ANNALS

OF THE

ROYAL BOTANIC GARDENS, PERADENIYA.

FIRST SUPPLEMENT.

A HANDBOOK OF THE VEGETABLE ECONOMIC PRODUCTS OF CEYLON, NATIVE, CULTIVATED, OR IMPORTED.

BY

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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.

(Annals of the Royal Botanic Gardens, Peradeniya—First Supplement.)

A HANDBOOK

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BY

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(Printed as a series of parts supplementary to the Annals of the Royal Botanic Gardens, Peradeniya, 1901, onwards.)

PREFACE.

IN view of the expansion of the activities of the Department of the Royal Botanic Gardens, Peradeniya, and the extension of work upon the various economic products of Ceylon, native or introduced, we have been for some time past engaged in collecting, classifying, and making easily available the immense mass of information about these products which is contained in the files of the Department, and in the numerous books preserved in the library at Peradeniya. At the same time the collections in the Economic Museum are being re-arranged and renewed in pursuit of a definite plan of classification of economic products. It being necessary to write out a large amount of the information thus gathered in a brief and simple form for the explanation of the specimens in the Museum, it seemed worth while, for the sake of all in Ceylon and elsewhere who are interested in the economic products of the Island, to make this more generally available by printing it in book form, giving brief but accurate information about all known useful vegetable products of the Island, with fuller details about such as are staple products.

It has been decided to issue the work in the form of Supplements to the numbers of the "Annals of the Royal Botanic Gardens, Peradeniya." It will appear as ready, in consecutive order, with separate paging from the rest of the journal, to admit of independent binding, and will be concluded by a detailed index of names and products. A limited number of copies will be placed on sale (at a price probably of Rs. 10–15) when the work is complete; this will probably be in the course of two or three years, and the whole work will likely form a volume of 400–500 pages.

The products dealt with include those which have been introduced into the Island for cultivation or trial, and so far as information is available, also those which are imported only, and are not cultivated or prepared locally. It will probably surprise most people to find how few native products of value the Island possesses, and what a vast number of introduced ones. Some are introductions of very early date, some of Portuguese, some of Dutch, and still more of English times. A large number of plants have been introduced by the Royal Botanic Gardens, and many by enterprising planters and others, within the last fifty years. All these, even when they have not proved successful, will be included wherever information is available.

The information given is necessarily brief, but it is hoped that it may be sufficient to answer the many questions of daily recurrence which are asked about economic plants and products. Those who require further details will find them in the numerous works quoted in the different chapters below, and by consulting the files preserved in the public consulting room of the Economic Museum at Peradeniya. The Library of the Peradeniya Gardens contains most of the works mentioned below, and an excellent collection of books on agriculture and planting, as well as nearly all important journals.

It has been our endeavour throughout to make the information as practical as possible, and to point out the general principles of botanical economic work for the benefit of the general public. Economic Botany is as yet too much in the stage of being a heterogeneous assemblage of facts with but few general scientific principles. We have endeavoured to indicate that there are some general laws underlying the mass of facts, though it be perhaps too soon to claim for the subject the rank of a science.

This work is of course chiefly a compilation from innumerable sources, and we can only express our indebtedness to these sources—books, letters, friends, &c.—in a general way. We are specially indebted to a large number of local friends, officials, and others, for much information on local native products.

We shall be greatly obliged to any one who will point out errors in the work, or aid us with information on local products. The order in which the work will appear will be seen by looking at the introductory chapter.

J. C. W.
H. W.

Peradeniya, October 25, 1901.

INTRODUCTION.

ECONOMIC Botany may be defined as the study of plants and their products with reference to their uses or possible uses in the arts, manufactures, or commerce. While thus a branch of Botany, it includes portions of, or comes into close contact with, many other departments of science, including Agriculture, Chemistry, Political Economy, Economic Zoology, Animal Physiology, &c.

When, in the yet distant future, we shall have attained to a good knowledge of Economic Botany, we shall know, among other things, what products are yielded by all plants, what particular plants or classes of plants yield particular products or classes of products, how the plants form these products, how they are best collected and prepared for further use, how the yield may be improved in quantity or quality, and what use may be made of every product. The progress of Economic Botany must therefore go hand in hand with that of agriculture and the selective improvement of crops; it will depend largely on progress in chemistry, vegetable physiology, and other subjects which to the unthinking appear of little or no "practical" value.

The student of Economic Botany, especially if he occupy a post in which immediate practical application of his knowledge thereof be required for daily use, is drawn in two somewhat conflicting directions, the one determined by the desire to know and find out as much as possible about every product of the vegetable kingdom, regardless of any immediate practical money-making application of that knowledge to the needs of the markets and commerce of the day, the other determined by the desire to find out new, useful, and valuable products and ways of using them, or new and improved methods of cultivating or preparing old products, thus rendering their cultivation more profitable.

A compromise between these aims must be effected, determined largely by the necessities of the moment. Economic Botany, if it is to become a science, and its professors, if they are ever to become more than mere rule-of-thumb empirics, must attend to all classes of vegetable products, comparing together all the facts obtained, classifying them, and drawing conclusions from them, with the object of finding out general laws of wide applicability. At the same time, the chief attention must, as a rule, be devoted to the staple products of the vegetable kingdom, with the object of obtaining as much immediately valuable knowledge as possible. Only, however, by wide study of all classes of plants and their products can this knowledge ever be more than empirical. Gradually, by the study of vegetable products and the physiological processes involved in their production in the plant, we shall obtain a clearer insight into the principles that govern the production, and have it at last in our power intelligently to control this production to suit our own ends.

Whilst, however, the student of Economic Botany must go into all the facts and deal with all classes of vegetable products, this is not what the general reader requires. What he wants is a succinct statement of the received principles of the subject, the general conclusions and laws at which its students have arrived, the essential detailed facts about the more important products of plants, and the outlines of the more important facts about the minor products, sufficient to guide him from mistakes in dealing with them. It is from this point of view that the present work is written.

