fact that the latter are usually free of the rock except at the base, and that they possess more capacity for growth in thickness of the cortical parts. This capacity, combined with an entire absence of any controlling skeletal tissue, such as is found in most flowering plants, or of fixed position, such as hampers the thalli of the closely attached Hydrobryums or Lawias, gives them a potentiality of varied form unexcelled above the somewhat similarly circumstanced brown algæ. For details of the very simple way in which all the very varied forms are produced, reference must be made to the details given above under Griffithella and Dicræa. The effects are sufficiently striking; it is difficult to realize that the objects figured in Plate XXVI. are really roots, or that most of them do not even differ varietally from one another.

Another line seems to be that represented by Hydrobryum lichenoides and H. sessile, as well as by the Farmerias. This form of branched simple ribbon-like thallus differs from that of Podostemon subulatus and P. Barberi in its greater branching, very firm attachment to the rock, and greater flattening and dorsiventrality, with extreme reduction of the secondary shoots. In Farmeria the branching is again endogenous, as in the forms with which we started, though very likely this phenomenon is one acquired subsequently in exogenously branched ancestors.

In H. sessile we see the thallus branching in the same way, but wasting no space upon the rock by long gaps between the branches, and at times there is even a tendency for the sinuses between the lobes of the thallus to disappear by subsequent growth. Carry this feature a stage further and the deeply lobed liverwort-like thallus of H. Griffithii or H. olivaceum griseum is reached, and with a further development of the growth of the bases of the sinuses the almost circular-outlined thallus of H. olivaceum zeylanicum is formed. In these plants the term thallus is very eminently suitable to the organ in question, which has hardly any "typical" root character left to it. It is developed from the base of the hypocotyl, sometimes endogenously but often exogenously, it increases by marginal instead of apical growth, is irregularly lobed, has a marginal "root-cap," and performs the function of assimilation, in addition to bearing the floriferous shoots.

As mentioned above in dealing with Hydrobryum, if we had only these plants before us, it would be difficult to know what to make of these thalli, but with the series of gradations before us, we must consider them as homologous with the thalli of Tristicha and the American Podostemons. These being unquestionably roots, though adventitious, in the ordinary morphological sense, there is no reason to refuse the term root to any of these thalli. On the other hand, though this is no doubt true, if we call these thalli roots we must use the latter expression in a very broad and vague sense, and as a classificatory rather than a descriptive term, much as we use the terms Dicotyledon, Fungus, Flower. The term root has so much more specialized and functional a meaning* than the terms stem or leaf in botanical work, that it is probably better not to apply it definitely to the roots of most of these Podostemaceæ, but to describe the organs in this family as thalli, leaving for further specification in each case whether the thallus is of "shoot" or "root" nature. None of the ordinary definitions of roots can be made to include the thalli of such plants as Hydrobryum without stretching them so much that it is difficult to exclude stem forms.

This of course is assuming that these thalli are phylogenetically descended from undoubted roots, *i.e.*, that some of their ancestors were provided with roots developed "adventitiously" at the base of the hypocotyl. There is every reason to suppose that such was the case, for we know this to be an extremely common feature in many plants, and especially in those which are unable for physical reasons to

* The reasons for this have often been pointed out, *e.g.*, by Sachs and Goebel.

form proper primary roots. A very large number of plants, as is well known, show such a development of adventitious roots, especially Monocotyledons and water plants.

The question then arises, whether an organ of "root" structure (*i.e.*, in general possessing the morphological and anatomical features of true roots, such as the presence of cap, absence of leaves, endogenous branching, centripetal primary xylem, &c.), developed endogenously and laterally at the base of the hypocotyl, is really a root. It is evident that it cannot be regarded as strictly homologous with the true primary root developed from the embryo, nor with roots which arise as branches of the primary root. No one, however, denies the title root to such growths, though it is usually qualified by the adjective "adventitious," and we perhaps hardly know their phylogenetic morphological value. It is every day becoming more clearly recognized* that there is much less of strict homology among the organs of plants than has hitherto been supposed, and that just as the evolutionary tree of the various groups of plants themselves is now constantly requiring pollarding (to quote a well known morphologist), or even perhaps coppicing, so too the organs found among plants may have arisen by many different lines of development, and that it is almost as difficult to fix the morphological value of an organ as to fix the systematic position of a plant, on a phylogenetic basis.

To prove the absolute "root" nature, then, of these thalli, is by no means easy, especially as we have not yet quite decided what is a root. We ought, to prove the homology of primary root and adventitious root, to trace back the phylogeny of each, till we find the two lines unite, by one developing from the other, or both from some parent form. In the absence of any clear knowledge of the phylogeny of the various groups of plants which we unite under Pteridophyta and Spermaphyta we cannot at present do this with any accuracy. But so long as we regard as roots the organs

**E.g.*, *cf.* Bower, Presidential Address to Botanical Section, British Assoc., Bristol, 1898.

which at present go under that name in the various groups of Pteridophyta, in the Gymnosperms, and in Monocotyledons and Dicotyledons, and include in the category not only the primary or embryonic roots, but also the roots which are adventitiously developed from stems or other parts, we must include in the general term the thalli of the Podostemaceæ. For the present this is no doubt the best course, just as it is still, and will probably long remain, best to continue using such classes as Fungi, Gymnosperms, Sympetalæ, though we now consider them as almost certainly polyphyletic ; until, however, our knowledge of the phyla is much more complete, it will be unsafe to venture far in proposing new classifications based thereon. Let us then accept the term root as the general classificatory expression for a group of organs which have certain features in common, but which have in great probability not all arisen from one phylum of descent. In this large group we must make many small ones, but it will be safer not to draw too many lines of connection through these until we know more of their actual phylogeny. Thus we may make classes for the roots derived directly from the embryo in each group of Pteridophyta and Gymnosperms, and probably may include in another the corresponding roots of Monocotyledons and Dicotyledons, the latter class probably to be united to one or more of the former. Secondary or adventitious roots, again, must apparently form another polyphyletic group, with many sub-groups, among which one must be kept for the thalli of the Podostemaceæ, another for the thorny roots of certain palms, and so on.

Our conceptions of the morphology of the root require to be much enlarged, just as has happened in recent years in the case of shoots, sporophylls, &c. The root in general is so uniform in structure, owing to general uniformity of function, and is so concealed from view and inconvenient to work with, that its morphology and other features have tended to be neglected in favour of those of the subærial organs.

In those cases where the primary axis is soon lost, as in Dicræa, Hydrobryum, or Farmeria, the mature plant forms an interesting parallel to the case of the aquatic Utricularias;* the latter are independent "leaves" of very varied form, the former independent "roots."

The formation of secondary shoots upon the roots is of course common in other families,† but it is carried to a degree of perfection in the Podostemaceæ that is unmatched elsewhere. It is clear that we cannot regard the secondary shoots of Lawia as homologous with those of the other genera, at any rate on the existing evidence, but we may fairly regard the secondary shoots which arise upon unquestionable root-thalli as homologous with one another, though they are not of course homologous with the primary shoots, from which they often differ very largely in structure, as well as in position and origin. It is evident, therefore, to make a momentary digression, that it is unsafe to draw morphological comparisons between the Podostemaceæ and other families, using the primary axis of the latter, and only the secondaries of the former.

The secondary shoots of the other genera than Lawia are borne upon the root-thalli, endogenously, and are formed near the growing apex in alternate acropetal succession. There is often a marked tendency for these shoots to be developed in pairs opposite to one another, but only rarely is the oppositeness found to be universal in any particular thallus.

In Tristicha the secondary shoot is large and complex, and ultimately bears many flowers; we do not yet know in what respect, if any, it differs from the primary axis. The ramuli, or branches of limited growth, are a curious feature of this genus and its ally Weddellina. In the South American Oenones, Moureras, &c., the secondary shoot is large, usually with large leaves, is more dorsiventral than in the Tristicheæ, and bears the flowers in a large inflorescence. In the Eupodostemeæ it is much smaller. In Willisia, to deal

* Goebel, in Ann. Buitenz., IX.

† Goebel, Organographie der Pflanzen, p. 478.

mainly with the Indian forms, it is still fairly large, but not branched, and as a rule bears one terminal flower only. Its leaves are like those of the primary shoot, but in a different phyllotaxy, and at length they form scaly bases. The anatomy of the stem itself is also different from that of the primary axis, not merely in the presence of the stiffening layer of tissue needed to hold the stem erect, but also in the construction of the vascular tissue, which shows decided dorsiventrality and other points of difference. In Podostemon the reduction of the secondary axis has gone further, and it is short and more or less prostrate, though branched, and bears few flowers ; it still, however, does a major part of the work of assimilation in the plant, as its leaves are large. It is much larger and more complex than the primary axis in the one species in which it has been investigated. In the remaining four Indian genera we find an extreme reduction of the size of the secondary shoots, accompanied by a flattening and enlargement of the thallus, which does much of the work of assimilation. In Hydrobryum, Farmeria, Dicræa, and Griffithella, the secondary shoots are at first mere tufts of leaves, endogenously formed in acropetal succession on the root-thalli, but towards the flowering season they elongate and bear each a few bracts, a spathe, and a terminal flower. They are not very dorsiventral until the flowers develop, and then there is usually an extreme dorsiventrality, most marked in Hydrobryum and Farmeria. In these forms the primary axis is also reduced to a great degree.

The most interesting general evolutionary features of the series of secondary shoots, then, are their gradual reduction in length, branching and complexity, and the diminution of the number of flowers to one, and finally the non-elongation of the axis until that one flower has to be developed upon it. The same kind of evolution seems to show in the American forms, from the large and complex secondary shoots of the Weddellinas and Moureras to the comparatively simple ones of the Podostemons and Mniopsides.

There is of course no direct evidence, other than that afforded by a general comparison, for the view that the small size and little complexity of the secondary shoots in the genera named is actually due to a reduction, but it would seem not unlikely that such has been the case.

A very noteworthy general feature in many of the thalli is their exogenous branching, and a brief consideration of the various cases may help to throw some light on the meaning of the difference between the two methods of origin of new organs, endogeny and exogeny. In the case of an ordinary subterranean root, it is easy to see that endogeny is advantageous to the lateral roots, and perhaps also necessary. The extreme tip of the root is forcing its way through the soil, and it would be difficult for either lateral roots or hairs to form on it without injury. By the time that the lateral roots do form, the surface cells have become full grown and comparatively thick-walled, and it is perhaps almost impossible for them to become again fully meristematic in such a way as to give rise to a new organ. It is therefore possible that there is an element of necessity in the endogeny of the branch root, as well as of advantage. This view is confirmed by the behaviour of adventitious roots formed upon the stem or upon old parts of the root, or even upon leaves ; as a rule they are also endogenous, though it often seems to be of no advantage to them that they should be so. Their origin is presumably determined by heredity or by the physical conditions of the surface tissues. Thus perhaps on the whole it comes about that endogeny is fixed in the heredity of the higher plants as the customary mode of origin of roots in general. The same reasoning also applies to the case of shoots developed upon the roots, which are also almost always endogenous.

In the Indian Podostemaceæ, we have a case of very plastic organisms in which, while they are apparently descended from plants with endogenous root formation and branching, the advantages of endogeny, and apparently also the necessity for it, have disappeared, so far at any rate as the lateral rather than vertical branching is concerned. Vertical organs will be more subject to scour, and perhaps to them it may be advantageous to be endogenously formed. We have then left, the powerful influence of heredity, and the time of appearance of the new organs, whether at the earliest stages near the apex, or later. In the case of the secondary shoots upon the roots, even when they are formed near to the tip, endogeny is the rule without exception. That there is perhaps some very strong reason for this may be inferred also from the fact that even in Lawia, with its shoot thallus, the secondary shoots are formed endogenously, on the mature parts of the thallus, though perhaps their late origin, when the surface cells are hard and full of silica, may be enough to account for this. Beijerinck* has shown that in Aristolochia Clematitis the secondary shoots show endogenous development when formed on old parts of the root, exogenous when on young ones.

In the branching of the more modified root-thalli, on the other hand, endogeny is distinctly rare; it occurs in Farmeria, but here the branches are formed very late in the development. It also occurs in Dicræa when branches are formed later in life on old parts of the root, but never at the apex, unless in case of rejuvenescence from an injured tip. In Tristicha the branching is endogenous, but it occurs at some distance from the tip. In most of these forms, however, the branching occurs quite close to the tip of the thallus, where the tissue is still fully meristematic, and is exogenous.

It is evident, then, that like other morphological features, endogeny and exogeny, fixed though they are so long as there is no serious change in function or circumstances, may be modified in accordance with changes in these conditions. Perhaps we may regard as one of the determining causes in the first differentiation of these two modes of

* Beob. u. Betr. ü. Wurzelknospen u. Nebenwurzeln. Verh. k. Akad., Amsterdam, 1886, d. 25.

origin the direct advantage of endogeny in many cases, and as another the physical necessity of it when the organ was developed at so late a period that the surface cells were no longer capable of full meristematic activity.

Having now traced the morphology of the thallus through the very remarkable series of forms that it exhibits, we must go on to deal with it from an ecological point of view, and endeavour to trace the correlation between the morphology and the general conditions of life, or, in other words, to determine the amount and degree of adaptation displayed.

One feature of great importance, common to all the thalli, is as we have seen the development of regular secondary shoots. In the simpler thalli, such as those of Tristicha and the American Podostemons, or even P. subulatus, this seems to be the only special function of the thallus as compared with an ordinary adventitious root, because the long creeping thread-like organ, with its comparatively slight hold of the rock, is not suited for purposes of anchorage of the long and complex secondary shoots. Anchorage of the latter, as soon as they have reached any considerable size, is provided for by the development of haptera.

The function of the thallus seems rather to be to spread rapidly over the rocks, developing new shoots at short distances, and holding them until they can form holdfasts of their own. Referring back to the general conditions of life, described in the introduction, we can easily see the advantages of this. If the water become shallow, as may easily occur at any time by a deficiency in the rainfall, the shoots are liable to be killed, or at any rate much injured, by exposure to the air, whereas the creeping thallus, which is also often more or less amphibious (or rather, capable of standing some exposure, for it never of itself emerges into the air), stands the best chance of surviving until a rise of water again occurs, and then forming new shoots. At the same time, the more shoots there are, the better for the chance of the plant as a whole, for some of them will have a chance of living, or even may never be exposed, and thus the life of the whole may be comparatively less injured than if there were only one or two shoots.

Another advantage of the thallus, and especially when combined with a dwarfing of the secondary shoots, is that it enables the plant to live in swiftly running water without danger of being carried away. At the same time, the importance of this advantage may be easily exaggerated. Hydrobryum olivaceum, the species which inhabits the swiftest water of all, has a tall primary axis with long leaves at the period when the water is deepest and most violent, and this axis can hold fast to the rock if the rest of the thallus be taken away. Many of the South American forms have very large leaves and shoots, and yet live in very swift water. We must therefore beware of regarding the thallus too much as an adaptation to life in swiftly moving water.

A third factor to be considered is the scour of the suspended matter in the water, which will be greater where the current is swifter, and which will probably be more injurious to the larger forms.

It would seem, then, on the whole, most reasonable to regard the thallus with its secondary shoots, the chief morphological feature of most of the Podostemaceæ, as probably adapted less to the rushing water as such than to the dangers inseparable from life in such water, *i.e.*, chiefly the ever present risk of exposure by the shallowing of the water, but also perhaps the increased scour. The more highly modified the thallus, the swifter on the whole is the water in which it lives, as we shall see in detail in dealing with the geographical distribution of the forms. We may also, perhaps, regard as adapted to the same dangers the slight amphibiousness of most of the thalli (perhaps partly due to the silica that they so often contain), and their great capacity for rejuvenescence by forming new growing points behind any injured part, or even on older uninjured parts.

The thallus, then, appears to be well adapted to such a mode of life, but we are now met as usual with the question whether the adaptation is a direct one, or only a perfecting of characteristics already existing in the ancestral forms, and which perhaps enabled them in the first place to adopt this peculiar mode of life. Here, as usual, we are checked in our inquiry by our ignorance of the phylogeny, and still more in this particular case by the absence of other families of flowering plants living in similar conditions, with which comparisons can be made. Neither the development of adventitious shoots on the root nor the regeneration of the growing points is at all uncommon in other families, and hence it seems very probable that both of these characters were well marked in the ancestral forms of the Podostemaceæ. But they are evidently of great value to these plants, and have become developed to a great degree of perfection, and may thus perhaps best be regarded as partial rather than absolute adaptations to the mode of life.

While the thallus, regarded broadly, is thus apparently not a direct adaptation, it is by no means improbable that there may be in it many partial direct adaptations, and we must now trace it a step further into the more peculiar forms, such as the Dicræas and Hydrobryums. In these we begin to find forms unique among the higher plants, and may therefore look for more evidence of direct adaptation. We have seen that the peculiar expansion of the thallus so marked in these highly modified forms is accompanied by a dwarfing of the secondary shoots, and perhaps on the whole by a slight increase in their numbers. It is easy to see that the dwarfing is in some ways advantageous to the plant, as it decreases the risk of exposure to the air when the water becomes shallow, but, on the other hand, it also decreases the assimilatory area and capacity of the plant, and the number of flowers borne on each shoot. Increase in the number of the shoots compensates more or less for these losses in some cases, and also such features as the development of larger leaves in Podostemon subulatus or Hydrobryum olivaceum, but at length in the cases of extreme dwarfing seen in Dicræa, Griffithella, Hydrobryum, and Farmeria, we find the expanded green thallus the chief organ of assimilation, taking on more or less of the anatomical and morphological construction of a leaf, or rather of the flat thallus of many Bryophyta or Algæ. These two features, the dwarfing of the shoots and the expansion of the thallus, are evidently more or less correlated, but we are met by the usual difficulty, whether one or the other, or neither, may be regarded as cause or effect.

The peculiar thalli just mentioned may be roughly divided into two groups, the algal forms of Dicræa and Griffithella (and some Podostemons to a less extent), and the more lichen- or liverwort-like forms of Hydrobryum and Farmeria. The extraordinary resemblance of many of these plants to algæ, especially the seaweeds of the rapidly moving or rising and falling water of the seabeach, has often been noticed, and some special cases of resemblance in detail have been pointed out above. Comparison of the general conditions of life given in the introduction with those which obtain for seaweeds in such positions as are occupied by many Fuci, Himanthalia, Bostrychia, and many more, will show that there is a considerable agreement in the two cases. That this is so is also suggested by the behaviour of the interesting algæ described by Goebel,* found at the tidal mouths of large rivers (but in fresh, not brackish water, owing to the great size of these streams), where they are exposed to the air during part of the day. Bostrychia Moritziana is one of these forms, which in its morphological construction is closely analogous to Podostemon subulatus, and which also occurs in the rapids of the mountain streams of Guiana, occupying there the same localities as the Podostemacea, Oenone Imthurni, a plant with filamentous creeping roots, upon which are borne prostrate secondary thalli of shoot nature, but not

* Ueber einige Süsswasserflorideen aus Britisch-Guyana ; Flora, 83, 1897, p. 436 ; Eine Süsswasserfloridee aus Ostafrika ; Flora, 85, 1898, p. 65 ; and Organographie der Pflanzen, pp. 30-34, &c.

unlike in form to the leaf-like root-thalli of Dicræa Wallichii or some forms of D. stylosa. Another of these algæ, Delesseria Leprieurii, is remarkably like Hydrobryum lichenoides or Farmeria metzgerioides, leaving out of consideration the comparatively insignificant secondary shoots of these forms. The leaf-like thallus of some of the Dicræas, again, is parallelled not only by the shoot thalli of Oenone and other South American forms, but also by the large leaves of many American forms, and all of these organs are in many respects closely similar to the thalli of many of the seaweeds. Still more curious forms of the Podostemaceous thallus occur as we have seen in Griffithella, but these are also parallelled in the Himanthalias and other algæ. The whole subject of these resemblances between plants far distant in relationship from one another is of course one of great difficulty, and it is impossible at present to do more than point out these very suggestive analogies of form which accompany analogy of the conditions of life, and which seem to indicate that an experimental and comparative morphological study of the forms of the Algæ and Podostemaceæ should be attended with interesting results. The parallellism also indicates that it is by no means unlikely that the extraordinary polymorphism of the thallus, which occurs in certain genera and species of the Podostemaceæ, *e.g.*, in Dicræa and Griffithella, may have its parallel among the algæ, and consequently that the latter group requires investigation from this point of view, to strengthen its taxonomic foundations. In both cases we are dealing with organs which are not hindered by a skeletal tissue from growing into almost any shape, and in which therefore a variety of form may be easily liable to occur with any slight change in the conditions of growth.

Not merely do many of the Podostemaceæ present close similarities to the seaweeds, but the least modified group, the Tristicheæ, presents remarkable similarities in morphological features, and in the arrangement and anatomy of the leaves, to many mosses or liverworts, especially to those of wet situations. Here again, comparative and experimental morphological study is required in both groups.