The Sources of the Economic Products of the Vegetable Kingdom.

Products of value are derived from an enormous number of different plants, and from a great number of different parts of plants. Roots, stems, leaves, bulbs, tubers, flowers, stamens, fruits, seeds, &c., are all possible sources of valuable products. It may conduce to clearness, and save subsequent repetition if the general principles of the formation of products in the plant be briefly described in this place. The ordinary green plant starts with the simplest materials, and from them elaborates complex products. It takes in water and simple salts dissolved therein from the soil by means of its roots, and takes in carbon dioxide gas from the air. From these simple substances it prepares its own food, the process taking place chiefly in the green leaves in the presence of air and sunlight. The food when prepared travels through the leaf stalks, stems, &c., to the places where it is required for the building up of new plant substance or the repair of waste. The living substances of which plants are largely composed are constantly being used up in respiration just as in animals, and require as constant renewal. The whole plant, however, does not consist of living respiring substance (technically known both in plants and animals as protoplasm). It may rather be looked upon, like an animal, as a mass of protoplasm arranged for working convenience upon a skeleton of fibres and cell walls, &c., which are not usually living. These are manufactured by the protoplasm out of the food supplied to it.

The food may go directly from the leaves to be used in making new protoplasm and skeleton at the growing part of the plant, or it may be put by for a time in the form of a reserve upon which the plant will draw at a later period, or which it passes on to its offspring. Thus, the talipot palm fills its stem with an enormous mass of reserve food ready for its final burst of flowers, in forming which, and in providing their seeds with reserves, the whole amount is used up. Nearly all plants supply their seeds with more or less stored reserve nutriment to keep the offspring growing until it has green leaves of its own, and can make its own food. In these reserves the plant always stores up both nitrogenous and non-nitrogenous materials. When required they travel away in solution, just as they came to the place where they have been stored, to the growing or respiring parts of the plant, or to form new reserve stores in another place.

Respiration is continually going on in all living parts, and breaking down the protoplasm into simpler bodies. Besides this the plant forms many classes of products, some of which are apparently temporary reserves, others skeletal (fibres, &c.) or otherwise useful, others apparently waste products. The latter are sometimes excreted on the outer surface of the plant, but more often, however, retained in special receptacles within the plant body. Among these products, whether useful to the plant or not, are many of great value to man, *e.g.*, indiarubber, resins, gums, alkaloids, other drugs, &c.

We may sum up this extremely fragmentary sketch of the chemistry of the plant in a graphic way, thus :—

Water and dissolved bodies. Carbon dioxide gas, &c.
Root. Green leaf.

Food prepared in green leaf.

Plant body, composed of—
Living Protoplasm.
Skeleton.

Reserves—
Nitrogenous.
Non-nitrogenous.

Waste Products.
Temporary reserve products.
Other products useful to the plant.

We may classify the products of plants on the basis afforded by the facts above sketched. Plants prepare from their food the following chief groups of products :—

Living protoplasm.

Skeletal substance—including fibres, cellulose (cell walls), woody tissues, &c.

Reserve materials—nitrogenous, such as proteids, amides, &c.; non-nitrogenous, such as carbohydrates (starch, sugar, cellulose, &c.), oils, &c.

Miscellaneous products—gums, resins, caoutchoucs, alkaloids, balsams, camphors, dyes, tannin, perfumes, &c.

Our knowledge of the chemistry and physiology of the plant is hardly as yet sufficiently advanced to enable us to form a good natural classification of economic products on the above basis. We are therefore compelled for the present to adopt a somewhat artificial grouping of the products with which we have to deal. In the Dictionary of Indian Economic Products and in the Agricultural Ledger Dr. Watt has adopted such a grouping, and for convenience of cross reference to Indian work it will be advisable to use a similar classification for Ceylon. This is in fact already employed in filing information at Peradeniya.

The principal products of the vegetable kingdom are grouped into eight chief classes, thus :—

I.—Gums, resins, caoutchoucs, guttaperchas, and other saps or exudations.

II.—Oils and fats.

III.—Dye stuffs and tanning substances.

IV.—Fibres.

V.—Drugs and medicinal products.

VI.—Edible products.

VII.—Timbers.

VIII.—Miscellaneous products and useful plants.

It is obvious that further subdivisions are required in each class, partly natural, partly artificial. Thus, the first class may be naturally divided into gums, resins, caoutchoucs and guttas, camphors, &c., the second into fixed oils and essential oils, and so on. For practical purposes we may make a further division, purely artificial, into important products or staples and minor products, terming these groups A and B respectively. This system will be used below. In each class we shall deal with the natural sub-classes in turn, and in each of these deal first with group A, then with group B.

It is almost needless to remark that in employing this classification products will not infrequently appear more than once under different classes.

The Collection of Economic Products.

Only in some cases can the products of plants be at once collected from them in a state fit for immediate use ; more often they require some preliminary treatment to put them into this condition. The kind of treatment, the methods employed in collection, and other similar points are dealt with below under the different classes of products.

The placing of Economic Products upon the Market.

The arts and manufactures require a large supply of raw materials of the most various kinds, belonging to the various classes described above. These materials are required in various forms, in regular supplies, and in varying quantities. They may be roughly divided, like those above mentioned, into important and minor products. The former are the basis of entire special industries or trades. They are in fact the indispensable articles of trade. The others are rather those which are rarely required, or which may be used as substitutes for the regular staples, or which may form the basis of new industries. These principles must be carefully borne in mind by any one proposing to take up the production of any economic product. If this product be one of the established staples, it will be needful for success to place upon the market at least as good a quality at no higher a price than that which is already being commercially handled. Further, the supply must be guaranteed regular and equal to the first samples. No manufacturer or user of a product will change to a new mark if he cannot be sure of a regular supply, though he may recognize the superiority of the new quality.

If, on the other hand, the product under consideration be one of the minor kind, we have to carefully consider its possibilities. If it can be used as a substitute for an established staple, it must be at least as good if its price be as high, or if inferior it must be possible to sell it at a proportionally lower cost. These requirements will be found to rule out of the world's markets the vast majority of the economic products of the vegetable kingdom; they may be used as fair substitutes, where locally abundant, for some staple product, but cannot compete with that product on the open market. If again, the minor product is one which may be made the basis of a new industry, it requires much capital and enterprise, usually applied in Europe or America, to start the industry, and the exploitation of the product passes out of the purview of Economic Botany altogether.

So far we have dealt with the world-market, *i.e.*, with economic products from the point of view of an export trade from Ceylon. There is, however, also a local market, in which local products have an advantage against imported ones, and it should often be possible to obtain a profitable local sale for an article which it would not pay to export. Ceylon imports many things for which local substitutes should be possible to a considerable extent, and some of these might even find a market as far as India. Instances will be found under the various classes of products described below.

Whether the product which it is proposed to cultivate or prepare be a staple or a minor product, it is of the first importance that it shall be prepared in the best possible way, and consequently samples of the best market kinds should be studied, and attempts made to imitate them as far as possible. Not merely is it needful to imitate the actual good qualities of the samples, but it is commonly at least politic also to imitate their general appearance and style of packing, &c. Brokers and merchants go largely by appearances in judging qualities of the products they handle, and consequently even a superior quality is liable to be overlooked or undervalued if its appearance be unfamiliar. The general appearance and make up of the various products is briefly touched upon in the chapters which follow, and an endeavour is being made to provide the Peradeniya Economic Museum with good samples of every kind to enable local cultivators and others to know as far as possible what to aim at.

The salient feature of the economic history of Ceylon in the past century has been a series of "booms" in different economic products, hitherto cultivated only by the native tropical races of men or only collected from wild plants. One by one, coffee, cinchona, tea, cacao, cardamoms, india-rubber, &c., have arisen into prominence. When Ceylon has tried to compete with the products of other European tropical colonies, the result has been less conspicuously successful—we may instance the cases of tobacco, sugar, nutmegs, ginger, pepper. Cacao is successful here, but when first taken up was not largely cultivated anywhere by Europeans. The history of the century now beginning will almost certainly be very different. Practically all products of any value in the tropics are now being cultivated by Europeans, and the resources of science, politics, &c., brought into play. The days of cheap success are over or nearly over, and those of more difficult competition are setting in. Ceylon occupies at present a most favourable position—a central location in the eastern seas, unlimited, cheap, and docile labour, a good climate for vegetation, great range of climates and soils, good road and railway carriage, plentiful freight to the great markets, and last but most important, well-established industries with great reputations for their products on the markets of the world, managed by experienced, enterprising, and capable men. She has, however, in the past century, almost completely lost several of her great industries, *e.g.*, cinchona, to her rivals in other parts of the world, and must beware lest others follow in the daily increasing competition. If she is to hold her own she must steadily improve her methods of cultivation and preparation of her products, rely less on a few important staples and encourage the cultivation of others, adopt every precaution to keep her crops free of disease, and in fact progress with the times, using all the resources of the most enlightened knowledge. It is our hope that the present work may assist in this.

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CHAPTER I.

GUMS, RESINS, CAOUTCHOUCS, GUTTA-PERCHAS, AND SIMILAR SUBSTANCES.

THE products here dealt with may be regarded as somewhat similar in origin, arising from the drying or coagulation of saps or excretions from the plant, or obtained from them by distillation or otherwise. They must be further subdivided, and the following grouping is convenient for the purpose :—

1. Gums (in the strict sense).
2. Resins.
3. Caoutchoucs or Indiarubbers and Guttaperchas.
4. Miscellaneous, including Camphors, &c.

Sub-section 1, Gums.

Gums are the product of disintegration of the internal tissues or cells of plants, and exude at the outer surface, usually on the bark of the stem. They are especially common in the plants of dry countries, such as Egypt, Arabia, Persia, India, Australia. They are collected in many cases from the natural exudations only, but perhaps more commonly from exudations at wounds purposely made in the bark. Collection is usually carried on in the dry weather, after the end of the rains.

Gums swell or dissolve in water, but are insoluble in alcohol or ether. They are thus distinguished from resins, but in commercial use the two classes of products are confused, some gums being termed resins, and *vice versa*.

Gums are usually brought to market in the form assumed by the exudations upon the trees, or in balls and other shapes made by pressing these together. The natural form is very often stalactitic, as may be seen in satinwood gum, owing to the running down of the exuding gum; sometimes it is almost leaf-like, as in gum tragacanth, owing to its exudation at a narrow crack; at other times it takes the form of small tears. The surface is sometimes quite smooth. *e.g.*, in the gums of Moringa and Anacardium, sometimes striated, as in gum tragacanth, or marked by rents or grooves; these markings are generally due to the shrinkage in drying.

The cleavage of a gum is generally conchoidal; the colour usually pale yellow to brownish red; the streak usually white.

Gums are generally transparent or translucent; the surface has commonly a vitreous lustre, but several are dull. Many are doubly refractive or rotate the plane of polarization. The specific gravity of samples of the same gum varies owing to the different amounts of air enclosed in them. When dry they are mostly easily powdered.

Nearly all gums are scentless; they have a characteristic slimy taste, often with a peculiar after taste.

All gums swell with water, but only some actually dissolve. The viscosity, a most important quality, is tested by making a solution of a given strength, say 10 per cent., and determining the time a given quantity takes to flow through the stopcock of a burette, as compared with that taken by the same quantity of a similar solution of gum arabic. The longer the time, the greater the viscosity.