To return from this digression, it would thus seem probable that the peculiar more or less expanded and assimilatory forms of the thalli (whether "shoot" or "root") in these highly modified plants, unique as they are among the higher plants, and parallelled in the lower plants with more or less similar conditions of life, taken together with the reduction of the secondary shoots, are largely adaptations to the mode of life, more especially to the rising and falling water with the attendant risks of exposure. The thalli and secondary shoots of course show, as Warming and Goebel have already pointed out, the common adaptations to life under water, such as flexibility of the drifting parts, absence of water-carrying or storing tissue except at the period of exposure for flowering, and so on. The most marked peculiarity, the absence of the large intercellular spaces, has been dealt with under Tristicha (p. 305), where it was mentioned that Goebel's explanation is probably the correct one, viz., that as the water is fully aerated, there is no need for the air spaces which in many water plants are needed for the oxygenation of the lower parts. That the Podostemaceæ are very closely dependent on the motion or aeration of the water is shown by the fact that if placed in still water in a vessel, or if cut off in a pothole by the fall of the level of the river, they quickly die.

Finally, we must briefly refer to the interesting stages shown in the life-history of the thalli, especially the changes that take place at the flowering season. In Ceylon they reach their full vegetative growth by about the end of October, and the secondary shoots begin to form their flowers in the last months of the year. By the time when the level of the water falls at the end of December the flowers are quite ready to open. Further north of course the floral development is earlier, corresponding to the shorter rainy season. In Tristicha ramosissima the flowers are developed upon all or most of the secondary shoots, upon short branches, and emerge from the water as soon as its level is sufficiently low ; by the time that the seeds ripen the thalli are commonly quite exposed upon the rock. In Podostemon subulatus the process is similar, but the flowers do not open till the water falls low enough to expose the tips of the spathes to the air. In the other genera the phenomena are more specialized, the secondary shoots being reduced and single-flowered. In general, all the secondary shoots do not become floriferous. In Hydrobryum, Griffithella, and Farmeria, it is usually the apical shoots which remain vegetative, and the same is the case in most of the Dicræas, but in D. Wallichii and in some forms of D. stylosa, and also at times in Griffithella, scattered shoots here and there over the whole thallus remain vegetative, while the rest flower. Details must be sought under the descriptions of the genera ; the interesting general point, and one which (*cf.* preceding paper, p. 191) has important taxonomic bearings, and has in the past led to much error and confusion, is the curious way in which the non-floriferous parts of the thalli fall away, leaving the now woody flowering portions.

During the flower development in the forms with reduced secondary shoots, the axis elongates, and an interesting change of form and function takes place in the leaves which are formed at this time (for details see Dicræa, p. 350), their sheathing bases enlarging to form bracts, while the filamentous assimilating tips finally fall away ; this process also, as explained in the preceding paper (p. 193) has led to many erroneous conceptions in taxonomic work based on herbarium material. Once fully exposed to the air in the flowering period, these tips soon fall off, together with any not woody parts of the thalli, so that the whole appearance of the plant is often changed. This is well illustrated in the plates accompanying this paper (*e.g.*, *cf.* XIV. with XV., XIX., 1 and 2, XXXIII. with XXXV., XXXVIII., 6, with V., &c.).

The Leaves.

These require but little discussion here. A distinction must of course be indicated between those of the primary and those of the secondary shoots, though in fact they appear to be quite similar in structure. In the Tristicheæ the leaves are singularly like those of many mosses, small, entire, and extremely delicate. In Mourera and other South American forms they are often of large or even immense size, and exhibit forms like those of many marine algæ. In the Indian Podostemeæ, however, they are always simple and usually subulate or linear. The two species of Podostemon, and Willisia selaginoides, have long leaves of considerable size, and those of Hydrobryum olivaceum may reach 10 cm. in length, but in the other forms the leaves are very small, rarely over 1 cm. long.

The dimorphism of the apical leaves in Lawia is very interesting, and is parallelled by what is found in Selaginella, and analogous to the construction of some mosses or liverworts. A time-dimorphism occurs in nearly all the other genera found in India. The vegetative leaves, as already sufficiently described, have slightly sheathing bases, but while the flower is developing the bases of the leaves become much enlarged and form sheathing scaly bracts, while the tips fall away. These scales show a lateral dorsiventrality of structure, in that the sheath is thicker on the upper side, and the more so the more marked the dorsiventrality of the secondary shoot.

A noteworthy feature of the leaves of the Indian Podostemeæ is the development of hairs upon the upper side, presumably for enlarging the absorbing area, as with the "Kiemenbüschel" described by Goebel and Warming in many South American forms.

The Haptera.

The morphology and the phylogeny of the peculiar anchorage organs which are so common in the order, and which Warming has named haptera, are questions of some difficulty. They are in general formed exogenously from the surface tissues of thallus or shoot, while these are young, and grow by a growing point rather like that of the roots. Not infrequently the apex shows a superficial layer of cells like the collenchymatous cap which occurs in most of the root-thalli, but very slightly marked, somewhat like that of the thallus of Podostemon subulatus. Reaching the substratum the haptera flatten out upon it. The flattening, and still more commonly a branching of the tip, commonly begin before the hapteron has reached the rock. As described in detail under Tristicha (p. 295), the hapteron behaves like a large root-hair or rather rhizoid.

Haptera, though exceedingly common, seem only to be developed when there is a definite need for their services as holdfasts, and it is consequently difficult to determine what is their phylogenetic morphological value, or whether indeed their occurrence is not another expression of the great plasticity of the tissues in these plants. Similar organs are common enough in Algæ, Lichens,* &c. Warming and Goebel regard them as organs *sui generis*, and probably this is the best course, though there seems no absolute improbability in their being modified adventitious roots, which have already gone through the change from endogenous origin to exogenous, such as seems in progress in the thalli of Hydrobryum olivaceum, &c.

The Spathe and Pedicel, &c.

The formation of the floral shoot from the vegetative, with the interesting change of structure and function in the leaves, has been sufficiently described. The interest of the floral bracts, spathe, and pedicel is chiefly taxonomic, and has been discussed from this point of view on p. 193 of the preceding paper. It is of particular interest in the present connection to point out the gradually increasing

* *Cf.* Sernander in Bot. Notiser, 1901; abstr. in Bot. Centr., 88, 293.

dorsiventrality of structure of these organs which accompanies the increasing prostrateness of the shoot. In the comparatively erect shoots the bracts are only slightly thicker on the upper than on the lower side, and the spathe stands erect and splits fairly uniformly into teeth at the tip, while in the Hydrobryums, &c., the bracts are very prostrate and much thicker on the upper side, and the spathe lies prostrate, splitting on the upper side to let the flower escape. In Lawia the spathe is physiologically represented by the cupule, which shows a marked dorsiventrality similar to that of the vegetative growing apices, and varying in the different forms.

Another interesting feature about these organs is the deciduous cortex of the pedicel, a phenomenon common to all the Indian and probably most or all of the other species. The length of the pedicel, as pointed out in the preceding paper, is a very variable feature, and the causes determining it require investigation.

The Flower and Fruit.

The main features of the morphology of these organs have been considered from a taxonomic point of view in the previous paper (p. 194), and need not be repeated here. Detailed accounts of many flowers and fruits may be found in the works of Tulasne and Warming, and also in the present paper.

The most interesting general features of the floral morphology are the substitution of the spathe for the perianth in all the more modified tribes, and the progressive dorsiventrality of the flower, which will be considered below. This dorsiventrality at last shows in the fruit also, the lower loculus being reduced or even abortive, and the ripe fruit splitting obliquely into two unequal valves. The development or absence of ribs in the wall of the ripe fruit is a character of anatomical and taxonomic importance. It has been sufficiently described and figured above under Dicræa, Podostemon, and Griffithella, which are good examples of the isolobous and anisolobous ribbed, and the smooth fruits respectively.

The natural history or ecology of the flower, like so many other features, also affords an interesting comparative study. The American Tristicheæ have a conspicuous entomophilous flower, projecting from the water on a long stalk, radial in structure, provided with a perianth, and freely visited by insects, to judge from the authors quoted by Goebel (13, p. 330). So far as the herbarium specimens show, most of the flowers seem to set seed, and as the seeds are small and very numerous, the plant has probably every advantage needed in this respect. In the next groups we find the perianth replaced by the spathe, an organ apparently composed of one or more of the uppermost leaves of the secondary shoot. As to how the change occurred, and as to whether it was of any advantage to the plants, we are as yet ignorant; further study is needed in South America. The perianth in these forms, *e.g.*, in Oenone, is still represented by a ring of small scales alternating with the andrœceum; the flowers are still insect-visited and emerge as before above the water, but as we progress along the series towards the Eupodostemeæ, we find a reduction of the size and conspicuousness of the inflorescence and of the individual flowers becoming more and more marked, and the flowers becoming dependent on the wind or on self-fertilization. At the same time the dorsiventrality of the flowers is increased by the loss of the upper stamens and perianth.

In the Eupodostemeæ, finally, we find a most remarkable state of things. The flowers are small and very dorsiventral, the perianth being absent or represented only by the two thread-like organs at the sides of the andrœceum, which itself is reduced to a single or forked stamen on the lower side of the flower. Even the fruit is dorsiventral in structure in some forms.

Dorsiventrality is usually supposed to be an attribute of entomophilous flowers, and to be a feature of direct advantage to them, and indeed this is probably very often the case. Here, however, we meet with the most extreme known zygomorphism in a group the flowers of which are wind- or self-fertilized, stand erect, and are very inconspicuous and not visited by insects. The dorsiventrality of the flowers seems, as will be discussed below in detail, to have been acquired at the same time that the flowers were progressing in the direction of increased anemophily and autogamy, and appears to be of absolutely no use to them, except in so far as it represents a reduction of the amount of material expended upon the construction of the floral organs. The more dorsiventral the flowers the more degraded their type, on the whole; they have, as compared with the higher American types, lost much of the certainty of the cross-fertilization, and gained little or nothing in certainty and abundance of seed, but only in reduction of material. However dorsiventral the flower becomes it still stands erect as long as it possesses a stalk, and when at last we come to the forms without the stalk we find the flower curving its ovary and stamens so as to get them as erect as possible. It seems as if the flower were, so to speak, struggling against the dorsiventrality to the last, and doing its best to try for a cross, even when the chance of such a thing has sunk to a very small figure.

It is difficult to resist the conclusion in looking at these flowers that the dorsiventrality which is the most marked feature of the order as a whole is not only no advantage to them, but is an actual disadvantage, against which they struggle, making various compromises, but always tending more and more in the direction of regular autogamy, which at last is adopted outright in Podostemon Barberi and possibly in other forms.

In the fruits of these plants we get perhaps even a clearer illustration of the general principle now under consideration. The fruit in this order is evidently a "land" fruit, and seems quite unsuited in itself or in the seeds for an aquatic existence; it shows no such adaptations as we may find in the Nymphæaceæ or other orders of water plants. It opens only in comparatively dry air, and the seeds are adapted to land existence for some time before germination. They ultimately germinate under water, but they are not suited to being shed in the first place into water. If dropped into water from the capsule they are carried away down stream, and have almost no chance or prospect of becoming attached in a place suitable for growth. One is surprised on the whole, in dealing with this order, to find so little provision for germination of the seeds in suitable places, where they can live and flourish. The only advantageous quality they seem to have in this respect is their small size, which helps them to cling in crevices of the rock or of the old thallus, but we must probably regard this as derived from their land ancestors, not as an adaptation. The mucilaginous outer coat, again, is rather a character of a land plant, and probably survives in the Podostemaceæ without being of any particular value to them in connection with their mode of life, though indirectly it must be of service. Wading birds may often be seen walking with wet feet over the fruiting thalli, and probably sometimes carry seeds to other localities. When a seed falls into a crack in an old thallus the swelling and subsequent shrinkage perhaps help to drive it well in. The fruit is very uniform throughout the order, the bicarpelled many-seeded symmetrical form persisting from Weddellina down to many of the Eupodostemeæ, *e.g.*, Dicræa. Here at last, however, the progressive dorsiventrality of the plants seems to show also in the fruit, and in Podostemon and Griffithella, Willisia, Hydrobryum, and Farmeria, the fruit is structurally dorsiventral, with unequal lobes. As Dicræa and Podostemon and Hydrobryum all live in similar circumstances, and all simply shed their seeds upon the rock as soon as the erect fruit opens, we cannot regard the asymmetrical development of the fruit as of any direct advantage; it would appear rather to be an expression of the continually increasing dorsiventrality of the floral parts in correlation with that of the vegetative organs. Perhaps in these cases, the dorsiventrality of the vegetative organs being greater, the gynæceum comes under its influence at an earlier stage in the development at the growing point of the secondary shoot. By a still further increase of the dorsiventrality we come to Farmeria indica, in which the interior of the fruit for the first time shows extreme vertical asymmetry, the lower loculus being aborted, while the placenta is developed chiefly at the distal end. In this form, too, for the first time, we find a reduction of the number of seeds to four without any intermediate stages showing in any other species, and a corresponding increase in their size. As however they are still shed upon the rocks, it is not easy to see if this is any advantage to them, or whether it is only another expression of the increasing dorsiventrality; but in the next species, Farmeria metzgerioides, we see the (so to speak) obvious next step taken, and the fruit, now dorsiventral to the extreme degree, remaining closed and sessile among the bracts, which thus hold the two seeds in position for germination *in situ* upon the rock when the water rises.

Here again, then, the dorsiventrality seems impressed upon the gynæceum and fruit quite apart from any consideration of direct advantage to the fruit or to the performance of its functions. In Podostemon the dorsiventrality is still slight, it increases through the series of Hydrobryums, and at last affects the interior of the fruit in one of the Farmerias, but without being of any apparent advantage. Then suddenly, we come upon Farmeria metzgerioides, in which, so to express it, the plant has been able at last to make a good use of the phenomenon.

The Seedlings.

It is not necessary to add much to what has already been said about these. We now have a general knowledge of the seedlings of Lawia, Dicræa, Podostemon subulatus, two species of Hydrobryum, and one of Farmeria, besides a couple of South American forms. It is very greatly to be desired that the other Podostemaceæ should be studied in this respect.

In plants which when mature show very unusual features in their morphological construction, such as the Cacti, Utricularias, &c., we are accustomed to derive valuable evidence as to the morphology of the plant from a study of its seedling, and the descriptions above given of the seedlings of many Podostemaceæ show that the seedling is a valuable subject for study here also, throwing considerable light on the morphology and the phylogeny of the thalli. Most of the interesting features of the seedlings have already been dealt with above under other heads, *e.g.*, the progressive reduction of the primary axis, the development of the thallus, the lack of exact homology between the primary axis and the secondaries, and so on. Dorsiventrality does not appear in the seedlings except in one or two cases, *e.g.*, in Podostemon to a very slight (and doubtfully hereditary) degree, and in Farmeria, in which as we have already seen the flower and fruit are extremely dorsiventral. The very peculiar case of the seedling of Lawia, in which dorsiventrality is acquired soon after germination, deserves special mention. In the other seedlings complete dorsiventrality is not as a rule acquired, the primary axis remaining radial in symmetry, and the dorsiventrality showing in the thallus. Like the mature plants, the seedlings of the Ceylon forms have simple leaves, while the American forms mostly appear to have compound leaves appearing at once after the cotyledons. It would be interesting to know the reason of this difference.

The seedling plants are well adapted to their peculiar conditions of germination and life. Except in Farmeria the seed is very small, and the seedling also, so that it is less liable to be carried away by the water. Haptera and rhizoids are formed at once on germination, so that the plant is firmly anchored, and as soon as possible the development of the thallus begins. In Farmeria metzgerioides, we have a peculiarly interesting case, the two seeds remaining inside the fruit, which is held firmly against the rock, so that germination takes place under the most favourable conditions for the successful growth of the young plant.

The dorsiventrality, dwarfing, &c., of the mature plants seem to show correspondingly in the seedlings, those showing them most early which have them most marked when mature, but we require a detailed comparative study of the family in this respect, such as Ganong has given to the Cactaceæ.*

Anatomy.

A number of anatomical features have been mentioned or described in the detailed part of the paper. Much also has been described by Warming, but there is yet need for much comparative investigation of these very curious plants, owing to the unusual features presented by the anatomy, in consequence of the far-reaching dorsiventrality of the vegetative organs. Attention may be called to the structure of the thalli of Lawia, Podostemon, Hydrobryum, Dicræa, &c., described above, to the presence of silica bodies, and to the peculiar growth in thickness of the vascular tissues in the thallus of Dicræa and of the cortex of the thallus in the same genus, as well as to the peculiar root-caps, especially the remarkable rim-like cap of Hydrobryum olivaceum.

In Dicræa and to a less extent in other genera, considerable anatomical changes take place at the time when the thallus is commencing to develop the flowers, owing to the demands made by the floral shoots for supplies of water and materials, especially when they are exposed to the air and begin to ripen their fruits. It is hoped to follow the present paper by others dealing with anatomy and other interesting features of many of the genera.

Owing to the peculiar habitat of these plants, and the rigidity given to the creeping thalli by the presence of so much silica, it would seem not unlikely that such genera as

* Ann. of Bot., 1898, p. 423.

Hydrobryum (*cf.* Plates XXXI., XXXIII.) would readily form fossils, which, if they had lost, as they probably would lose, their secondary shoots, might even be mistaken for liverworts. No fossil Podostemaceæ have as yet been described, but it is not unlikely that some may ultimately be found, perhaps in the mountains of North America or North-East Asia.

Physiology.

Under this head a few miscellaneous notes may be summed up, but the order still requires, and should repay, detailed physiological investigation on the spot.

Nutrition probably takes place through the surface cells in the same way as in other water plants, the rhizoids appearing to be chiefly or entirely anchorage organs. An interesting feature in the nutrition is the great quantity of silica often present in the surface cells of the thalli, less often in the leaves or shoots. In such thalli as that of Lawia it is present in such quantity as to blunt a razor in cutting a single section. Whether this silica is taken up from the rock or from the water must at present remain an open question, also the further question whether it has any physiological function. It makes the thalli more rigid, and probably helps in preserving them from too rapid drying up when exposed to air. Those thalli which contain a large quantity of it are able to withstand considerable exposure and yet revive when again submerged.

These plants expose large assimilating and absorbing surfaces, often further increased by the development of hairs on the surface of the leaves. The leaves show the general structure of shade leaves, and have usually chlorophyll in the epidermis. Most of the forms have a great development of anthocyan in the surface cells, and consequently a red colour when alive.

During the greater part of their life the Ceylon and Indian forms store up vast quantities of starch and other reserves in the thalli and bases of the secondary shoots, so that when the time comes, the development of the flower, its expansion, and the ripening of the fruit take place with great rapidity. As a rule some starch is left in the thallus after the seeds are ripe, and this helps in regeneration of the growing points if it be again submerged.

As regards sensitiveness to stimuli, there is as yet little to be said. The thalli do not seem at all rheotropic, but the creeping forms follow out every irregularity of the substratum, whether owing to effects of contact or of light or gravity. At the flowering period the stems change their sensitiveness and stand erect, though while developing they were commonly horizontal.

On the Dorsiventrality of the Podostemaceæ, and its bearing on current views of the Mechanism of Evolution.

No other family above the liverworts shows so marked and far-reaching a dorsiventrality in organization, and the Podostemaceæ are often quoted in discussions of this phenomenon. Their dorsiventrality has been described in general terms by Warming (43), Goebel (13, 14), and others, but several interesting points have as yet escaped notice, especially the remarkable series of stages in a progressive dorsiventrality exhibited by the members of this family, and the curious feature presented by so many of them, of erect anemophilous autogamous flowers, which at the same time possess the most extreme structural dorsiventrality which occurs among the flowering plants.

We may best illustrate this by a series of actual instances, working downwards from the less modified types of the order. In Tristicha ramosissima and in Weddellina squamulosa there is but little structural dorsiventrality of the plant taken as a whole; it is only expressed in the creeping position of the thallus. The secondary shoots stand up in the water, and are radially constructed, while the radially symmetrical flowers emerge through the water on erect xs. In Weddellina they are entomophilous, in Tristicha ramosissima anemophilous. Perhaps entomophily may be regarded as the more primitive condition in the order, but there is little evidence to prove this, and the point does not matter to the present argument. In the other species of Tristicha there is rather more dorsiventrality in the vegetative organs ; the thallus is similar to that in the preceding forms, but the shoots arising from it show a distinct bilaterality, the leaves being in lateral and upper ranks, and the branches in one plane, much as in a Selaginella or in the dorsiventral branches of many flowering plants. The flowers still appear to stand erect and to emerge through the water, but they also show signs of zygomorphism, in that there is a suppression of the upper stamen and of one lateral stamen as compared with the flower of T. ramosissima.