As regards chemical constitution, gums may be classified according to the proportions of arabin, cerasin, and bassorin they contain. Arabin, really a mixture of glucosides, is fully soluble in water, and gums containing large quantities of it are the best for adhesive purposes. The best is gum arabic (Acacia), and other good gums of this class are those of Feronia and Anacardium. Cerasin is insoluble in water, merely swelling up. It is characteristic of the gums of the cherry (Cerasus), almond, peach, and allied plants. Bassorin is slightly soluble in water. Gum tragacanth consists almost entirely of it, and it also occurs in large quantity in Cocoanut and Moringa gums. Lastly, the gum of Cochlospermum Gossypium consists of a mixture of cerasin and bassorin. Gums are used in the arts for adhesive purposes, in calico printing, in sizing, and in confectionery and pharmacy. Large quantities are imported into Great Britain, including over 3,000 tons of gum arabic per annum. Ceylon imports a considerable quantity from India and elsewhere. In 1899 about 70 cwt., valued at Rs. 764, were imported from India, Hongkong, Australia, &c. There is rarely any export of gum. The south and south-west of the Island contain few useful sources of gum, and the climate is too wet for the accumulation of any large exudations, but in the north there are several gum-yielding trees and a drier climate. It should be possible to obtain enough gum locally to prevent the need of importing any but small quantities of special kinds.

The market value of gums is small. Good gums of the gum arabic type are worth from £1 to £5 per cwt. Gum tragacanth is worth from £4 to £12 per cwt. Probably few, if any, of the Ceylon gums are worth more than £1 to £2 per cwt. We have seen above that the chemical constitution is simple, and what is wanted in a gum is that it shall be a pretty pure arabin or bassorin, like gum arabic or gum tragacanth. Most of our gums could merely be marketed as inferior gum arabics or tragacanths. The only fairly good kinds known among our local gums are those of the Cashew (Anacardium occidentale), the Elephant Apple (Feronia Elephantum), Odina Wodier, Anogeissus latifolia, and Margosa (Azadirachta indica). It is difficult to dispose of gums of inferior quality. A gum to be marketable should be a good gum of its class, whether arabic, tragacanth, or cherry. What is wanted in the greater proportion of the uses of gum is that the gum shall dissolve freely in cold water to form a smooth homogeneous and pale-coloured mucilage.

The pale colour is very important, and rules out most of our local gums. A good gum should be unmixed; mixed gums fail to dissolve at a uniform rate in water. Great care must be taken in the collection to avoid contaminating the gum with pieces of bark and other extraneous matter. Before export the gum should be sorted into qualities, and the packages should be uniform in quality and true to sample. The London brokers remark that it is of little use shipping small quantities; if it be desired to establish a new gum on the market, at least 4 or 5 tons should be sent, and a regular supply of the same quality be guaranteed practicable. Consumers will not change the gums they use for others of which the supply is precarious.

Probably there is never likely to be any appreciable export of gums from Ceylon, but it is by no means impossible that there should be less import trade, some of the imported gums being replaced by local qualities. Some of the imported gum is the best gum arabic for medicinal use, and so far no local gum has been discovered good enough to replace this. A good deal of gum is, however, imported for use in mucilage for adhesive purposes, and much of this might be replaced by local supplies. The gums of Feronia, Odina, &c., give good mucilages, though somewhat darker in colour than gum arabic. Calico printing and the manufacture of colours are practically unknown at present in Ceylon, but in the event of their establishment there are several gums for which a use might then be found.

The foregoing brief account will suffice to describe the general features of this class of substances, and to furnish a few elementary hints to any one thinking of endeavouring to start the collection or export of gums. A collection of nearly all the different kinds of gums known in the colony, either native or imported, will be found in the Museum at Peradeniya. A list of the known Ceylon native or imported gums follows, arranged according to the scientific names of the plants which furnish them.

The astringent substances known as Kinos or Gum-kinos, which exude from the bark of Pterocarpus Marsupium and other trees, are included among the gums described below, and will be again mentioned under the heading of Drugs, to which they more strictly belong.

A.—STAPLE GUMS.

GUM ARABIC, in the broadest sense, is the product of many species of Acacia. The chief source is *A. Senegal*, Willd. (*A. Verek*), a common tree of N. Africa and W. Asia, which yields the gums known as Arabian, Kordofan, Senegal, Sennaar, Suakin, Geddah, Somali, &c., collected in different parts of the countries mentioned. The gums of N.E. Africa often travel to Europe *viâ* Bombay, and are known as East Indian, but are not produced in India, though sometimes adulterated there with local gums. A small quantity of gum also comes from W. and S. Africa, Australia, and other places, and is the product of many different species of Acacia.

The gum usually flows freely; the stems are sometimes wounded beforehand. The form of gum arabic varies with the species and country of origin.

The fracture is conchoidal, with glassy lustre. Colour pale yellow to brownish. Good kinds are fully soluble in cold or hot water; poor kinds leave a gelatinous swollen mass undissolved. The solution is slightly acid. The ash of good gums is about 3 per cent.

The best kind is Kordofan gum, which occurs in round pellets to about an inch in diameter, and pale yellow.

The best qualities are used in liqueur making, medicine (Acaciæ Gummi of the British Pharmacopœia), and to give lustre to silkwares, &c., in the process of dyeing, also in making the best water colours; inferior qualities are used in colour making, for adhesives, and in calico printing. The value of gum arabics is from £1 to £5 per cwt. Ceylon imports the gum for mucilages and for medicinal use.

GUM TRAGACANTH is the product of various species of Astragalus found in Greece and W. Asia. It flows naturally or from artificial wounds. The best kind is Smyrna gum; others are Syrian and Morea tragacanths. The typical form is leafy, with striated cross markings, but some kinds are thread-like or in pellets. The colour is whitish, the gum translucent. Tragacanth consists of bassorin mixed with a soluble gum. It is used in making colours and in printing, and by shoemakers for giving a gloss to leather; also in medicine.

A group of bassorin gums, known as Bassora, Kutira, or Hog Gums, mostly Indian, furnish inferior tragacanths to the market. They are mentioned below.

B.—MINOR GUMS.

Acacia arabica (Karuvel, T.; Fl. Cey., II., 122*), the Babul of India, planted in dry zone, yields an arabin gum, used in calico printing in India, and as a food. *A. Catechu*, Willd., the Cutch of India, yields a similar gum.

A. decurrens, Willd., the Australian Black Wattle, planted in the upper montane zone, yields an insoluble gum, used in Australia in place of isinglass for jellies, or mixed with glue for sizing leather in tanneries.

A. Farnesiana, Willd., the Cassie Flower of India, native of America and Australia, naturalized in the low-country, yields an arabin gum.

Adenanthera pavonina, L. (Madatiya, S.; Anaikuntumani, T.; Fl. Cey., II., 120), common in low-country, often planted, is said to yield a gum.

Ægle Marmelos, Corr. (Beli, S.; Vilvam, T.; the Bael Fruit; Fl. Cey., I., 229), cultivated in low-country, is said to give a fair arabin gum.

Albizzia amara, Boiv. (Uyil, T.; Fl. Cey., II., 130), in dry low-country, rare, is said to yield a good arabin gum.

* References thus made are to Trimen's Flora of Ceylon, 1893–1900.

A. Lebbek, Benth. (Mara, S.; Kona, Vakai, T.; Fl. Cey., II., 128), in dry zone, rare, often planted, is said to yield an insoluble gum, used in India under the name "Lera" to adulterate gum arabic. *A. procera*, Benth., planted at Peradeniya, is said to give a gum.

A. odoratissima, Benth. (Suriya-mara, S.; Ponnaimurankai, T.; Fl. Cey., II., 129), common in low-country, and in India and Malacca, yields a dark brown soluble gum.

A. stipulata, Boiv. (Kabal-mara, Hulan-mara, S.; Fl. Cey., II., 129), common in moist low-country, often planted for shade, and in India and Malaya, yields a gum used by the Nepalese for sizing paper.

Anacardium occidentalé, L. (Kaju, S.; Montirikai, T.; Cashew Nut; Fl. Cey., I., 317), common in low-country, probably introduced by the Portuguese, yields Cashew gum, collected in S. America, a gum of inferior type, only partially soluble in water. Might prove useful locally as mucilage.

Anogeissus latifolia, Wall. (Dawu, S.; Vekkali, T.; Fl. Cey., II., 162), in the Bintenna district, rare, and S. India, yields a clear gum of arabin type, used for calico printing in India, especially with certain dyes, for which it is preferred to gum arabic. Also used as a food.

Artocarpus incisa, L. (Rata-del, S.; Breadfruit), and *A. integrifolia*, L. (Kos, S.; Pila, T.; Jak), both largely cultivated in Ceylon, are said to yield gums. *A. Lakoocha*, Roxb. (Kana-gona, S.; Fl. Cey., IV., 99), moist zone, rare, yields a dark gum.

Azadirachta indica, A. Juss. (Kohomba, S.; Vempu, T.; Margosa or Nim; Fl. Cey., I., 244), common in dry zone, and planted, and in India, yields a pale yellow gum.

Bassia longifolia, L. (Mi, S.; Illuppai, T.; Fl. Cey., III., 79), common in dry zone and S. India, is said to yield an inferior gum, used medicinally.

Bauhinia racemosa, Lam. (Mayila, S.; Atti, T.; Fl. Cey., II., 116), common in dry zone, and India to China, is said to give a gum of tragacanth type known as "Semla gond" in India (*cf.* Agric. Ledger, 1900, p. 115). *B. Vahlii*, W. & A., introduced at Peradeniya from N. India, 1880, and other species of *B.*, probably yield similar gums.

Bombax malabaricum, DC. (Katu-imbul, S.; Parutti, Kaddu-parutti, T.; the Cotton Tree; Fl. Cey., I., 160), common to 2,500 feet, Indo-Malayan, yields a reddish-coloured bassorin gum.

Borassus flabelliformis, L. (Tal, S.; Panai, T.; Palmyra Palm; Fl. Cey., IV., 336), cultivated in dry zone, yields a dark gum from wounds.

Butea frondosa, Roxb. (Gas-kela, S.; Parasu, T.; Fl. Cey., II., 66), Bibile and other places in dry zone, and in India. A dark red astringent juice exudes from natural or artificial wounds, and hardens into translucent ruby tears, the Bengal "Kino" of commerce. It may be purified by solution in water, is used chiefly in medicine, but might also find employment as a dye or tan. Not collected for export in Ceylon.

Cassia Fistula, W. & A. (Ehela, S.; Tirukkontai, Kavani, T.; Fl. Cey., II., 103), common in dry zone, and India to China, yields a dark soluble gum. *C. siamea*, Lam. (Wa, Aramana, S.; Vakai, T.; Fl. Cey., II., 108), is said to yield gum.

Cedrela odorata, L. (Sweet Cedar), introduced at Peradeniya from W. Indies in 1884, and sometimes planted for shade; and *C. Toona*, Roxb. (Red Cedar, Indian Mahogany, &c.), introduced from India in 1852, and often planted for shade, yield gums.

Chickrassia tabularis, A. Juss. (Hulan-hik, S.; Aglai, Kaloti, T.; White Cedar, Chittagong wood; Fl. Cey., I., 252), frequent in Central Province about 2,000 feet; Indo-Malayan, yields a light-coloured gum in India.

Chloroxylon Swietenia, DC. (Buruta, S.; Mutirai, T.; Satinwood; Fl. Cey., I., 252), common in dry zone, and in S. India, yields a brittle brownish soluble gum, which might be of local value.