From these genera we branch off at once to Lawia, in which the vegetative organs already show the most extreme possible structural dorsiventrality, with a growing point symmetrical only about a vertical plane, and with upward displacement of the leaves. Nevertheless, perhaps because this dorsiventrality is of recent acquisition and heredity is strong, the flower is radial in symmetry, and stands erect as soon as it emerges from the cupule. This latter organ shows a strongly marked difference between its upper and lower sides, but though the flower is developed inside the cupule in a horizontal position, it does not itself show any sign of zygomorphism, unless it be in minor anatomical details.

The next stage is seen in the Oenones and Marathrums. Here the root is very like that in the preceding forms, but perhaps with rather more structural dorsiventrality, while the secondary shoots are strongly dorsiventral and prostrate. The flowers, however, are still erect and radial, and are apparently developed in a more or less erect position in the inflorescences. They are apparently insect-fertilized, but have the perianth reduced and replaced by the spathe as already described. Passing on a stage further, we come to the Lophogynes and Apinagias, which have strongly marked dorsiventrality in the vegetative organs, especially in the secondary shoots. Here, as in Tristicha hypnoides, we find the flowers again showing zygomorphism, in that the stamens on the upper side are suppressed, as compared with the radial flowers, and the upper stigma is often smaller than the lower.

From these we pass to the Eupodostemeæ, all of which show a very high degree of dorsiventrality in the vegetative organs and also in the floral, but the rule indicated above seems to hold throughout, that the dorsiventrality is most marked in the vegetative organs, and shows less or later in the floral shoot, spathe, stamens, stigmas, ovary, and fruit, in the order named. Thus in Dicræa there is a highly dorsiventral thallus, the growing point, as well as the other morphological and anatomical features, showing the asymmetry about the horizontal plane, but the secondary shoots, though reduced, still stand comparatively erect until late in their life, so that the earliest stages in the floral development, or the impulses to that development, perhaps occur at a time when the shoot is still not prostrate. The flower is extremely dorsiventral, and the upper stigma is smaller than the lower, but the fruit is isolobous. The flower, though horizontal or nearly so in the ripe bud, bends upwards and stands erect as soon as the spathe opens. The bracts and spathe both exhibit differences of structure between their upper and lower sides, but much less marked than in some of the succeeding genera; the difference is most marked in the most prostrate shoots, *e.g.*, in D. stylosa.

In Podostemon and Mniopsis the general characters are much the same, but the secondary shoots are longer and with marked structural dorsiventrality from the very first. The flowers emerge in a comparatively erect position, but show more zygomorphism than in Dicræa, in that the ovary is often rather larger in the upper than in the lower loculus, while the fruit, though erect, is always anisolobous, the larger upper valve persisting, while the smaller lower one falls off.

In Griffithella the vegetative organs are like those of Dicræa, but the secondary shoots appear to be more prostrate at an early period ; the question, however, requires further investigation. The flower and fruit show similar zygomorphism to that of Podostemon. The same is the case in Willisia, though the secondary shoots at the flowering time are stiffly erect ; their condition in the earlier period of the life-history has yet to be discovered. The thallus of this species, at any rate, is highly dorsiventral. In Castelnavia there is a highly dorsiventral thallus, accompanied by extreme zygomorphism of the flower and fruit ; in some species the flowers are developed in a horizontal position in cavities of the thallus.

In Hydrobryum the thallus is also highly dorsiventral ; the secondary shoots are like those of Dicræa, and late in life as the flowers develop, become exceedingly dorsiventral in structure, showing it in a high degree in the bracts, and in the spathe, which splits along the upper side. The flower, though developed in a more or less prostrate position, stands erect as soon as it emerges from the spathe, at least in those forms in which it possesses a stalk, while in the stalkless forms the ovary and stamens curve upwards as much as possible. It is extremely zygomorphic, and the various species show different degrees of the phenomenon. All show it in the stamens, but in H. Griffithii the fruit is only very slightly zygomorphic, though as it ripens it becomes more or less prostrate ; in H. sessile it is anisolobous and erect, and in H. olivaceum much the same, while in H. lichenoides its zygomorphism is extreme, correlated perhaps with the fact that in this form the secondary shoots are often comparatively prostrate throughout their life. In Farmeria the morphological construction is similar to that in H. lichenoides, and here we find the most extreme dorsiventrality in the family, though the flower still curves upwards when the spathe splits. The lower loculus of the ovary is much displaced towards the lower side, a pro that may be seen in an incipient stage in Mniopsis, &c., and its ovules are completely absent, while those of the upper loculus are reduced in number and increased in size, and the placenta is developed mainly at the distal end of the ovary. In this form dorsiventrality appears at last in the very embryo.

This remarkably interesting series thus seems to show clearly that in the whole of this family dorsiventrality is more or less strongly marked, and that its impress is first shown in the vegetative organs, *i.e.*, in the thallus and secondary shoots, followed by the bracts, spathe, and flower, while in the latter the stamens first and most commonly exhibit it, followed by the stigmas, carpels, interior of the ovary, fruit, and finally seed or embryo. Always the dorsiventrality is most strongly marked in the vegetative organs, and is often present in them to a slight or even great degree (Lawia) without necessarily showing in the floral organs, while when the latter are exceedingly zygomorphic the vegetative organs are usually still more so.

To put the matter in other words, it would appear that *the dorsiventrality of the flowers, which is the most important morphological character in the classification of this order, is a direct result of, or in direct correlation with, that of the vegetative organs*, being greater the greater the dorsiventrality of the latter.

This conclusion is confirmed by the argument from the ecological relations of the flowers. We have seen above that the dorsiventrality of the floral organs appears to be of no value to them, but if anything a positive disadvantage, and that as it becomes more and more marked the flower becomes more and more self-fertilizing by aid of the wind or by simple contact, while in Podostemon Barberi it is cleistogamic. At the same time, too, the flowers stand erect, an unusual feature in such zygomorphic forms.

It seems, then, not unreasonable to conclude that *the dorsiventrality of the floral organs has been*, so to speak,

... upon them by that of the vegetative organs, or by their position upon the latter, *without any reference to advantages or disadvantages to be derived from it in the performance of the functions of the floral organs themselves.* The only demand made upon them, so to speak, has been that they should not cease to set seed ; this they have continued to do with success, but in the more dorsiventral flowers the chance of cross-fertilization is much diminished, and even in some cases lost altogether.

To turn for a moment to the general conditions of life described in the introduction, the total of these, acting upon submerged organisms with creeping roots and secondary shoots and with subaerial flowers and fruits, would seem almost to necessitate more or less of dorsiventrality, and as the vegetative organs are in more direct relation to these conditions, the effect may be expected to show in them first or only ; that it shows also in the floral organs is perhaps an accident of the physiological nature of these plants or of plants in general. Whether the effect on the floral organs is direct, or through the vegetative, we cannot say. It would seem perhaps most probable that the dorsiventrality of the flower has not only followed but been determined by that of the vegetative organs and the bud-position; it never reaches any great structural intensity in cases where the dorsiventrality of the vegetative organs or of the position of the developing flower is not also highly marked. It apparently shows later in the evolution than the dorsiventrality of the vegetative organs, but it seems gradually to work through the series of floral organs, beginning with the bracts and spathe and showing at last even in the interior of the fruit and in the seed.

It should be especially noticed that the structural dorsiventrality of the flowers is accompanied by two other phenomena which are always regarded as of high morphological and taxonomic importance, suppression of parts (here shown in perianth, stamens, carpels, ovules) and union or branching of stamens or receptacular prolongation (according to the particular interpretation put upon the forked andrœceum of most of the Eupodostemeæ).

We can scarcely suppose the floral organs to have led the way in the dorsiventrality, because throughout the family we find the vegetative organs to be the more dorsiventral, and we have also seen that the floral organs appear to derive no advantage from their zygomorphism; further, zygomorphism is almost unknown in floral organs that are developed in erect positions on radially symmetrical organs.

The general conclusion we have thus drawn is led up to by two separate lines of argument, one from the morphological construction of the organs in the whole series of Podostemaceæ, the other from a consideration of the ecological features of the flowers and fruits. If it be correct we ought to find confirmative arguments from the general phenomena of dorsiventrality in other plants. A general comparison of these phenomena shows at once that dorsiventrality is much more common in the vegetative organs than in the floral, but that it is also frequent in the accessory organs of the flower, less so in the essential organs, especially in the fruit or seed. Again, within the same family, compare, for example, the slight dorsiventrality of the vegetative and floral organs of Potamogeton with the great dorsiventrality of those of Zostera and others. There are many cases in which the vegetative shoots are not themselves dorsiventral in structure, but the zygomorphic flowers which they bear are developed in horizontal positions, a feature which we have seen to be one of importance in determining the degree of dorsiventrality in the Podostemaceæ; even in these cases it is not to be forgotten that there is marked dorsiventrality in the leaves.

One of the marked features in the flowers of the Podostemaceæ is that the absent stamens are always those of the upper side of the flower; this again is an almost universal feature in other dorsiventral flowers, *e.g.*, in the

Tubifloræ, in the Orchidaceæ, Liliaceæ, Musaceæ, &c. The flower of Stellaria media is usually regarded as radial in symmetry, but Burkill,* by examination of a great number of flowers, has shown that there is a distinct tendency for the upper stamens to be most often absent; here perhaps we have the phenomenon in its incipient stage.

Again, in the Podostemaceæ the upper stigma is generally smaller than the lower, and this is a very common phenomenon among zygomorphic flowers.

With regard to the immediate mechanism of the production of dorsiventral structure, we as yet know but little. Vöchting has shown,† in certain cases of slight floral dorsiventrality, that rotation upon the clinostat during development will entirely prevent the curvatures of the organs concerned from taking place. Other phenomena have been noticed elsewhere, which tend to show that gravity has at least been an active factor in the production of dorsiventrality. In the peculiar thalli of Dicræa stylosa fucoides and Griffithella Hookeriana Willisiana above described, the thallus is usually drawn out most upon the lower side, while it is symmetrical if it grow in an erect position.‡ Light too may have something to do with the production of dorsiventral structure, by retarding the growth of the illuminated side, or in some more direct way. Further physiological and experimental morphological work is required before we can draw any definite conclusions in regard to the mechanism of the production of these or other morphological phenomena. In any case, the various possible agents have all a clear field for the full exertion of their action in most of the Podostemaceæ, in consequence of the peculiar mode of life of these plants.

It would seem then most probable that to a large extent dorsiventrality in the floral organs is due, not to natural

* Variation in the number of stamens and carpels. Journ. Linn. Soc., XXXI., 1895.

† Ueber Zygomorphie .... Prings. Jahrb., XVII., 1886.

‡ And *cf.* Goebel on Stereum, Flora, 1902, vol. 90, p. 471.

selection in reference to the performance of the function of the flowers, but to the direct action of other causes, and that directly or indirectly it is mainly the result of dorsiventrality of the vegetative organs and horizontal position in development. If we accept this view, it renders much more easy the task of explaining the structural peculiarities of many zygomorphic flowers, as we no longer need attempt to explain every detail of structure in reference to the visits of insects or to the advantages of cross-fertilization, and can easily explain many such cases as those in the Labiatæ, where, though (following the rule above indicated) the upper stamen is absent, the working of the mechanism of the flower is effected by having the stamens on the upper side, and so on.

If we do not accept this explanation, we have to find another to deal with the very remarkable facts. We can hardly suppose that the process of evolution in the order has been from the markedly dorsiventral to the less dorsiventral forms, for the former exhibit all the peculiar features of the order together, and are perhaps the most aberrant types among the flowering plants. If we do, however, accept it, we are driven then to suppose that the floral organs have become radial and entomophilous, and that the vegetative organs have followed by losing their dorsiventrality, though we know that the more dorsiventral they are the better they are suited to their peculiar mode of life, and the less competition the species meets with. This, then, would be a case of characters of great importance being forced upon the vegetative organs in spite of their disadvantage to those organs, or at least non-advantage. Probability, analogy, and the general evidence are all in favour of the former view, that it is the floral organs whose advantages have been disregarded in consequence of the imperative claims of the vegetative organs.

If we suppose the dorsiventrality of the flowers to have been the subject of natural selection, independently of the vegetative organs, we have to explain the very remarkable fact that its degree seems to depend upon that of the vegetative organs, and that it is never found without the latter, to say nothing of such difficulties as the erect position of most of the flowers and the apparent disadvantage of their dorsiventrality to them.

It is evident that if this general contention be accepted as probable it opens up many new points of view, and many lines of research. There is as yet no evidence to show how the reaction affects the actual sporangia, the gametophyte, or the essential sexual generative cells; the question requires investigation, in view of the fact that the lower groups of plants, from which the higher are supposed derived, are so largely dorsiventral in structure. The general evidence above seems to indicate that in the higher plants the dorsiventrality is derivative, and that radial structure has in general preceded it.

If, now, we accept the dorsiventrality of the flower as in great degree the consequence of that of the vegetative organs —let the mechanism or correlation be what it may—we are led to some important deductions which once more raise several questions which have of late been formulated from other considerations, and which must be set at rest.

If one character—or two, for suppression seems forced upon the flower of the Podostemaceæ as well as zygomorphism—of great importance in morphology and taxonomy may thus be forced upon an organ without reference to its advantage or disadvantage in the performance of the functions of that organ, it seems only likely that other characters may have been forced upon the same or other organs in similar or other ways, and consequently that the study of adaptation must enter upon a new phase, or rather, must be accompanied and checked by the study of experimental and comparative morphology, and of variation and correlation, if we are to expect further valuable results. The study of correlation has already yielded many interesting facts, but in ontogeny rather than in phylogeny; the case of the dorsiventrality of the flowers of the Podostemaceæ seems at last to provide a good instance of fixed or phylogenetic correlation, to support the few yet adduced.

It is also evident that the familiar statement that the characters of an organ or organism are partly hereditary and partly adaptive does not cover the whole truth, and that we must allow for the presence of what we may perhaps term correlative or induced characters, characters due to correlation or to the parallel action of similar causes, and not necessarily advantageous, though fixed in the heredity.

The objection is often brought against the theory of natural selection that many specific characters—and less often that generic characters—are useless to their possessors. Hitherto, however, so far as I am aware, few cases have been adduced in which it has not been possible to reply that further investigation may prove the usefulness of these characters, or that they may have been derived from useful characters in ancestral forms. In the few cases not to be explained in these ways, correlation has been adduced.* In the Podostemaceæ we have perhaps the best instance of some specific and still more generic and tribal characters, apparently due entirely or almost entirely to correlation or to direct action of external causes, and not to natural selection. Natural selection, however, may well have acted largely on the vegetative organs, which are most directly concerned with the external conditions of life.

We are perhaps, at least in Botany, too much in the habit of regarding evolution from an extremely analytical point of view, taking the characters of an organism singly, and more or less unconsciously assuming that the evolution has affected one at a time, as represented by a diagram of dichotomous branching in one plane, such as that given by Darwin† to illustrate the possible formation of new species, and thus implying that a change in any organ must necessarily be accompanied by some advantage to that organ or

* *Cf.* Darwin, Origin of Species, 6th ed., p. 116; Wallace, Darwinism, ch. VI.

† Origin of Species, 6th ed., p. 90.

to the organism of which it forms a part. We ought rather to consider the whole organism or species together, remembering that there may be for it a kind of general balance sheet of profit and loss,* in which it is not necessary even for success and expansion that there should be a profit under every item, but that the species will lose or gain according to the balance on the total of all the items, some of which may in themselves be very disadvantageous. In the Podostemaceæ we have a striking case in point. Once in the rushing water, the general conditions of life and variation, in conjunction with the hereditary peculiarities of the family, have produced, so far as we can judge, a certain general type of vegetative structure and habit suited to the environment, while the floral system has been forced to accommodate itself to the changes of the vegetative, the only demand made upon it being that it should continue to set plenty of seed and try for cross-fertilization as much as possible under the circumstances. The disadvantages of the floral construction forced upon these plants have apparently been made up for by the advantages of the vegetative.

Another interesting point brought out by this method of looking at the facts is the insecurity of the basis on which our conceptions of species (at least the large "Linnean" species), genera, and still more the higher groups rest, and the great need for a more exact and quantitative foundation in our science. Supposing in the case in question that the dorsiventrality of the environment and heredity were to act only on the vegetative organs, without any correlative or induced action upon the floral organs, we might then have to include almost all the Podostemaceæ in perhaps three or four genera at most, as we should only have a very few marked distinguishing points, *e.g.*, the presence or absence of perianth, the distinction between shoot- and root-thalli, between thread-like and ribbon-like

* *Cf.* Bateson, Materials for the Study of Variation, p. 12 ; MacLeod in Bot. Jaarb, V., or abstract in Willis, Manual and Dictionary, vol. I., p. 46.

thalli, and so on. Most of the present genera and tribes would be united with others, or perhaps the tribes might become genera, the genera species, though in nearly all their essential features, *i.e.*, in those related to the environment and to the mode of life, the plants would be as different as ever. This insecurity must remain until the study of experimental morphology with variation and correlation shall provide us with a more reliable quantitative test of generic and other differences. On the whole, perhaps, our specific and generic grouping will be found ultimately supported by the facts of evolution so far as they may be discovered, but it is well at times to remember the insecurity of our position. It is partly in view of this insecurity of the larger grouping, that though in the classification of the Indian Podostemaceæ in the preceding paper I have used the large Linnean species, I have used proportionately small genera, in which vegetative characters have been possible of use in addition to the floral.

The next question that may be raised is whether many of our groups, such as the Linnean species, and still more the genera, tribes, sub-orders, orders, and larger groups are or are not polyphyletic. The question is already being raised by the fact that so many of the largest groups, *e.g.*, the Fungi, the Gymnosperms, the Sympetalæ are proving to be polyphyletic, so far as the evidence of palæobotany and morphology enables us to judge, but the considerations above given raise it from a different standpoint, and enable us to see one way in which the phenomenon may have arisen. We can easily imagine a case like the following. Let A be a species of Podostemaceæ, with a marked but not extreme dorsiventrality of the vegetative organs, and let it give rise by gradual evolution to three species, K, L, M, of which K and M are more, L less, dorsiventral than itself in the vegetative organs, while in all other respects K is more nearly allied to L than to M. Now let these go on to evolve further species, X, Y, Z, respectively, the dorsiventrality still increasing in the case of the first and last, but X and Z remaining nearly akin to Y in every other respect. The increasing dorsiventrality will at least re-act on the floral organs—let the mechanism be what it may—and the latter will show increased dorsiventrality. Now the phenomena of this increasing dorsiventrality seem, as we have seen, to follow fairly definite laws, and hence it is by no means unlikely that the same phenomena will show in X and Z, while they do not show in Y, which has not increased its vegetative dorsiventrality. We shall thus get a polyphyletic genus formed, with two species X and Z, which may be each as nearly akin to Y as to one another, though Y is not included in their genus. The genus will be polyphyletic in that there is no common ancestor which possesses the generic characters.

There is no necessity, perhaps, for the case to be so simple as that just sketched. It is quite possible that species not at all closely allied may take the same generic step, so to speak, which brings them close together in our schemes of classification, though their immediate ancestors might have been far apart by the criteria used.

The same reasoning will of course apply to the case of a number of forms taking a similar tribal or sub-ordinal step when the conditions occur, and in fact the larger the group and the fewer the characters on which it is based, the greater the likelihood of its being polyphyletic.* It is by no means unlikely that some of the many cases of genera where the different species seem to have each of them some of the generic characters of surrounding genera, while all have their own generic character, may be due to some such process of evolution as that just sketched. Thus in Hydrobryum it is quite possible that the smooth-fruited H. sessile may belong to a different phylum from the other species with ribbed fruits, or in Farmeria, that the two species may be derived from different phyla, though of course the facts may be explained on other hypotheses. Just as an idea or a discovery

* An old rule in a new and more easily-fitting dress.

is very often made approximately at the same time by more than one mind acting on somewhat similar materials in similar ways, so we may imagine the same generic or ordinal step taken by allied or similar species at about the same time or in relation to similar causes. This of course is only a supposition, but the question as to whether many genera and other groups are or are not polyphyletic is raised on sufficient evidence to require that it shall be investigated and set at rest, as well as the further question, whether, if any genus or other group is found to be polyphyletic, it is to be retained as an artificial group or divided into others, even though there may be the very closest similarity among its members.

It is evident that if the phenomena here suggested are at all common, the process of evolution may in these cases have been much swifter than we are usually inclined to believe, many forms perhaps having undergone parallel developments, so that the evolution may be likened to the climbing of steps by several individuals at once.

To follow up the same line of thought, it is clear that it may considerably alter some of the prevailing views upon geographical distribution, for if the generic or ordinal step may be taken separately by similar or allied species, these species may be already separated by large distances, and the genus or order may thus conceivably arise in two or more phyla at different places. It is no longer absolutely necessary to suppose, to take the particular case in hand, that the extremely zygomorphic-flowered Eupodostemeæ must have spread from a common centre occupied by one original ancestral species with the sub-ordinal characters; there may have been, in India and in the other regions where this sub-order is found, several species which under the influence of similar causes may have taken the steps, so to speak, which transformed them to representatives of this sub-order. All that is necessary is the final stage in the zygomorphism of the andrœceum, reducing it to one single or double stamen on the lower side of the flower.