Citrus Aurantium, L. (Peni-dodan, S.; Narankai, T.; Orange), *C. decumana*, L. (Jambola, S.; Jamblica, T.; Shaddock or Pumelo), and *C. medica*, L. (Sidaran, S.; Nar-attam-palam, T.; Citron), all cultivated, yield inferior gums.

Cochlospermum Gossypium, DC. (Kinihiriya, Ela-imbul, S.; Kongu, T.; Fl. Cey., I., 70), a Central Indian tree, planted near temples in Ceylon, yields a poor gum, mixed bassorin and cerasin, insoluble in water, sold in India as a Kutira or hog gum (see above).

Cocos nucifera, L. (Pol, S.; Tennai, T.; Cocoanut; Fl. Cey., IV., 337), cultivated in all tropical countries, is said to yield a bassorin gum.

Cycas circinalis, L. (Madu, S.), common in wet zone to 1,500 feet, and in Eastern tropics, yields a clear gum.

Enterolobium cyclocarpum, Griseb., introduced at Peradeniya from W. Indies in 1884, yields a poor arabin gum.

Eriodendron anfractuosum, DC. (Imbul, Pulu-imbul, S.; Silk Cotton Tree; Fl. Cey., I., 161), common in low-country, yields a red resinous gum.

Erythrina indica, W. & A. (Erabadu, S.; Mulu-murukku, T.; Fl. Cey., II., 63), common in low-country, often planted, yields a poor dark brown gum.

Feronia elephantum, Corr. (Diwul, S.; Vila, Vilatti, Mayaladikkuruntu, T.; Wood Apple; Fl. Cey., I., 228), common in dry zone, and Indo-Malayan, yields (in India) an arabin gum, easily soluble in water, of quality equal to medium gum arabic, used in dyeing, paints, &c. Suitable for local use as mucilage.

Grevillea robusta, Cunn. (Silky Oak), Australian, introduced at Peradeniya in 1856, extensively planted in the hills, yields a poor bassorin gum.

Hymenæa Courbaril, L. (Locust Tree), S. American, introduced at Peradeniya in 1882, is said to give an arabin gum.

Mangifera indica, L. (Amba, S.; Manga, T.; Mango), cultivated in Ceylon, is said to give an inferior arabin gum.

Melia Azedarach, L. (Bead Tree, Indian Lilac), Indian, cultivated in Ceylon, is said to yield gum.

Moringa pterygosperma, Gaertn. (Murunga, S.; Horse-radish Tree; Fl. Cey., I., 327), yields a Kutira (bassorin) gum.

Myristica laurifolia, Hk. f. & Th. (Malaboda, S.; Palmanikam, T.; Fl. Cey., III., 434), common in wet zone 1,000 to 5,000 feet, yields an orange-red astringent gum, little studied, possibly of the nature of a kino.

Odina Wodier, Roxb. (Hik, S.; Odi, T.; Fl. Cey., I., 318), common in the low-country, and in Tropical Asia and Africa, yields Jingan gum, of arabic type, but inferior, favourably reported on in Europe. Used in India for mixing with whitewash (see Agric. Ledger, 1900, p. 169).

Phyllanthus reticulatus, Poir. (Wel-kayila, S.; Pulla, Pullanti, Mipullanti, T.; Fl. Cey., IV., 19), common in dry zone, and in Asia and Africa, affords a styptic gum, little known, possibly of kino value.

Poinciana regia, Boj. (Flamboyante), Madagascar, early introduced at Peradeniya, is said to yield a soluble gum.

Prosopis juliflora, DC. (Algaroba, Mezquit Bean), S. American, introduced at Peradeniya in 1880, is said to yield a gum.

Prunus Cerasus, L. (Cherry), occasionally cultivated at 6,000 feet, yields cherry gum, partially soluble in water, composed of about 35 per cent. cerasin, arabin, &c.

Spondias dulcis, Fors. (Hog Plum), W. Indian, cultivated in Ceylon, and *S. mangifera*, Willd. (Embarella, S.; Ampallai, T.; Fl. Cey., I., 327), common in the low-country, are said to yield gums.

Sterculia urens, Roxb. (Kavali, T.; Fl. Cey., I., 164), rare in Ceylon, Indo-Malayan, yields a bassorin (hog) gum.

Pterocarpus Marsupium, Roxb. (Gammalu, S.; Venkai, T.; Fl. Cey., II., 90), common to 3,000 feet, and in S. India, yields Malabar kino. It is largely collected in Madras, the trees being tapped on a herring-bone system, and the kino collected, dried, and exported (see Agric. Ledger, Med. Ser., 15). *P. indicus*, Willd., introduced at Peradeniya, and now a common low-country shade tree, is said to yield a kino.

Tamarindus indica, L. (Siyambala, S.; Puli, T.; Tamarind; Fl. Cey., II., 114), Indian, cultivated in Ceylon, is said to yield a blackish partly soluble gum.

Terminalia belerica, Roxb. (Bulu, S.; Tanti, T.; Fl. Cey., II., 159), common in low-country, mostly planted, Indo-Malayan, is said to yield abundant gum of bassorin type. *T. Catappa*, L. (Kottamba, S.; Country Almond), planted in Ceylon, yields a dark gum in India.

Trema orientalis, L. (Gedumba, S.; Fl. Cey., IV., 82), common in Ceylon, is said to yield gum.

Wrightia zeylanica, Br. (Wal-idda, Sudu-idda, S.; Fl. Cey., III., 137), common in low-country, is said to yield a gum.

Sub-section 2, Resins.

Resins are the product of secretion or disintegration of the internal tissues or cells of plants; they are usually formed in special cavities or passages, and escape to the surface if wounds are made in the bark. They are usually collected at wounds made for the purpose, often on a very large scale.