Indications are accumulating from many quarters, from palæobotany, from morphology, from the study of variation, and from other considerations, to show that the question of the possible polyphyletic origin of many groups hitherto supposed monophyletic, whether large species, genera, orders, or higher groups, is one which will soon demand much attention. Should this phenomenon prove to be at all common, it will of course explain many problems which have hitherto been great difficulties to students of evolution or taxonomy.

All these suggestions of course contain a large element of speculation, but if we admit, and the evidence in its favour seems fairly strong, the first hypothesis, that the dorsiventrality (including suppression of organs, &c.) of the flowers, fruits, and seeds of the Podostemaceæ has been very largely determined by causes having nothing to do with their functions, while at the same time we regard these features of the floral structure as our great criteria in classification, all the questions above raised follow inevitably, and once raised on good evidence they must be settled one way or another before we can feel secure as to the stability of the foundation upon which so imposing a structure has been raised in the sciences of biology. If we do not admit the hypothesis, we must find another which will as well explain the facts, themselves so striking that they demand explanation.

It is clear that we require a detailed investigation of most of those comparatively constant structural features, especially in the floral organs, upon which we base our classifications, in order to discover among other things, whether, as seems to be the case in dorsiventrality, there is any correlation between them and any of the features of the vegetative system, or any other factors which may have been more or less causal; any such correlation once traced or even imagined, the phenomenon should be the subject of physiological and experimental morphological investigation, as well as of variational studies.

The Geographical Distribution of the Indian Podostemaceæ.

Owing to their being confined to mountain streams, and to their somewhat imperfect mechanism for seed-dispersal, the Podostemaceæ are very local in their distribution, and as has already been several times mentioned, each river or group of rivers or even each section of each large river often possesses its own local forms or species of each genus represented in it. With a complete knowledge of the forms in all the mountain streams of the tropics, it should be possible therefore to arrive at conclusions of great importance as to geographical distribution within these regions, but at present only the beginnings of such knowledge are at our command.

The only method of distribution which appears to be of any avail to carry these plants from one river to another is the adhesion of the sticky seeds to the wet feet of wading birds; these may often be seen in the dry season walking over the thalli, and the seeds must cling to their feet. It is therefore unlikely that any carriage of the seeds over more than a few hundred miles ever takes place. and in general the distances travelled will be much less. As in India and Ceylon the flowering takes place in the north-east monsoon, and as it is easier, in all probability, for a plant to suit itself to a longer than to a shorter vegetative period, it would seem not unlikely that the general migration may be southwards rather than northwards; but there are numerous other factors to be taken into consideration, and it is not safe to say more than that perhaps this is the tendency at the present time.

The order is practically confined to the tropical regions of the globe, and only passes into the warm temperate zones in a few districts. The local distribution of the forms is of considerable interest, and helps to throw light upon their evolution and adaptation. So far as India and Ceylon are concerned, we find that in general the larger forms live in the lower levels of the country, in the larger streams, and in the more southern districts, *i.e.*, in the districts with the best distributed rainfall and the longest vegetative season. This may be best shown by a few examples. Thus in Ceylon the species that occur at the highest levels are Hydrobryum lichenoides and H. olivaceum, while those that descend lowest are the large Dicræas. In the Nilgiris H. olivaceum is found at least as high as any, accompanied by the most prostrate of the Indian Dicræas, D. dichotoma, while the large species of the Malabar region, Tristicha ramosissima, Podostemon Barberi, Dicræa stylosa, &c., occur at low levels. Or again, to consider the size of the streams, whether in Ceylon, South India, the Bombay Ghats, or Assam, the only species found as yet in really small streams (often in mere becks of a yard or two in width) are Hydrobryums, Lawias, and Farmerias, with rare exceptions. Again, to deal with the latitudinal range, the species which go furthest into the more northern regions of short vegetative season are also the Lawias and Hydrobryums, while the larger genera are confined to the more southern regions. Lastly, consider the immediate local habitat of the species growing at one place, *e.g.*, at Hakinda. As has been fully described under the individual forms, each form has in general its own peculiarity of habitat, and is but little mixed with the others, except at places where the conditions vary very much in a small area, for instance where an eddy joins a swift current in the main stream. As will be easily seen by reference to the details of habitat given under each species, the larger forms live in the less rapid and violent water, which of course is also the less liable to rapid shallowing.

It is thus evident that the dwarf forms affect, and are apparently best suited to, swift streams and rapid water which may easily or quickly become shallow. The question then arises, whether their adaptation is to the swiftness or to the shallowness, or to both. Probably, as has already been pointed out, the latter condition is the more important, as even the large forms can stand much swifter water than what they usually affect without difficulty, and some of the dwarf forms, *e.g.*, Hydrobryum olivaceum, only become completely dwarf as the water-level is falling, and have tall shoots at the season of deeper and swifter water. Some of the largest American forms inhabit very rapid water.

With regard to the local distribution of the different genera, it may suffice to note that the richest region is the south-western corner of India, together with Ceylon; here there occur three endemic genera, Lawia in the Tristicheæ, and Griffithella and Farmeria in the Eupodostemeæ, while there are endemic species in Tristicha, Podostemon, Dicræa, and Hydrobryum (and probably Willisia). Only the three last occur in the eastern peninsula. It will be noticed at once that the distribution of the Podostemaceæ in Ceylon and South-West India is just like that of the so-called Malayan element of the Ceylon and Malabar flora, rich in the south and fading out to the north. Only one species has as yet been recorded from the Malayan region (30), but this shows affinities to the Abyssinian Sphærothylax. Tristicha and Dicræa have their nearest relatives in Madagascar, while Hydrobryum, the most widely distributed of the Indian genera, is related to Sphærothylax. It would seem, therefore, not impossible that the order reached India and Malaya (including Burma and Assam) from the south-west, but if so, there must almost certainly have been, in the land forming the passage between India and Madagascar,* some hilly or mountainous country, for even Tristicha and Dicræa require fairly rapid water with a rocky bottom.

The Origin of the Podostemaceæ.

This is a somewhat difficult question, which must be left for detailed consideration in connection with the anatomical investigations yet to be completed. The embryonic development and characters are so typically dicotyledonous, and

* *Cf.* Willis and Gardiner. The Botany of the Maldives, Ann. Perad., I., 1901, pp. 5, 141, 161

the other characters of the flowers and fruit, &c., are so simple, that one must regard the order as representing an old phylum of true Dicotyledons. The next question that arises is whether it has descended from aquatic or terrestrial ancestors. On the whole, considering the terrestrial type of both flower and fruit, the latter seems most probable. A possible origin for the order seems to be from plants already growing on the banks of mountain rivers, with creeping adventitious roots upon which secondary shoots were regularly developed. We can imagine these plants "taking to the water" by means of these shoots, which in the intermediate period of transition would have to be more or less amphibious. Possibly the anatomical difference between the primary axis and the secondaries may indicate that the latter became adapted to the new existence sooner than the former. We do not yet, however, so far as I am aware, know to what extent primary and secondary axes differ in other plants. The anatomy of the primary axis in the few Podostemaceæ yet examined is more like that of other water plants than that of the secondaries, which perhaps indicates the origin of the order from some form akin to the Nymphæaceæ or other ancient group of water plants, far back in the evolution of the Dicotyledons.

The Systematic Position of the Podostemaceæ.

This also is a question for further discussion when further evidence shall be available. The family is very isolated, like so many other groups of submerged water plants. In our present ignorance of the phyla of the evolution of the higher plants, the most we can hope to do is to trace some line of apparent descent near to which we may place the order. I have already indicated* that I regard the Sympetalæ, as do many other authors, as polyphyletic; one of the lines of their phylogeny seems to me to run through the neighbourhood of the Englerian cohorts Rosales, Myrtifloræ,

* Manual and Dictionary, vol. I., p. 68.

and Contortæ, connecting to the Tubifloræ. Now there is little doubt that the Podostemaceæ have some affinities to the Saxifragaceæ, as pointed out by Warming (43), and to the Lentibulariaceæ, as pointed out by Hooker (18), while long ago Gardner (12) pointed out what is possibly their nearest relationship, viz., to the Nepenthaceæ and the allied orders, such as Sarraceniaceæ. These are tropical orders, and the ancestors of the Podostemaceæ were probably also tropical. On the whole, therefore, I think that the order may well be placed near the cohorts Rosales and Sarraceniales, but the whole question requires much further investigation.

The General Evolution of the Podostemaceæ.

To sum up in a few words the general bearing of the above discussion upon the question of the evolution of these plants in reference to the general conditions of life which were considered in the introduction, we may perhaps regard it as not improbable that the order is descended from tropical Dicotyledonous plants rather far back in the evolution of the Dicotyledons. These plants may have been aquatic or may have been terrestrial; they probably had creeping adventitious roots bearing secondary shoots, and capable, like most such roots, of rejuvenescence after any injury to the apex; their flowers were probably erect, regular, with simple perianth, insect-fertilized; their seeds small, ripening in the dry season of the year. Gradually we can picture these plants taking to life in moving water with a rocky bottom, to which their roots would fasten them, and later, as the water strain became greater, developing haptera (perhaps by some modification of roots) to resist this strain. The roots, thus becoming more exposed to the action of light and contact, as well as of gravity, would probably, like the creeping roots of orchids, &c., tend, under the influence of one or more of these causes, to become more or less flattened and chlorophyll-bearing. Accompanying this expansion of the root and its assumption of assimilatory functions there would appear to have been usually a dwarfing of the secondary shoots, ultimately going so far as to reduce their axes almost to nothing, as in the Dicræas and the Farmerias. As this dwarfing progressed, the plants would become more and more suited to life in shallower (and in general also swifter) water, and would spread into regions of shorter vegetative season, into the higher regions of the hills, and into the smaller streams, as well as into the swifter water of the larger streams. In this way they would escape more than ever from competition, and perhaps be enabled to evolve in greater variety of form than might otherwise be the case.

The dwarfing at the same time would seem to have been accompanied by an ever-increasing dorsiventrality of the vegetative structure, the roots becoming more and more flattened and thalloid, and taking over more and more the functions of assimilation. This dorsiventrality would seem to have ultimately re-acted on the floral organs, which became more and more zygomorphic, with suppression and other important phenomena accompanying the zygomorphism. At the same time the flowers appear to have become more and more anemophilous and self-fertilized. Most, if not all, of the changes in floral morphology on which the groupings of the order are largely based would seem thus to be correlative or induced, and not to have been the subject of natural selection, unless in a very minor degree, a conclusion which opens up interesting general considerations.

In conclusion, I wish to thank, in addition to the friends mentioned at page 182 of the preceding paper, my wife, without whose help this paper would never have reached its present state of comparative completeness, Professors Warming and Goebel, and Dr. Treub, to whom I am indebted for references and criticisms.

Peradeniya, July 15, 1902.

Explanation of Plates IV.–XXXVIII.

Note.—In consequence of its having been decided, after some of the later plates had already been printed, to omit certain anatomical details, it has been found necessary to omit Plates XXIII., XXVII., and also the last two Plates (already mentioned in the preceding paper) XXXIX. and XL. The total number of plates published with this paper is thus 33.

All drawings and photographs are the work of the author, with the exception of fig. 2, Pl. XXX., for which he is indebted to Mr. A. de Alwis. It may be noted that the photogravures, being prepared directly from the negatives, show much detail, and will bear a magnification of two or three diameters under a lens.

Owing to the great local differences in these plants the source of the material is quoted in most cases.

Plate IV.—General view of part of Hakinda rapids on the Mahaweliganga near Peradeniya (the background is part of the forest reserve of the Experiment Station), showing Podostemaceæ exposed upon the rocks in the dry season.

The island rock in the left-hand bottom corner is covered with fruiting Dicræa elongata; the rock to the extreme left, in the sheltered bay, is covered with Podostemon subulatus. To the right of it, in the less rapid part of the main current, is Dicræa elongata. The rocks at the little fall (which is about 3 feet high) are covered with Hydrobryum olivaceum, while the parts between the fall and the Dicræa bear both this species and Lawia zeylanica, as also does the central island.

Plate V., **Tristicha ramosissima**; herbarium specimen prepared by Mr. C. A. Barber by floating out under water (material from S. Kanara, No. 2,518), × 4/7. This gives a very clear idea of the general habit in the vegetative condition; the creeping root-thallus runs through the middle of the sheet, giving off secondary shoots (often paired) with hapterous bases, and bearing branches of two kinds, long and short, the latter (ramuli) with filamentous leaves.

Plate VI.—The same. The left-hand specimen shows the branching clearly; at each node two branches, long and short, the latter below the former. The right-hand specimen shows the floral and fruiting shoots, and the way in which the ramuli lose their leaves at this season. The floral shoots have a few leaves at their bases, and a couple of ramuli, and stand erect, emerging from the water in which the main shoot is drifting.

Plate VII., **Tristicha ramosissima.**—Fig. 1 Portion of thallus (*th.*) attached to rock, showing hapterous discs or feet (*h.*), from which the secondary shoots (*s.s.*) spring, × $1\frac{1}{2}$ (C. A. B. 2,518). 2 Tip of thallus in optical section, showing root-cap (*r.c.*), × 35 (Anamalai). 3 Rhizoids developing from thallus, × 60 (Anamalai). 4 The same against the rock, with dark cement secretion. 5 Portion of thallus (*th.*) with commencement of development of endogenous secondary shoots (*s.s.*), × 6 (Anamalai). 6 The same, later, with hapterous foot (*h.*). 7 Transverse section of thallus, feet, and secondary shoots, diagrammatic, showing endogeny of shoots (*s.s.*), and vascular strand (*v.b.*) with its branches to shoots, × 35 (Anamalai). 8 Lower end of a hapteron, showing mode of branching and spreading upon the rock (Mundakayam), × 3½. 9 Portion of thallus with peg hapteron developing, and first appearance of secondary shoot (*s.s.*) near top of hapteron (do.), × 3½. 10 Base of a full-grown secondary shoot, with large haptera (*h.*) on rock, × 3½ (do.). 11 Optical section of apex of ramulus, showing development of leaves, × 320 (C. A. B. 2,517). 12 Stem with two leaves (*l.*) and ramulus (*ra.*), × 15 (Anamalai). 13 Tip of leaf of ramulus, × 400 (C. A. B. 2,517). 14 Base of same, in optical section, × 400 (do.). 15 Stem, near apex, with ramuli (*ra.*) and branches of unlimited growth (*br.*), × 2 (do.). 16 Ramulus of Anamalai plant, × 4¼. 17 Transverse section of young stem, showing epidermis (*ep.*), parenchymatous cortex (*p.c.*), and vascular strand (*v.b.*), × 80 (C. A. B. 2,517). 18 Transverse section of stem lower down, showing inner and outer collenchymatous cortex (*i. col.*, *o. col.*), × 80.

Plate VIII., **Tristicha ramosissima.**—Fig. 1 Transverse section of stem in vascular region, showing inner collenchyma and bundle. In the latter the cells, as at *g.g.*, show a certain tendency to grouping, × 320. 2 Shoot from herbarium material (Mundakayam) showing two lateral branches with ramuli; these lateral branches seem to be of very slow growth or to have ceased growth at an early period, × 1½. 3 A single lateral shoot from the preceding, × 5. The arrangement of the leaves is drawn from poor herbarium material, and is probably incorrect. 4 Shoot arising on thallus in December, with haptera (*h.*) forming at base, and with minute leaves, × 3½ (Mundakayam). 5 Similar shoot in half-ripe fruit, with ramuli and hapterous base. On the thallus (*th.*), besides three other similar shoots, there is arising at *x* a very short floral shoot, consisting practically only of a cupule with flower, on a reduced axis, × 3½ (C. A. B. 2,517). 6 Flower, × 6 (do.). 7 Cross section of pedicel of young flower, × 80, showing epidermis (*ep.*), parenchymatous cortex (*p.c.*), central cylinder (*st.*), and medullary cavity (*m.c.*). 8 The same in half-ripe fruit, with the outer part of the cylinder (*lig.*) woody, surrounding the thin-walled vascular tissue (*v.t.*). 9 The same in ripe fruit, the parenchymatous cortex fallen away.

Plate IX., **Tristicha ramosissima** (figs. 1–3). 1 Transverse section of pedicel of flower, showing medullary cavity (*m.c.*) with vessels (*v.*), phloem-tissue (*phl.*), and lignified tissue (*lig.*), × 600. 2 Floral shoot with half-ripe fruit, showing cupular leaves, ramuli, &c., × 4 (Mundakayam). 3 Cupule, with flower removed, in section, × 4.

Lawia zeylanica (figs. 4–14). 4 Seedling just germinated, showing cotyledons with indication of plumule between them, swollen hypocotyl, and rhizoids fastening it to the rock, × 35. 5 Older seedling, with five leaves, × 11. 6 A similar seedling, from behind, × 11. 7 A slightly older seedling, from above, × 11. 8 An older seedling, from the side, showing the lateral growth of the thallus and the dimorphism of the leaves, × 11. 9 The same, from above, × 11. 10 A growing point in which the distichy of the lateral leaves is unusually well shown, and in which the upper leaves look as if together they might represent a third rank, × 4. 11 Tip of a thallus showing the formation of a branch, and the large leaf standing centrally in the fork, also the mode in which the lateral leaves overlap, × 6. 12 Large seedling, showing mode of growth, arrangement of the leaves, and mode of branching, with gradual breaking away of thin tissue between branches, × 9. 13 A small plant of *L. z. Parkiniana*, nat. size. 14 A growing point of the same enlarged.

Plate X., Lawia zeylanica.—Ripe fruiting plants, dry, on pieces of rock, taken in the dry season, × 7/15. 1 (left-hand) *L. z. Gardneriana*, showing short pedicels, fruits, and general amorphous appearance of the thallus as seen in most cases at this season. 2 (large stone) The same, an unusually good specimen, showing the branching of the thallus and the fan-like apices. The margins are covered with cupules, the openings of which can be clearly seen, the fruit-stalks having fallen out. 3 (upper right-hand) *L. z. konkanica*, from Kasara, showing the longer pedicels; the form of the thallus cannot be distinguished. 4 (lower right-hand) *L. z. malabarica*, C. A. Barber, S. India Flora, No. 2,525, from Beltangadi, showing pedicels of intermediate length.

Plate XI., Lawia zeylanica.—1 Transverse section of thallus (var Gardneriana), × 320, showing epidermal layers (*ep.*), parenchymatous cortex (*p.c.*), vascular bundles (*v.b.*), and silica bodies (*s.*). 2 Thallus in surface view (*Gardneriana*, gathered in December, 1898), showing fan-like lobes, with numerous growing points now each forming a cupule, arrangement of the leaves along the course of the vascular bundles (*v.b.*), and appearance of the endogenous rosettes (*ros.*), × 5/3. In the right-hand lobe the leaves are omitted and the course of the bundles alone indicated. 3 Portion of a leaf in surface view, × 500, showing silica bodies (*s.*) and elongated central cells (*v.b.*). 4 Transverse section of leaf, × 240. 5 Vertical longitudinal section of a growing point, × 150, showing the meristem (*m.*), the upper and lower leaves (*u.l.*, *l.l.*), and the collenchymatous cell-layer on the lower margin (*col.*). 6 Transverse section of thallus, × 20, through the origin of a rosette, showing the new meristem (*m.*) developing leaves (*l.*); *ep*, the epidermis of the thallus. 7 The same after emergence of the leaves, × 15. 8 A growing point forming by rejuvenescence on the edge of the thallus, × 6. 9 *L. z. Parkiniana*, a specimen showing the branching and the rosettes, × 8/7.

Plate XII., Lawia zeylanica Gardneriana.—A museum specimen preserved in alcohol, × 5/6. Young plants in vegetative condition, gathered in August or September at Hakinda, showing the mode of branching, the general form, and the flabelliform apices. Some of the large lobes show division by small hedges of leaves (represented by white lines) forced upwards by the lobes against one another.

Plate XIII., Lawia zeylanica.—1 Apices of var. *konkanica*, in fruit, × 4½. 2 The same in section to show the shallow cupule. 3 Cupule and open flower of var. *malabarica* (C. A. Barber, No. 2,150), showing the stamens closely pressed against the stigmas at anthesis, × 5½. 4 Transverse section of vascular strand in pedicel of flower, × 600, showing parenchymatous cortex (*p.c.*), lignified tissue (*lig.*), and medullary cavity (*m.c.*). 5 Cupule of *L. z. Gardneriana*, × 6, before emergence of flower. 6 Flower of *L. z. konkanica* (Igatpuri) emerging under water from shallow open cupule, × 5. 7 Fruit of the same, × 5. 8 *L. z. Gardneriana*, longitudinal section of cupule (*cu.*) and included flower, showing leaves (*l.*), anthers (*anth.*), stigmas (*stig.*), ovary (*g.*), and perianth (*p. r.*), × 30, 9 Transverse section of the same, diagrammatic, × 20; *v.b.*, the vascular bundles. 10 Transverse section of flower of *L. z. konkanica* (Kasara), × 45, showing perianth, stamens, ovary, placenta, vascular bundles, &c.