Resins are insoluble in water, but are mostly soluble in alcohol, ether, and carbon disulphide; they burn with a sooty flame. They may be roughly divided into three classes, resins, gum-resins (more or less of gum mixed with true resin), and balsams (more or less fluid, either resins dissolved in ethereal oils, such as Canada balsam and turpentine, or resin-like fluids, such as Balsam of Peru).

Resins are sometimes brought to market in the form assumed by the exudations, *e.g.*, drop-like or stalactitic (*cf.* p. 16), sometimes in large tubers which are dug up from the soil in the neighbourhood of the trees, or even in places where trees no longer exist, and sometimes in various artificial forms—tears, cylinders, flakes, &c. The surface may be smooth, or marked by characteristic facets, cracks, &c., caused by shrinking or weathering.

The cleavage is commonly vitreous or conchoidal, the lustre usually vitreous, the colour often characteristic, yellow, brown, or red, or sometimes colourless. Some resins are transparent, some opaque, most only translucent. Most give a white streak, are brittle and easily powdered, and commonly have a characteristic smell or taste.

The melting points of resins vary from 75°-360° C., and are characteristic for the various kinds. Their solubility varies much with regard to the different solvents, some dissolving easily, others with difficulty, in alcohol, ether, carbon, disulphide, oil of turpentine, cajuput oil, benzol, &c.

The chemistry of resins is complex, and does not require discussion in this work; reference may be made to Wiesner's Rohstoffe, and to works on chemistry. They are divided into two main groups, those which, like benzoin, storax, &c., contain esters of aromatic acids, and those which, like sandarach, copal, dammar, &c., contain only resinic acids.

The chief use of resins in the arts is in the manufacture of varnish, which consists of a solution of resin in oil of turpentine, alcohol, or other solvents. When brushed over the surface of wood or other object to be preserved, the solvent evaporates, leaving a thin coating of the resin. The manufacture of varnishes is dangerous, on account of the heating required, and the great inflammability of the substances employed. They may be roughly classified into oil and spirit varnishes; the former include the ordinary carriage and copal varnishes, made by melting the resin, mixing with the required quantity of clarified linseed oil, afterwards boiling and mixing with the suitable amount of oil of turpentine. The latter are chiefly the fine varnishes used in photography and cabinet work, and are made by dissolving the resin in spirit of at least 60 over proof, by the aid of gentle heat. Details of the processes of varnish-making can be found in such books as Spon's Workshop Receipts, Ure's Dictionary of Arts and Manufactures, &c. There is every reason to suppose that several very good varnishes might be locally made in Ceylon, from local resins, and thus replace some of the imported varnishes. The matter is well worth investigation.

Resins are also used in medicine, in the manufacture of lacquer, and in other arts.

Ceylon contains, as will be seen from the list below, a good many trees which yield valuable resins, but there appears to be very little export and the local use is but little, while all the varnish used in the Island is apparently imported. Some of the local resins are used medicinally. It is hoped to carry out a series of experiments upon the uses of the local resins. Attention may be specially drawn to Calophyllum, Canarium, Dipterocarpus, Doona, Garcinia, Semecarpus, Styrax, Vateria, Vatica, below.

The market value of resins varies very much, according to the kind and quality. Common copals, &c., vary from £3 to £20 per cwt. In preparing a resin for market, especially a resin of any hitherto unfamiliar kind, the remarks above made under gums, as to cleanliness, absence of any admixture of foreign bodies or other resins, and sorting into qualities, apply with the same force.

A.—STAPLE RESINS.

COPAL OR ANIME RESINS.—These are hard resins melting at high temperatures. Their botanical source varies, and has yet to be satisfactorily made out in many cases. Several of the African copals are dug from the ground, having flowed from trees that formerly existed there. The best kinds come from Zanzibar, often *viâ* Bombay (these are often sold as "Bombay"), and from Madagascar. Kauri copal from Australia and New Zealand is the product of the Coniferous tree Agathis australis, Steud. (the Kauri or Cowrie Pine), and other species of Agathis; it is also often dug up in a tuberous form. Manila copal, from the East Indian Archipelago, formerly supposed to be derived from the Dipterocarpous tree Vateria indica, is now regarded as derived from Agathis loranthifolia, Sal. (A. Dammara, Rich., cultivated at Peradeniya, where it was introduced in 1881). South American copal is the product of Hymenæa Courbaril, L., the Locust Tree, cultivated at Peradeniya since 1882. Other copals are derived from species of Trachylobium (Trop. Africa and Asia) and other sources.

Copals are very valuable for carriage varnishes and lacquers, also for good photographic varnishes. Their value increases, other things being equal, with the height of the melting point.

Ceylon apparently possesses no native resins of this class, but some of these trees have been introduced and grow well here, and might be worth further cultivation if a local use can be found for the resins.

DAMMAR.—This is an East Indian resin, appearing on the market as colourless or yellowish lumps, or stalactites, rather soft and smooth, with a very faint smell when fresh. Its source has yet to be satisfactorily determined, but appears to be a Dipterocarpous tree, Shorea Wiesneri, Stapf. It is a very valuable material for lacquers and varnishes; the latter are made with oil of turpentine, and are very colourless. It is also used in medicine. Other dammars are also obtained from Shorea robusta and other Dipterocarps, of which Ceylon has several (*e.g.*, Dipterocarpus, Doona, Vateria, Vatica, below), and from some of the Burseraceæ, *e.g.*, Black Dammar from Canarium strictum (introduced here in 1871). The copal resins of the various species of Agathis were formerly confused with dammar.

ELEMI.—Under this name are classed the resins of the family Burseraceæ; they are balsamic, white in colour, stiff, rich in ethereal oils, and are used in varnishes and lacquers, especially spirit varnishes, in medicine, and in lithography. The best is Manila Elemi, supposed to be derived from

Canarium commune, L. (Java Almond, introduced into Ceylon), a sticky yellowish-green resin. Others are American. Ceylon has several species of this family, but none (except Canarium zeylanicum, *q. v.*) known to yield good elemis; further study is however required.