Plate XIV., **Podostemon subulatus.**—1 (left-hand) Stone with fruiting stalks, × 2/3. Most of the fruits have lost one valve. The secondary shoots are more or less concealed in a mass of dead shrivelled leaves (*cf.* Pl. XV.). **Dicræa elongata.**—2 (small upper left-hand stone) Fruiting specimen, in which the creeping thalli are bearing fruit, for comparison with fig. 3 and Pl. XIX., × 2/3. **D. dichotoma.**—3 (upper right-hand) Fruiting specimen, × 2/3, showing creeping thallus with distichous fruiting shoots; the free drifting ends of the thalli mostly absent. **D. stylosa kanarensis.**—4 Fruiting specimen, × 2/3, showing long pedicels in most cases, but with some short ones. The broad alga-like thallus can be seen in the upper left-hand part.

Plate XV., **Podostemon subulatus** Mavœliæ, × 4/5.—Plant gathered at Hakinda in August, in full vegetative growth, showing the long distichous leaves and tufted habit. To the left are isolated secondary shoots, united at the base by the thread-like creeping thallus.

Plate XVI.—The same. 1 Seedling, × 5½, showing cotyledons (*cot.*) and first two leaves. 2 A larger seedling, × 5½, with beginning of thallus (*th.*). 3 An older seedling, with thallus bent into line with axis, × 5½, showing branching of thallus and first endogenous secondary shoot (*s.s.*). 4 Apex of a thallus, × 16, to show origin of secondary shoot. 5 An apex from above. 6 Portion of a young plant, × 4, showing the way in which the thallus branches right and left alternately, and the origin of the shoots (*cf.* fig. of Bostrychia Moritziana in Goebel's Organographie, p. 32). 7 Transverse section of thallus, × 20, showing outline, vascular strand (*v.b.*), and the foot formed by the root-hairs (*f.*). 8 Transverse section of secondary shoot through leaves at apex, × 10. Plant in vegetative condition, gathered 1-9-98; the concavity of the shoot is towards the upper side, and the leaf-sheaths are thicker on that side; *v.b.*, the vascular strands. 9 Transverse section of pedicel of flower, × 150, showing epidermis (*e.p.*), more columnar on upper side, parenchymatous cortex (*p.c.*), and vascular bundle (*v.b.*). 10 Flower in open spathe (*spa.*), × 6; *l.l.*, the leaf in whose lower axil it arose; *std.*, the staminodes or perianth segments at sides of andrœceum. 11 A fruiting secondary shoot in dry season, nat. size. 12 Fruit, × 6, from side that was upper in bud, showing back of larger lobe, with its three decurrent ribs. 13 The same from the side, showing the way in which the smaller valve breaks away.

Plate XVII., **Podostemon Barberi.**—1 Part of a plant, nat. size, slightly diagrammatic, showing thallus (*th.*), secondary shoots (*s.s.*), and flowers. 2 Flowering shoot, × 1¼, the flower still enclosed in the spathe (*spa.*). 3 Transverse section of thallus, × 20, showing vascular bundle (*v.b.*) and mass of rhizoids (*f.*). 4 Transverse section of thallus, × 90. 5 Flower in spathe, the front of which is removed, × 6. 6 Transverse section of the ovary, × 60, showing six-ribbed outline, the dehiscence ribs (*deh.*), the vascular bundles (*v.b.*), the inner epidermis (*i.e.*), and the deciduous outer part of the pericarp (*decid.*). 7 Part of dehiscence rib, × 150, to show method of splitting; *i.e.*, the inner epidermis; *deh.*, the splitting layer. 8 Transverse section of the inner epidermis of the fruit, to show construction of the wall, × 320. 9 The fruit, in transverse section, × 60, for comparison with fig. 6; the outer tissues have fallen away, and the rest have become woody.

Plate XVIII., **Dicræa elongata.**—1 Seedling, × 6, showing commencement of thallus (*th.*). 2 Larger seedling, × 6, showing development of first free drifting thallus (*dr. th.*) from the creeping thallus. 3 Base of seedling, × 40, showing cotyledons (*cot.*), endogenous thallus (*th.*), and exogenous hapteron (*h.*). 4 Seedling, × 4½, with drifting thallus forming at right angles to creeping thallus; *p.a.*, the primary axis. 5 Apex of drifting thallus, × 5, with root-cap and origin of secondary shoots. 6 Transverse section of drifting thallus, × 20, showing parenchymatous cortex (*p.c.*) and vascular bundle (*v.b.*). 7 Cortex of drifting thallus in transverse section (taken about middle of length, 1-9-98), × 80, showing commencement of cell division. 8 Transverse section of vascular strand, near apex of drifting thallus, gathered 1-9-98, × 320; ×, primary xylem; *col.*, collenchyma. 9 A small part of the same strand, lower down, × 320, showing commencement of formation of secondary tissue. 10 The same, older, × 320, with formation of secondary xylem nearly complete. 11 Transverse section through thallus at exit of secondary shoot, × 16. *V.b.*, the vascular strand with branch to shoot; *col.*, the collenchymatous layer; *d.c.*, the part of the cortex which finally shrivels; *v.a.*, the growing point of the shoot; *l.*, its leaves. 12 Transverse section of ovary, × 60, for comparison with Podostemon; *i.e.*, the inner epidermis; *v.b.*, the vascular bundles.

Plate XIX., **Dicræa elongata**, × 3/8.—On the left fruiting specimens from Hakinda, gathered in dry season. On the right a plant in water, gathered in September in vegetative condition, showing the creeping thalli at base, with long drifting thalli, along whose edges are the little tufts of leaves representing the secondary shoots.

Plate XX., **Dicræa elongata.**—1 Piece of thallus, × 4, showing rejuvenescence from the base of an old portion re-submerged; *th.*, creeping, *dr.th.*, drifting thallus. 2 Fruit, × 6, for comparison with that of Podostemon (Pl. XVI.), to show isolobous development and mode of dehiscence. **D. dichotoma.**—3 A small piece of thallus and secondary shoots, to show zigzag form often assumed. 4 Transverse section of thallus in flowering season, × 20, to show deciduous (*dec.*) and persistent (*pers.*) parts of cortex; *v.b.*, the vascular strand. 5 Portion of flowering thallus, showing projections under the floral shoots, × 1½. 6 Secondary shoot, × 2, in leafy condition, just beginning to form a flower. 7 Later stage, with spathe (*spa.*) visible between upper pair of leaves with enlarged sheathing bases. 8 Later stage, with leaf tips falling away. 9 Flowering shoot, with bracts at base whose leafy tips have completely fallen; spathe open, flower fully expanded. 10 Fruit, × 6. **Dicræa Wallichii.**—11 A portion of a plant from herbarium material, × 3, showing form of growing apices, and development of the secondary shoots, with vascular bundles (*v.b.*), the latter thickened where they lead to shoots, about to bear flowers. 12 A small portion of the base of a plant (Cherra), × 2, showing vascular bundles before the beginning of development of flowers. 13 The same after development of the flowers (these not shown). 14 Base of a plant from below (Weddell's D. pterophylla, spirit material collected by Hooker), nat. size, to show the stout foot with ascending thallus. 15 Open flower, with spathe and bracts, × 2.

Plate XXI., Dicræa Wallichii Khasiana, × 4/7.—On the left are two stones from below water, Cherra, Dec., 1901, showing the closely appressed broad alga-like thallus with marginal buds ; on the right three stones from above water at same place, showing the fimbriate fruiting thalli, the intermediate tissues having fallen away. The various single plants occupying the centre of the plate show all stages in the process ; all are from Cherra. The three small specimens in the left-hand upper corner are the originals of Weddell's D. pterophylla ; the larger lobed specimen below them opposite the space between the rocks is an original specimen of Griffith's D. Wallichii ; the rest were collected by myself in Dec., 1901.

Plate XXII., Dicræa stylosa.—1 Apex of form *laciniata*, × 5, with root-cap (*r.c.*), secondary shoots (*s.s.*), and vascular bundles (*v.b.*). 2 Seedling of form *fucoides*, × 5; *hyp.*, the hypocotyl, with cotyledons (*cot.*), young thallus (*th.*), and secondary shoots (*s.s.*). 3 A young plant of *fucoides*, nat. size, showing general habit of the form that is only attached by a basal foot. 4 Vertical section of foot of same, × 2. 5 Longitudinal section apex of thallus of *fucoides*, diagrammatic, showing root-cap (*r.c.*) and vascular strand (*v.b.*), × 80. 6 The same apex, from above, with secondary shoots (*s.s.*). 7 Transverse section of thallus, × 10, to show general form when young, and central vascular strand. 8 Transverse section of same thallus, × 150, showing epidermis (*ep.*), parenchymatous cortex (*p.c.*), and vascular strand with its two groups. 9 An older thallus, × 80, to the right of the vascular strand (*v.b.*), to show the way in which the cortex grows in thickness and the thallus curves upwards at the side.

Plate XXIII. is omitted, see above.

Plate XXIV., Dicræa stylosa.—1 Floral shoots of var. *fucoides*, × 4, one with open, one with closed, spathe (*spa.*). 2 Open flower of var. *Bourdillonii*, with vascular bundle leading to it (*v.b.*), × 2½. 3 Portion of plant of var. *kanarensis*, × 3, showing the acuminate form of the ripe bracts, the irregular distribution of the floriferous shoots, and the thickening of the tissues leading to them (*w.*). Dicræa minor.—4 Plant or part of plant, from spirit material collected by Hooker, × 1½. 5 A secondary shoot ready to flower, × 2½. 6 A shoot with ripe fruit, from Griffith's dry material, × 3. Griffithella Hookeriana.—7 Apex of a thallus (C. A. Barber, 2,149), × 4, showing development of leafy and floral shoots. 8 Floral shoot of same form, × 6, showing bracts with leafy tips still persistent. The flower is ready for fertilization ; it has become twisted round in emerging from the spathe (*spa.*); *std.*, the staminode or perianth segment on one side of fertile stamens. 9 Transverse section of ripening ovary, × 20, showing absence of vascular bundles in the wall ; *pl.*, the placenta, with its ovules (*ov.*) ; *f.*, the thick-walled cells forming inner layer of pericarp. 10 Part of pericarp enlarged, × 320, showing dehiscence layer (*deh.*), inner epidermis (*i.e.*), sclerenchyma (*scl.*), and thick-walled cells (*f.*).

Plate XXV., Griffithella Hookeriana Willisiana, × 3/7 (C. A. Barber, Nos. 2,515, 2,519).—1 (large left-hand rock, 2,519) A single submerged plant, in vegetative condition, showing the mode of growth and branching, and more or less prostrate leafy secondary shoots on margins of thallus. 2 (uppermost) Small plants (2,515) in ripe fruit, more or less shrivelled, but showing much variety of form, most often more or less discoid and prostrate. 3 (upper right hand) The same, but with stalked and scalloped forms. 4 (lower right-hand) Creeping form (2,519), with half-ripe fruits on the secondary shoots.

Plate XXVI., Griffithella Hookeriana, × 2/3.—The arrangement of the figures is—

1	4	7	10
2	5	8	11
3	6	9	12

1–6, var. Willisiana (C. A. Barber, No. 2,515); 7–12, var. Bombayensis (Atgaon). Illustrating the extraordinary polymorphism of the thallus. Some are only in bud, some in ripe fruit. 1 and 4 are similar forms from the top of the rock, showing radial symmetry; the latter is seen from below, and has only a very short basal stalk. 2 and 3 are from the sides of the rock, and are drawn out on the lower side. 5 and 6 are prostrate discoid forms closely attached at all points to the rock. The Atgaon forms are very complex in shape; the foot can be seen in 7, 8, 9, 10. No. 9 is seen from below. No. 11 is in fully ripe fruiting condition, and the thallus is much whiter than in the rest.

Plate XXVII. is omitted, see above.

Plate XXVIII., Willisia selaginoides, Hydrobryum lichenoides Fentonii.—A large stone, over which the water was still flowing to a depth of about an inch, from the Sholai Aar, Anamalais, January, 1901, × 7/18. This shows particularly well the habit of these two forms. The Willisia is in ripe fruit, though the lower parts of the secondary shoots are still submerged; in many cases the fruits appear to be stalked, owing to the falling away of the cortical tissues of the stems. The prostrate branching habit of the Hydrobryum is easily seen, and the numerous unopened floral buds at the angles of the branching (*cf.* Pl. XXXI.).

Plate XXIX., Willisia selaginoides.—From the same place, specimens in ripe fruit, × 2/3. These show the 4-ranked scale leaves and the sessile fruits; in some more or less of the cortical tissues have fallen away, leaving the fruits on stalks.

Plate XXX.—The same. 1 A portion of the crustaceous thallus, gathered in January from below the water, with secondary shoots (*s.s.*), showing the mode in which new ones are formed at this season, × 3½. 2 A small plant from herbarium material collected in October, showing two axes of the type I imagine to be primary, one broken off at the middle. The leaves of these are long and narrow, like the tips of the leaves of the secondary shoots (nat. size, drawn by A. de Alwis). 3 Spathe at top of shoot, × 4. 4 Open flower at top of shoot, × 4. 5 Ripe fruit, × 4. 6 Open fruit, × 4, showing the way in which the valve bends downwards after dehiscence, and the double stalk on which the fruit appears to stand owing to the fall of the cortical tissues. 7 Transverse section of ripening pericarp, showing inner epidermis with its cuticle (*i.e.*, *cut.*), the sclerenchyma layers (*scl.*), and the outer deciduous parenchyma (*par.*), × 600.

Plate XXXI., Hydrobryum lichenoides, × 11/18.—Order of figures :—

1 3 4
2 5

1, 2, and 5 are var. *Khandalense*, gathered on perfectly dry rocks, the plants quite dead, the fruits mostly open. 3 is var. *Bhorense*, with its long-stalked fruits. 4 is var. *Khandalense*, gathered below the water, to show (*cf.* Pl. XXVIII.) the habit and the sessile prostrate floral shoots. In 1 the tips of the leaves are persistent in many of the shoots ; in 2 the very short-stalked fruits can be made out.

Plate XXXII.—The same (figs. 1–6).—1 A seedling of var. *kelensis*, from Hatton, × 4, showing cotyledons (*cot.*), primary axis, origin of the thallus (*th.*), and secondary shoots (*s.s.*). 2 Tip of thallus of a young plant of the same, × 4, showing thallus and secondary shoots, and course of vascular strands (*v.b.*). 3 Portion of thallus developing a floral shoot from a former vegetative shoot, × 5½, showing enlargement of bases of leaves. 4 Portion of thallus of same, in ripe fruit, × 5½ ; the spathe is split irregularly, and the fruit-stalk stands erect. The shoot at ✱ is omitted. 5 Stigmas of three flowers of var. *Shillongianum*, × 6, to show variety of form ; the stamens in section on lower side. 6 Stigmas of var. *Khandalense*, × 6.

H. sessile (figs. 7–9). 7 Portion of thallus in ripe fruit, × 6, to show branching ; the lobes of the thallus almost touch each other. The shoots are like those of the other species. 8 Open flower, × 5½, showing bracts long stamens, &c., from above. 9 The same from the side, showing the perianth segment or staminode, *std.*, and curvature of ovary, &c.

H. olivaceum zeylanicum (figs. 10–18).—10 Embryo from ripe seed, × 6. 11 A young seedling, × 6, showing cotyledons, hypocotyl, hapteron (*h.*), and commencement of thallus (*th.*). 12 A rather older seedling, × 6, with the first leaves forming, and with more than one hapteron. 13 The same, from above, to show arrangement of leaves at growing point. 14 An older seedling, clasping an old capsule, × 8. 15 Tip of a primary axis, × 6½, showing arrangement of leaves. 16 Tip, from above, × 6. 17 Tip of older axis, × 6, with three growing points. 18 Seedling with thallus developing higher up than usual upon the hypocotyl, × 8.

Plate XXXIII., Hydrobryum olivaceum, dead plants in ripe fruit, × 3/4.—The upper left-hand stone is covered with the var. *anamalaiense*, turned to show the ribbed fruits on their short stalks. The others are all var. *griseum*, and show the habit well, especially the small plant in the lower left-hand corner. The large right-hand rock shows the way in which the thallus in this form often becomes crumpled and ridged. The secondary shoots can be easily made out, with the large terminal spathe pointing towards the margin of the thallus and open on the upper side. In the middle of the large rock, on the left of the chief thallus, two portions of another plant are colliding with it.

Plate XXXIV., Hydrobryum olivaceum zeylanicum.—1 A seedling clasping an old capsule, × 5½. The primary axis has been lost, and the secondaries are much larger than usual in so small a plant ; *th.*, thallus ; *s.s.*, secondary shoots ; *p.*, the old capsule stalk. 2 Vertical longitudinal section of growing margin of thallus, × 320, showing meristem and root-cap. (*r.c.*). 3 A young plant in May, nat. size; *p.a.*, the primary axis; *s.s.*, the secondary shoots; *th.*, the thallus. 4 Slightly diagrammatic reproduction of the original drawing of Podostemon Gardneri (the primary axis, *p.a.*, with its brush of leaves), with the addition of part of the thallus, and with two secondary shoots; gathered in August; nat. size. 5 Transverse section of thallus, × 320, showing epidermis (*ep.*), parenchymatous cortex (*p.c.*), and a vascular strand (*v.b.*). 6 Portion of thallus, × $4\frac{1}{2}$, showing stages in the transformation of vegetative into floral shoots by the enlargement of the bases of the now prostrate leaves and the fall of their tips.

Plate XXXV., Hydrobryum olivaceum zeylanicum, a plant in vegetative condition, gathered in August, × 4/5.—This shows the habit particularly well, but it should be noted that most of the leaves, both of the primary shoot and the secondaries, have fallen off, owing to the specimen having been kept in standing water for some time. If photographed in the perfectly fresh condition, the thallus would be completely hidden by the leaves, except at the margins. The primary axis is visible at the lower side of the picture, and the mode of branching of the thallu is clearly seen. The photograph shows, what is not visible to the eye, the actual overlapping of the lobes in one or two places. The younger leaves of the secondary shoots near the margins can be seen emerging from the thallus.

Plate XXXVI., Hydrobryum olivaceum zeylanicum (figs. 1–5).—1 Secondary shoot, × 4, the flower just about to emerge from the spathe (*sp.*), which has split along the upper side. 2 Open flower, from the side, × 4. 3 Piece of rejuvenescent thallus, developing from an old portion which has been re-submerged, × 7. At *an* the first sign of appearance of the secondary shoot; *s.s.*, an older shoot. 4 Rejuvenescence from the side, × 7. 5 A monstrous thallus, described at p. 391; *p.a.*, the primary axis bent down.

H. Griffithii (figs. 6–8).—6 Portion of thallus, near a sinus, with secondary shoot in floral condition at the angle, × 4. 7 Ovary and stigmas from side, × $4\frac{1}{2}$. 8 Stigmas of various flowers from same locality, × 8, to show variety of form (*cf.* Pl. XXXII., figs. 5, 6).

Farmeria metzgerioides (figs. 9–16).—9 Embryo from seed, × 8. 10 Young seedling, × 5, showing cotyledons (*cot.*) and first development of thallus (*th.*); *f.*, the foot. 11 Larger seedling, with two leaves, × $5\frac{1}{2}$. 12 Older seedling, with first secondary shoot forming (*s.s.*), × $5\frac{1}{2}$. 13 Seedling with two thalli, from above, × $5\frac{1}{2}$. 14 Two seedlings starting from the seeds in a capsule enclosed in the old bracts (*br.*), × $5\frac{1}{2}$. 15 Seedling with two thalli, × $5\frac{1}{2}$. 16 The same seedling as in fig. 13, from below.

Plate XXXVII., Farmeria metzgerioides (figs. 1–9).—1 Young plant, × 5; the cotyledons and primary axis are still present, while the thallus has grown out and branched (*br.*), the secondary shoot (*s.s.*) being on the posterior side of the branch. 2 A thallus forming flowering shoots in December, × 4. 3 Thallus with branch (*br.*) emerging on anterior side of secondary shoot; the arrow points towards the apex of the thallus. 4 Stamens, × 5. 5 Contents of ovary, from above; the thick distal placenta (*pl.*) bears two ovules on the basal side, × 20. 6 The same, from the side, showing the septum (*spt.*). 7 The same, from the upper side, with the ovules bent down ; *s.*, the stalk bearing the thick placenta. 8 The fruit, × 20, from the side. 9 Interior of fruit, from the lower side, × 20, showing the two septa, the stalk of the placenta, and the seeds.

Farmeria indica.—10 Plant, from shrivelled rock-dry material, showing thallus (*th.*) with hapterous discoid feet (*f.*), × 6.

Plate XXXVIII., **Farmeria indica.**—The three small stones at the left show this species, with its branching habit, and small discoid feet, × 3/5.

Farmeria metzgerioides.—The two central stones show this species, in ripe fruit, the fruits being held firmly against the rock by the persistent bracts. **Tristicha ramosissima.**—The large right-hand stone is covered with the creeping thalli of this plant, on which the discoid hapterous feet can be clearly seen (C. A. Barber, No. 2,518). The secondary shoots have been removed. *Cf.* Pl. V.

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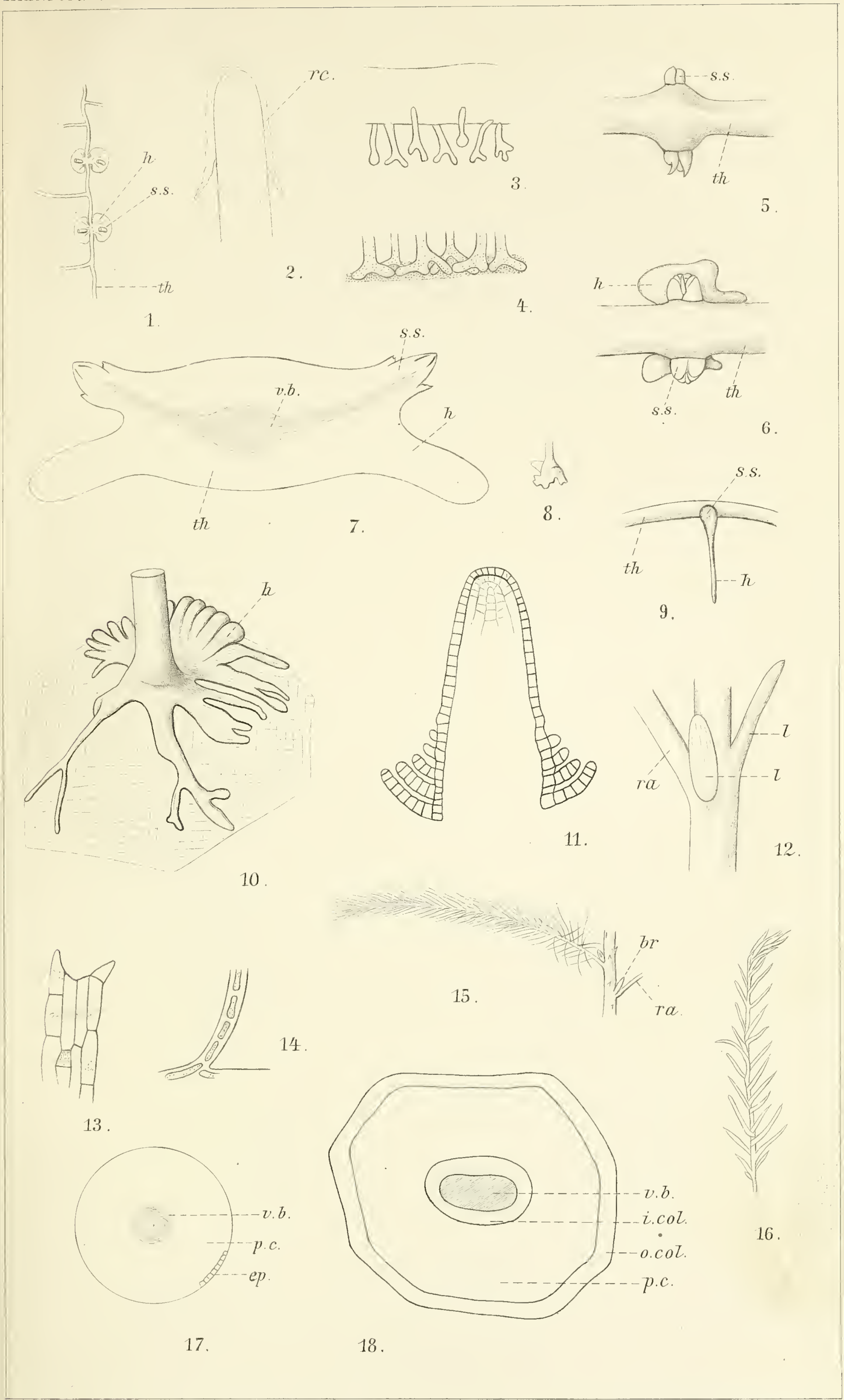
PODOSTEMACEÆ AT HAKINDA.

46

TRISTICHA RAMOSISSIMA, Willis.

TRISTICHA RAMOSISSIMA, Willis.



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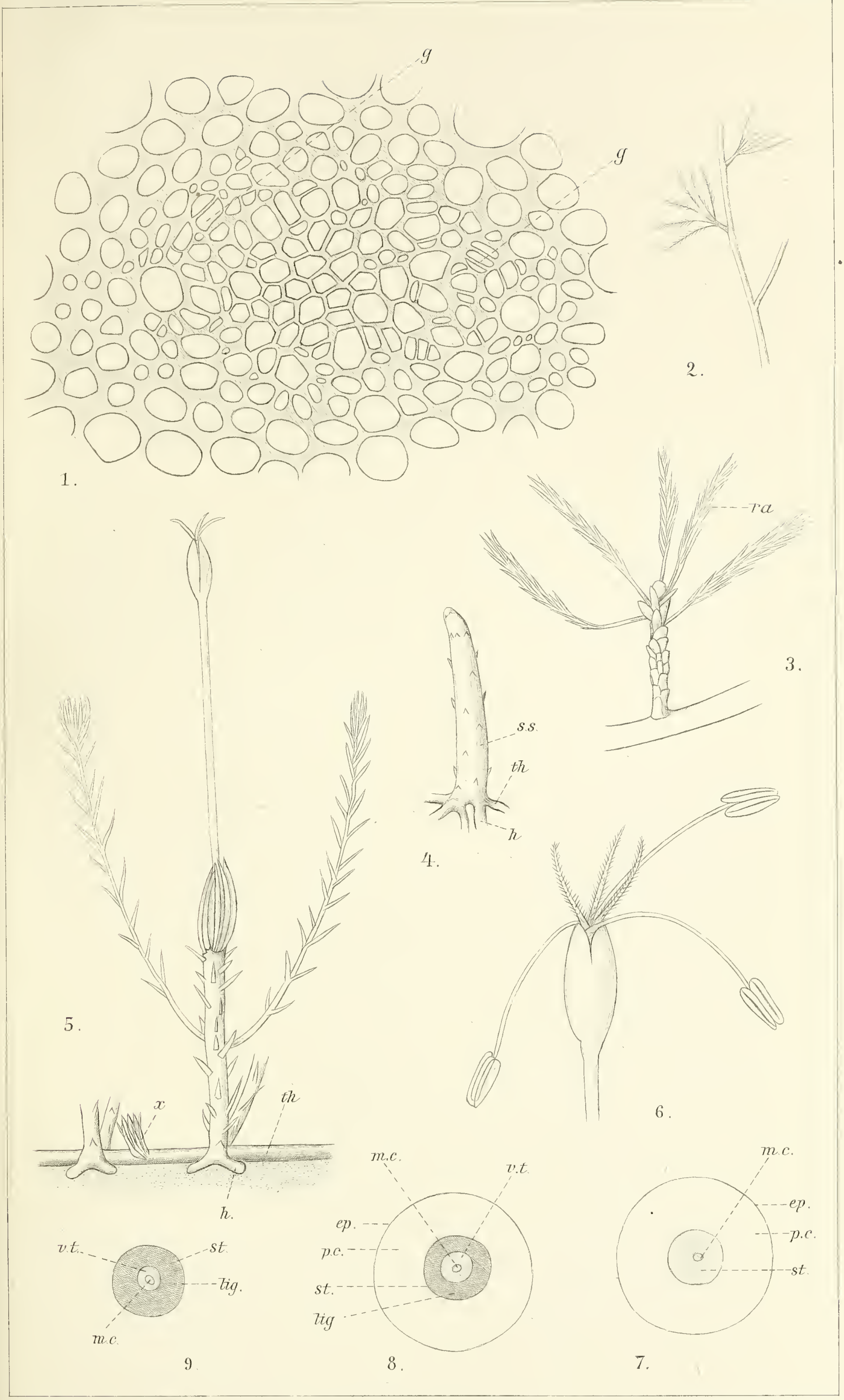

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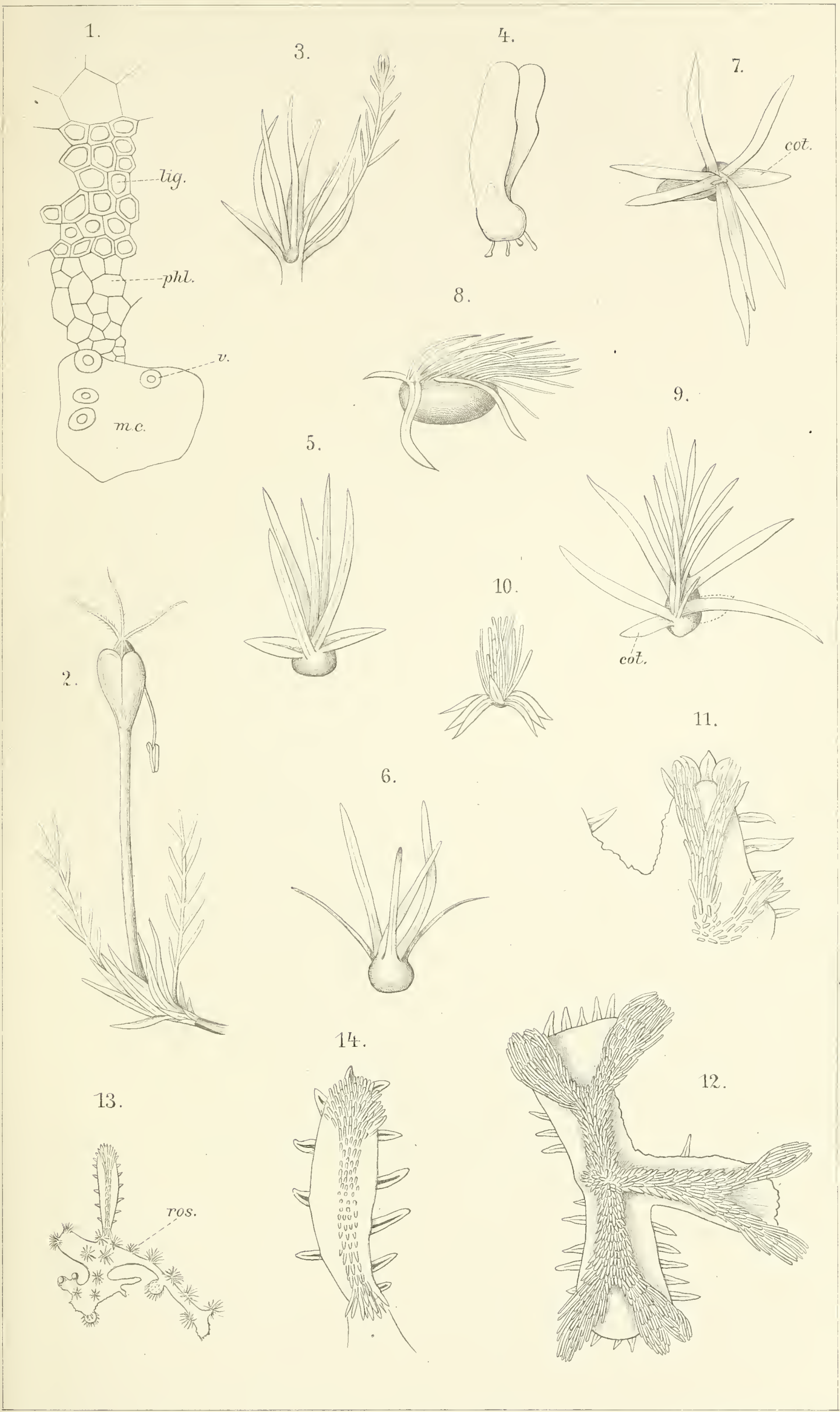
TRISTICHA RAMOSISSIMA.



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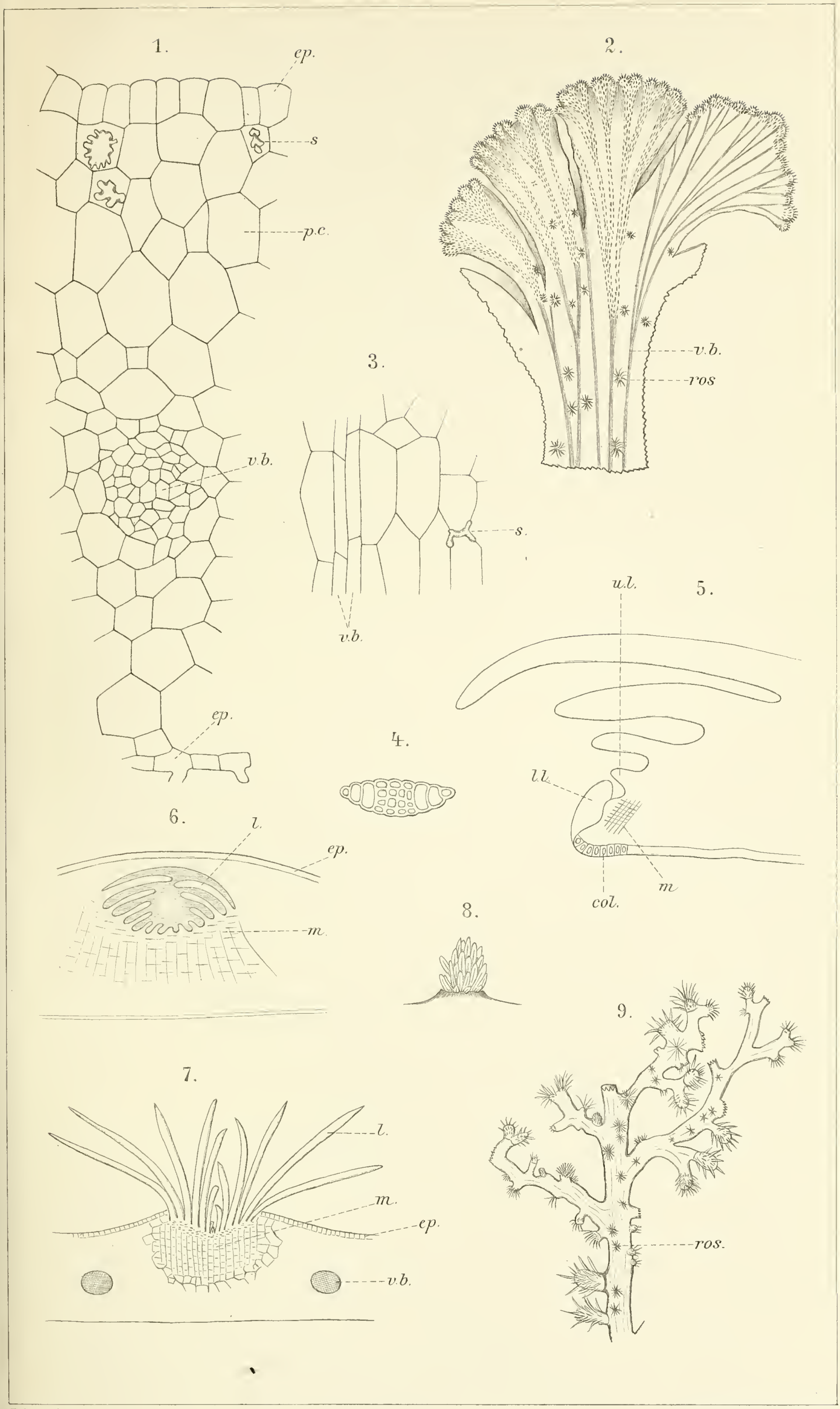
TRISTICHA RAMOSISSIMA (1–3) LAWIA ZEYLANICA (4–14)

LAWIA ZEYLANICA, Tul.



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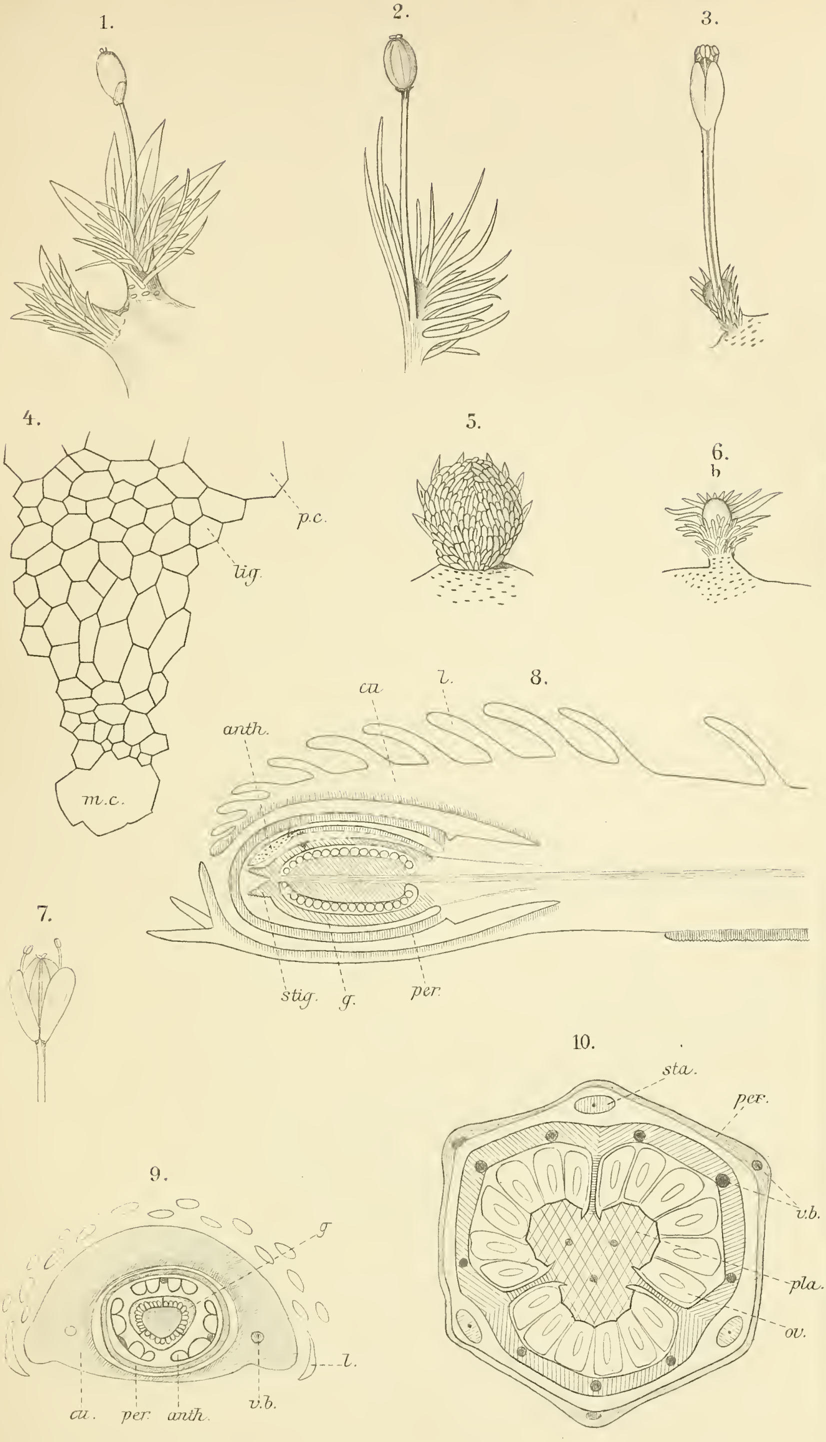
LAWIA ZEYLANICA

LAWIA ZEYLANICA, Tul.



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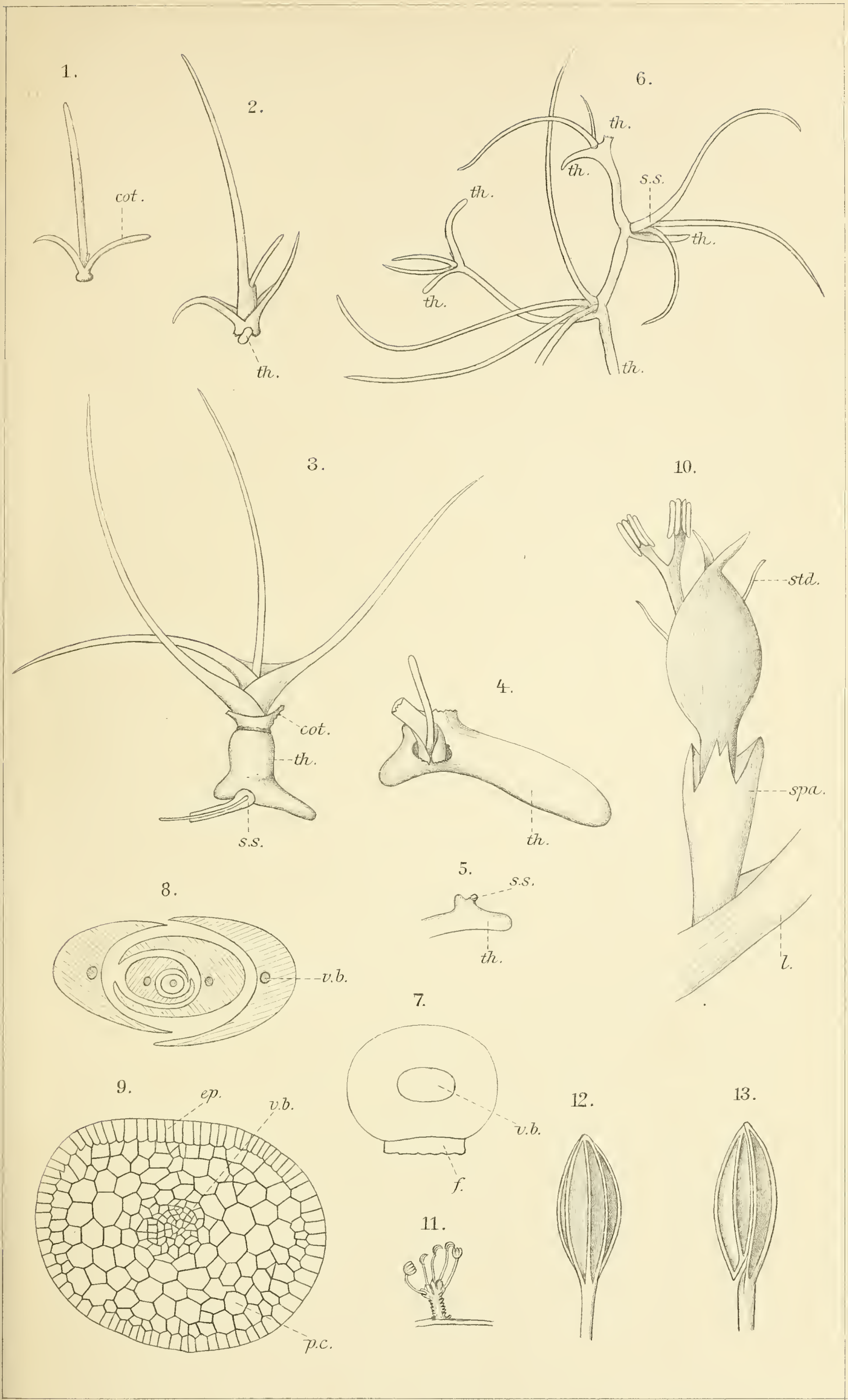
LAWIA ZEYLANICA.

PODOSTEMON SUBULATUS, Gardn.; DICRÆA SPP.

PODOSTEMON SUBULATUS, Gardn.



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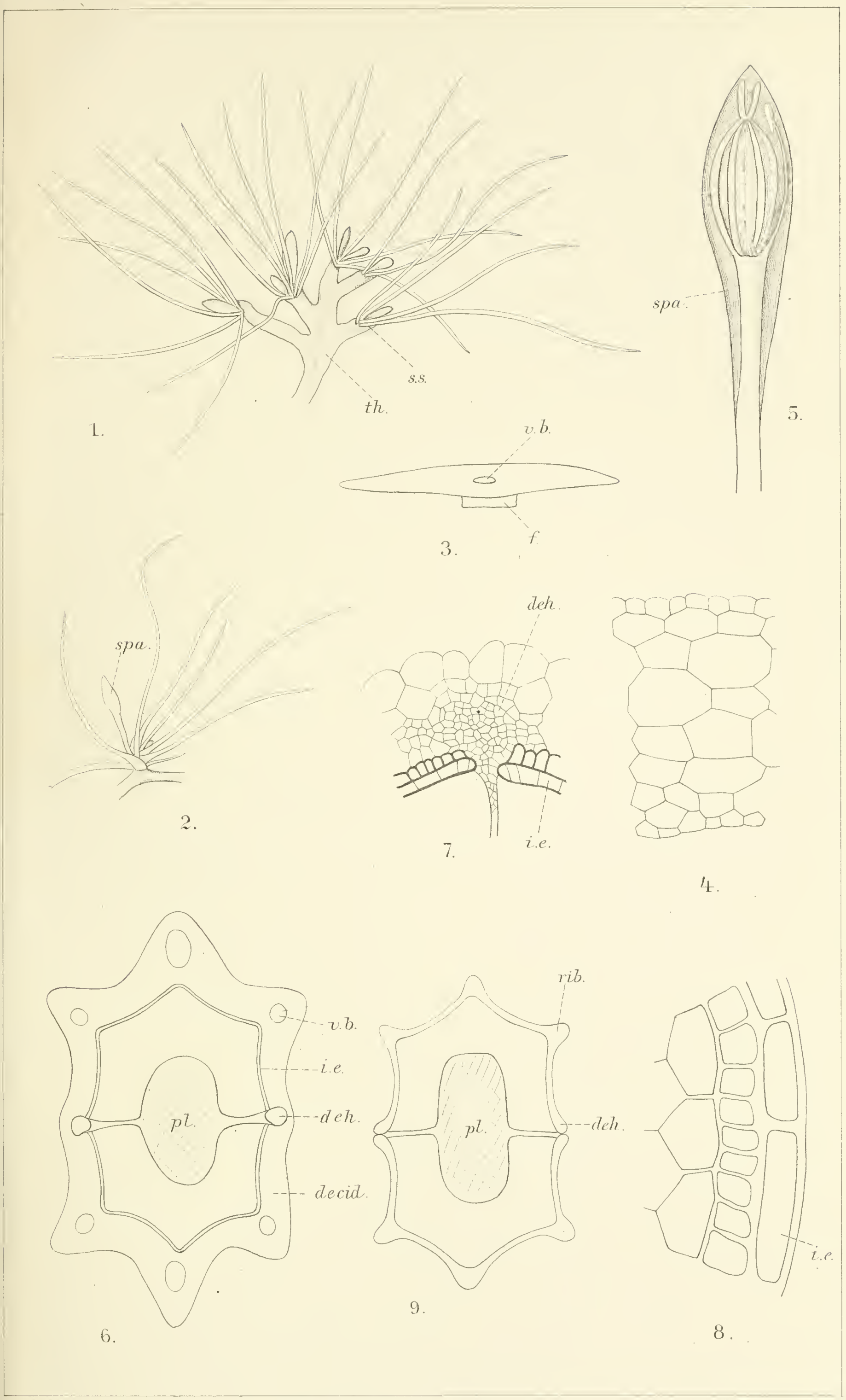
PODOSTEMON SUBULATUS.



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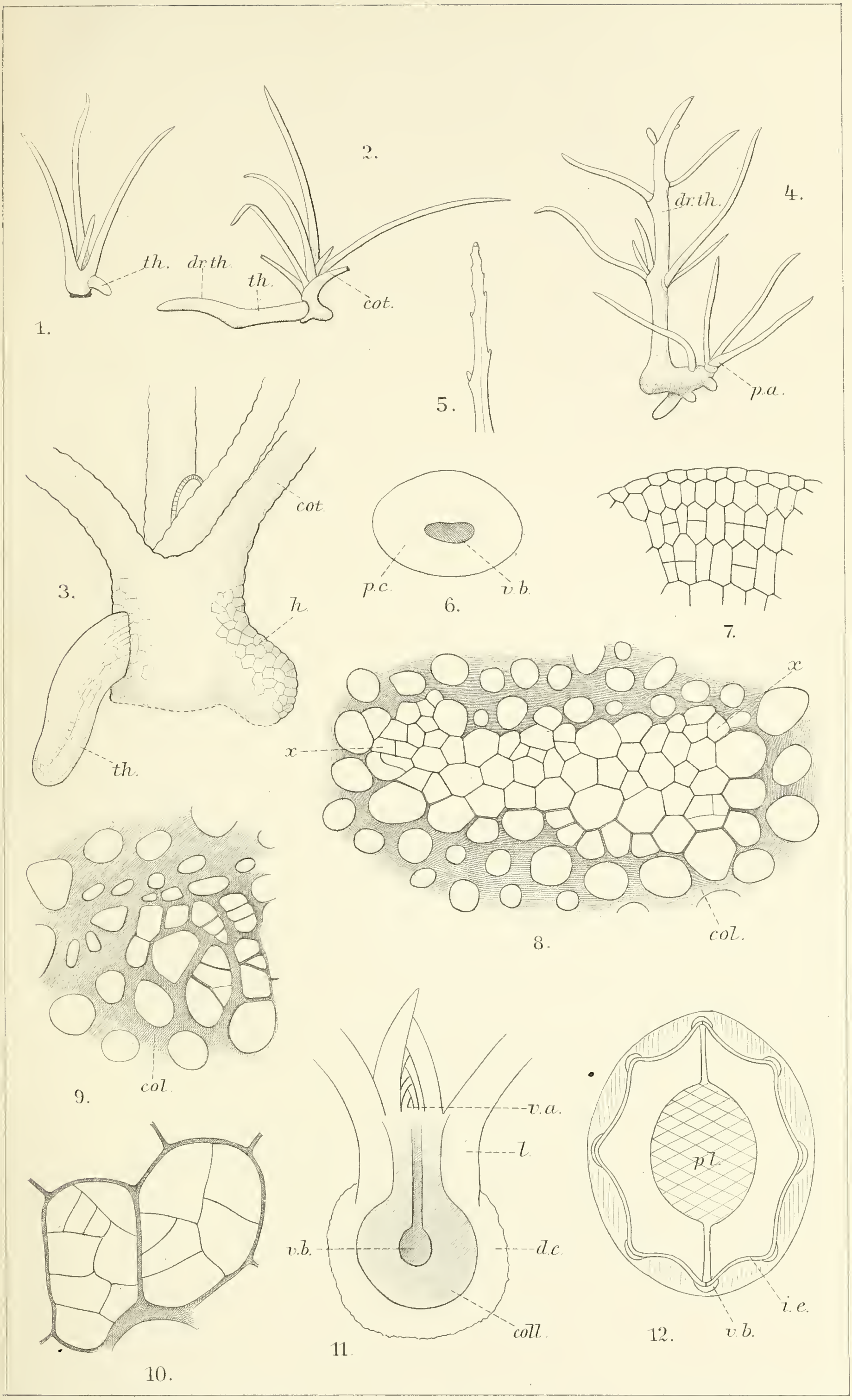
PODOSTEMON BARBERI.



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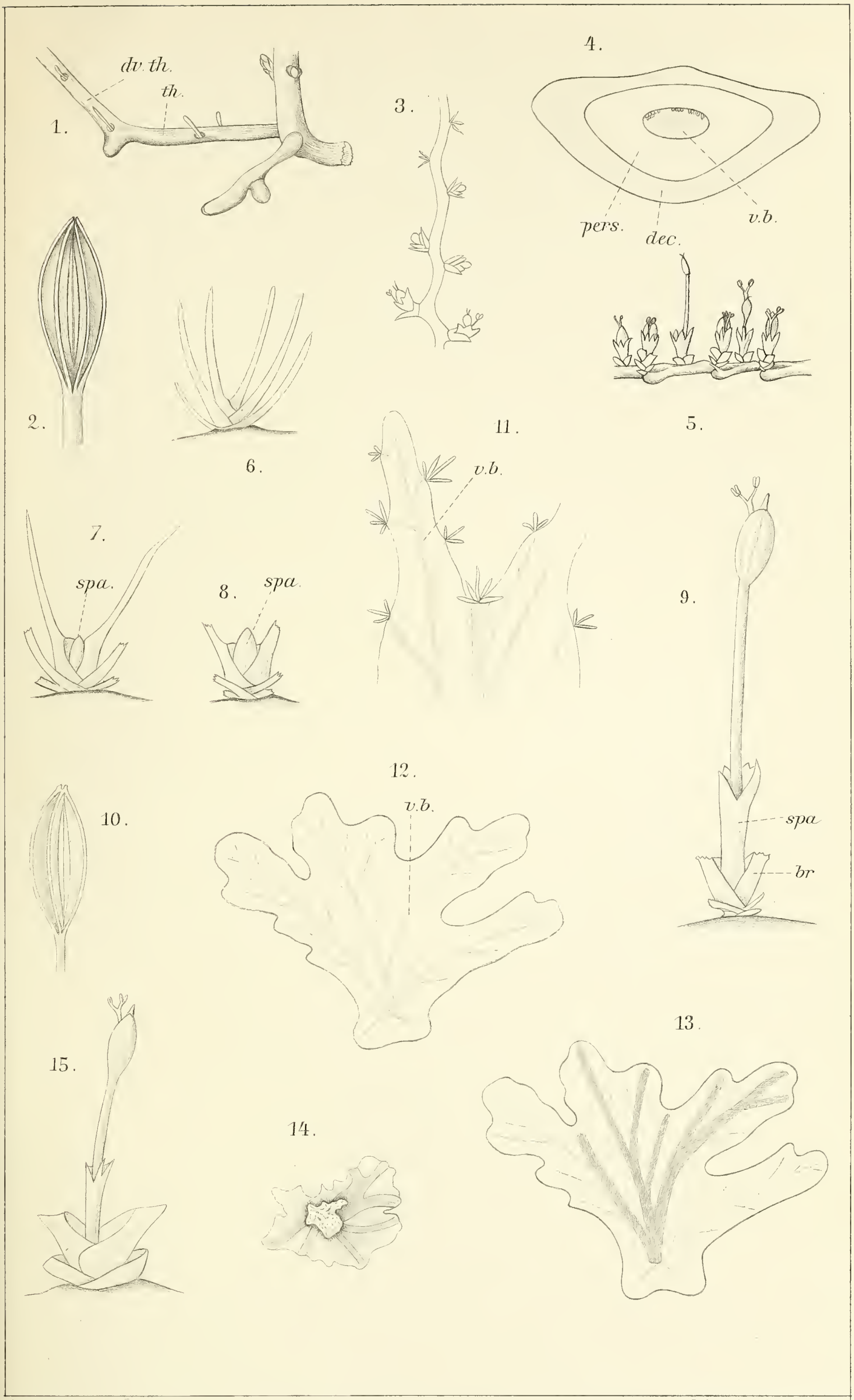
DICRÆA ELONGATA.

DICRÆA ELONGATA, Tul.



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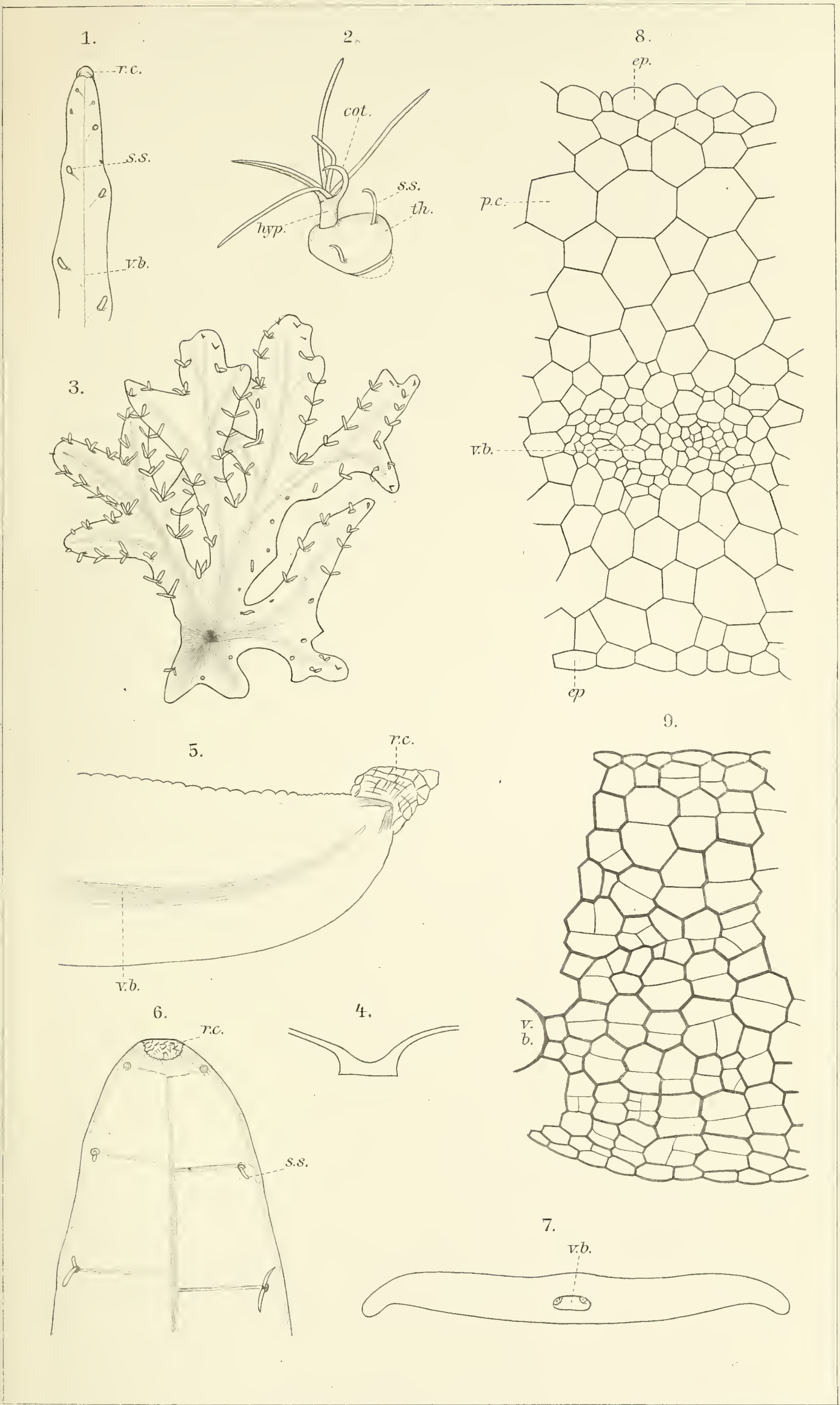
DICRÆA SPP.

DICRÆA WALLICHII, Tul.



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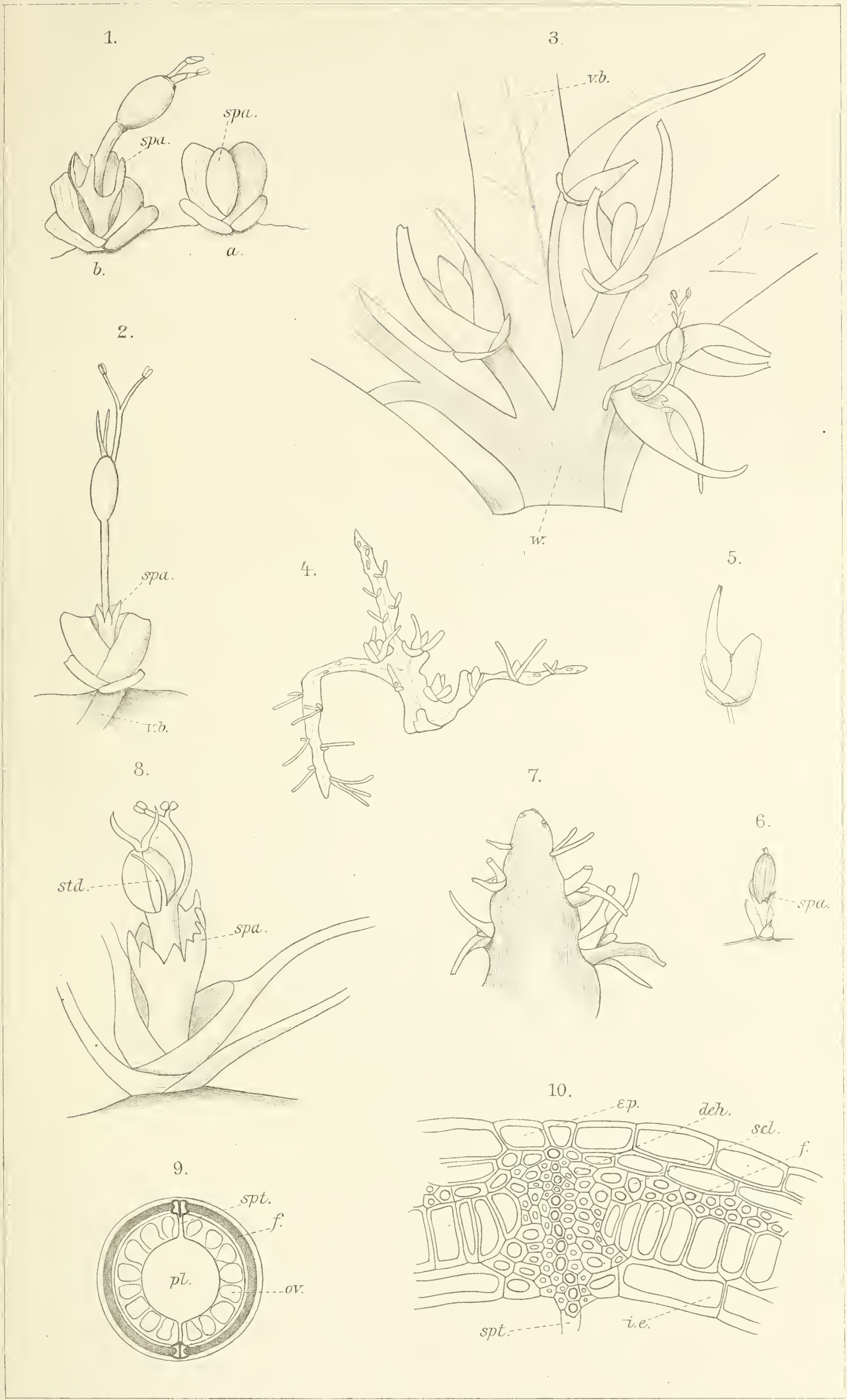

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DICRÆA SPP. (1-6) GRIFFITHELLA (7-10).

GRIFFITHELLA HOOKERIANA, Wmg.

GRIFFITHELLA HOOKERIANA, Wmg.

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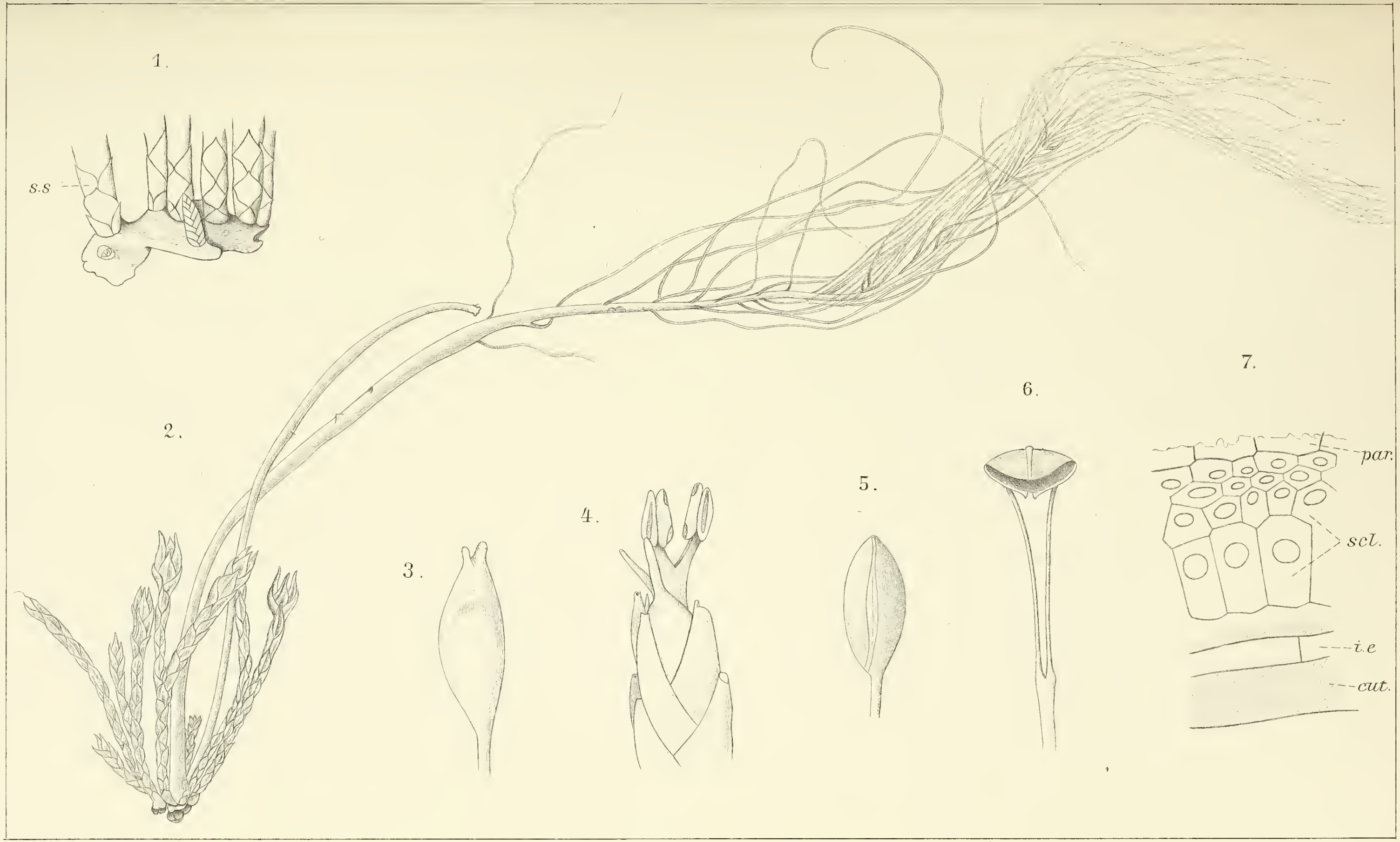
WILLISIA SELAGINOIDES, Wmg.; HYDROBRYUM LICHENOIDES, Kurz.

WILLISIA SELAGINOIDES, Wmg.



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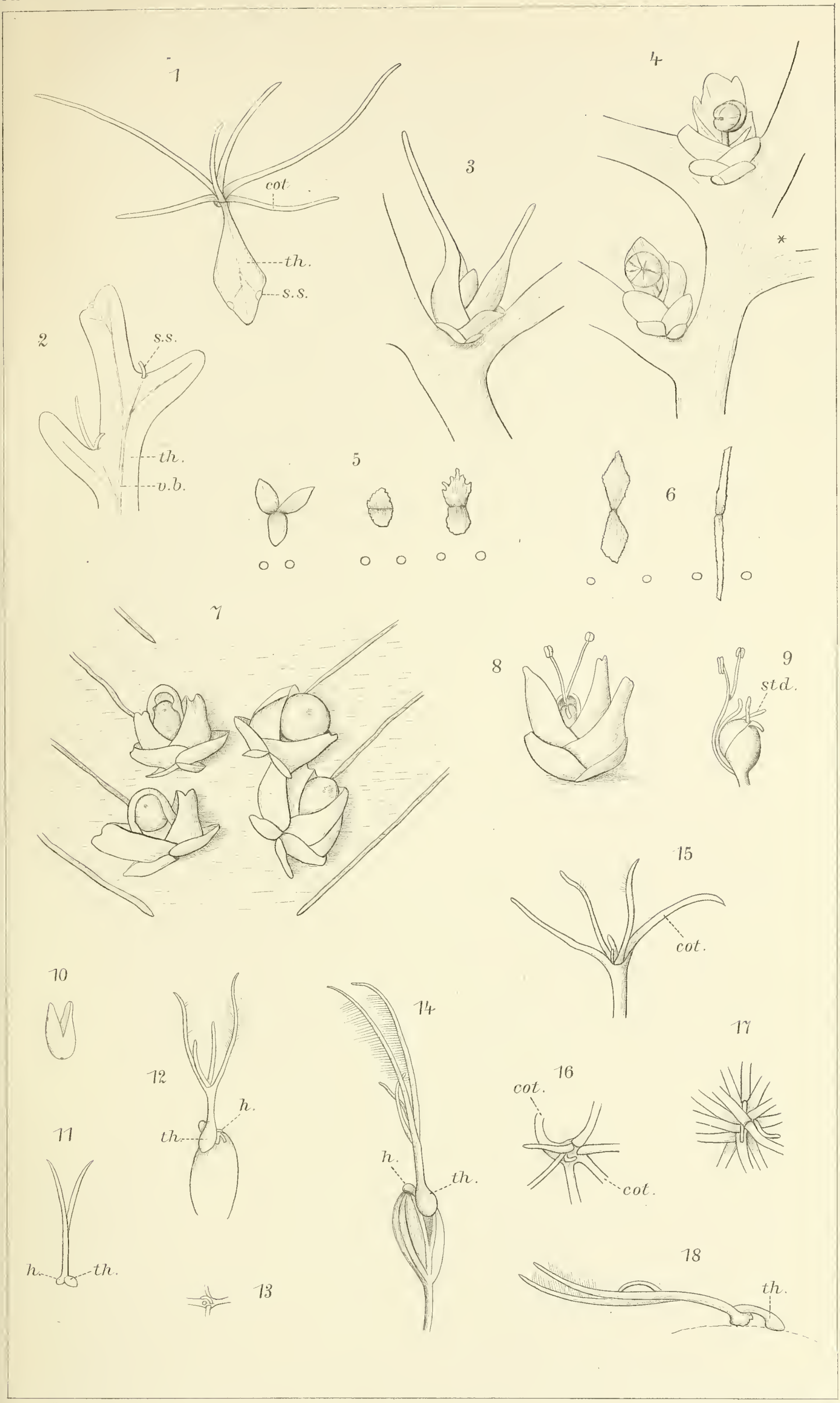
WILLISIA SELAGINOIDES.

HYDROBRYUM LICHENOIDES, Kurz.



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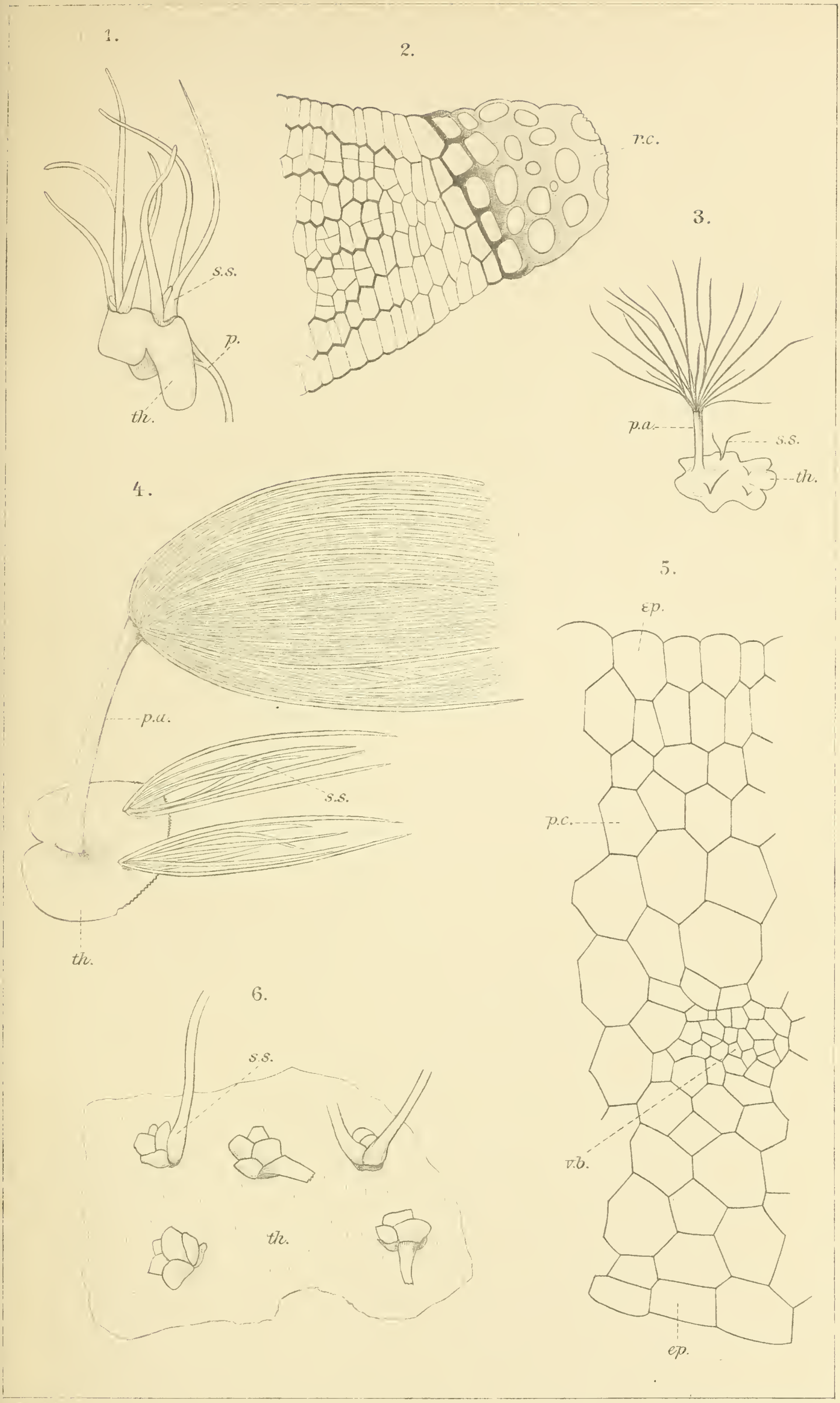
HYDROBRYUM SPP.

HYDROBRYUM OLIVACEUM, Tul.



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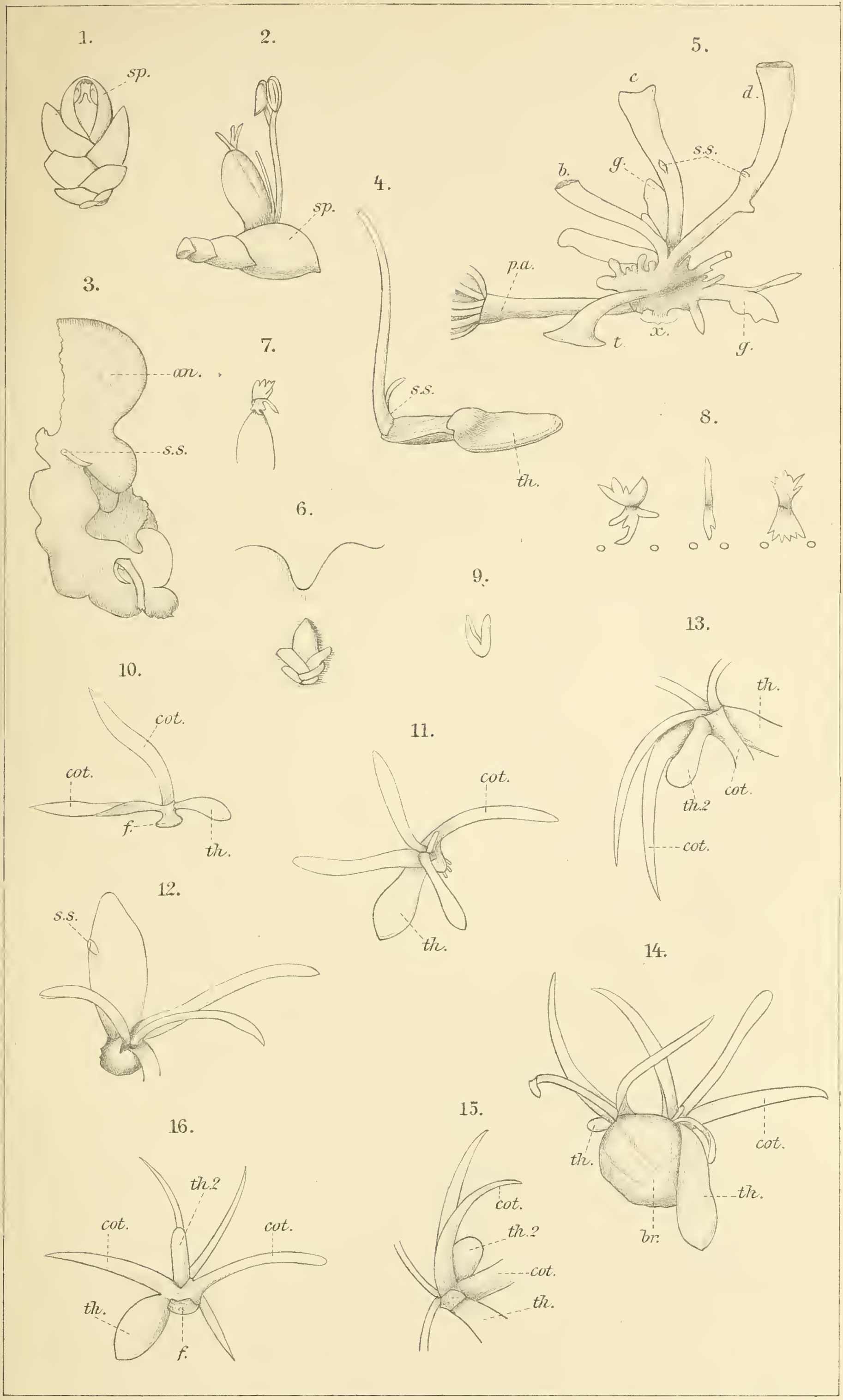
HYDROBRYUM OLIVACEUM.

HYDROBRYUM OLIVACEUM, Tul.



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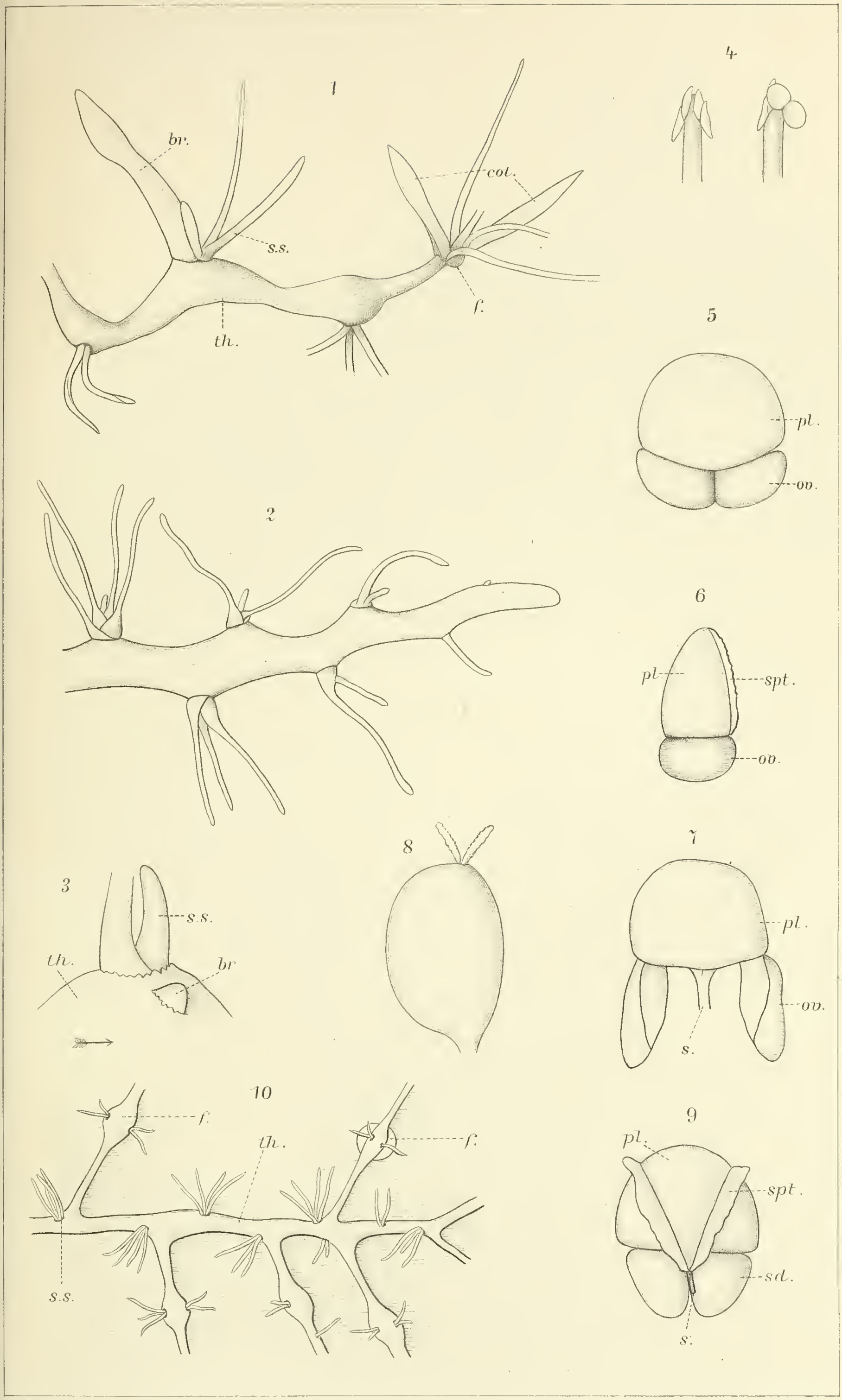
HYDROBRYUM SPP. (1-8); FARMERIA M. (9-16).



FARMERIA METZGERIOIDES (1-9); F. INDICA (10).

FARMERIA SPP.; TRISTICHA RAMOSISSIMA, Willis.

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