GAMBOGE.—This is a gum-resin, derived from Garcinia Hanburyi, Hk., f. in Siam and S.E. Asia, and from G. Morella, Desr. (Gokatu, S.), in Ceylon. The former is often regarded as only a variety of the latter. Other species of this genus are also used. Gamboge is chiefly exported from Bangkok, Saigon, and Singapore. It is collected in Siam, &c., from definite incisions made in the tree, often spiral cuts, at the foot of which are placed small tubes of bamboo, in which the resin is collected and dried ; the gamboge is then removed and exported as "pipe" gamboge, the best quality. In Ceylon but little is collected ; strips of bark about an inch wide are taken off, the gamboge runs out and hardens, and is then broken off.

The freshly broken surface is reddish-yellow to brownish-red. When rubbed with water, gamboge makes the familiar emulsion used for painting. It is used for colouring spirit varnishes, in metal varnishes, gold size, and in medicine. The market value of good pipe is now £16 to £17 per cwt.

RESIN (COMMON).—The common market resins or rosins are the products left behind when turpentines are distilled as described below. Some of them are known as white pitch or colophony. They are used in varnish, lacquer, in resin-soaps, glue, &c.

TURPENTINE, often confused with Oil of Turpentine, is the name under which the balsams of the pines, spruces, firs, larches, and a few other conifers are classified. They are chiefly derived from Europe and N. America, and are usually obtained by tapping the trees in various ways. They consist of admixtures of resin, water, and oil of turpentine. The finest kinds, such as Venetian Turpentine, Strasburg Turpentine, and Canada Balsam, are clear and transparent, the common kinds are turbid. By distillation, resin is left, as described in the last paragraph, and oil of turpentine goes over.

B.—MINOR RESINS.

Agathis loranthifolia, Salisb. (*Dammara orientalis*, Lam.).—See Copal. *A. robusta*, Lindl., the Queensland Kauri Pine, introduced at Peradeniya in 1865, a fine tree, is said to give a copal.

Ailanthus malabarica, DC. (Kumbalu, Wal-bilin, S.; Fl. Cey., I., 230), in wet low-country, S. India, Burma, yields a brown fragrant resin from the inner bark, used in dysentery and as material for incense. Known as Mattipal.

Aquilaria Agallocha, Roxb. (Eagle wood, Aloes wood, Akyaw), Burma, introduced at Peradeniya in 1884, yields a fragrant resin from the wood; the tree is felled and cut up, and the chips used in incense.

Araucaria Cookii, Br., from New Caledonia, introduced at Peradeniya in 1865, yields a gummy resin.

Balsamodendrum Berryi, Arn. (Mul-kilivai, T.; Fl. Cey., I., 238), rare in dry zone, cultivated for hedges at Jaffna, yields a gum-resin in India. *B. Myrrha*, Nees, the Myrrh, Arabia and N. Africa, cultivated in W. India, is the source of Myrrh, a medicinal gum-resin, the market for which is chiefly in Bombay. *B. Opobalsamum*, Kunth., in the Red Sea country, is the source of the medicinal gum-resin Balm of Gilead, imported to Bombay, and also used as a perfume. *B. Roxburghii*, Arn., in E. Bengal, introduced at Peradeniya in 1883, yields a greenish gum-resin used by masons in making fine plaster (Watt).

Boswellia Carterii, Birdw., in Arabia and N.E. Africa, is the source of the gum-resin Frankincense or Olibanum, the trade in which is largely at Bombay.

Callitris quadrivalvis, Vent., in Algeria, &c., yields from incisions the resin known as Sandarach or Arar, used in varnishes, and when powdered used, under the name of Pounce, to prepare the surface of parchment or paper. Its market price is £3 to £6 per cwt. *C. robusta*, Br., the Australian Pine, introduced at Peradeniya, yields a resin like Sandarach, used in varnishes.

Calophyllum Inophyllum, L. (Domba, S.; Punnai, Dommakottai, T.; Fl. Cey., I., 100), common in low-country, especially on the coast, and in Tropical Asia and Australia, yields a yellowish-green gum-resin not unlike the East Indian Tacamahac of commerce (which is derived from *C. Tacamahaca*, Willd., in Madagascar).

Canarium bengalense, Roxb., in Assam, &c., introduced at Peradeniya in 1881, yields an inferior copal-like resin, used in India as incense, and sold at Rs. 3 per maund in Calcutta. *C. commune*, L., the Java Almond, introduced into Ceylon before 1824 from the Malay Archipelago, is supposed to be the source of Manila Elemi (see above). *C. strictum*, Roxb., of S. India, introduced at Peradeniya in 1891, yields Black Dammar. Vertical cuts are made in the bark, and the base of the stem is fired by means of brushwood piled against it. The dammar begins to flow two years later, and the flow is said to last ten years. The resin is useful for varnishes, &c., but is too expensive to compete on the market with the cheaper resins (Watt). *C. zeylanicum*, Bl. (Kekuna, S.; Pakkilipal, T.; Fl. Cey., I., 239), common in the low wet country, endemic, yields large quantities of a gum-resin like Manila Elemi (*q.v.*), clear, fragrant, and balsam-like. It is used locally for fumigation, and occasionally for lights in houses when mixed with sand.

Carapa moluccensis, Lam. (Fl. Cey., I., 251), in mangrove swamps on W. coast, is said to yield a brown resin.

Convolvulus Scammonia, L., in the Mediterranean region, cultivated in India, is the source of the gum-resin Scammony.

Copaifera officinalis, L., in Central America and the West Indies, introduced at Peradeniya in 1880, is the source of Copaiba, which is largely used in medicine, paper-making, varnish, and lacquer. The method of tapping it is said to be to cut a hole a foot square into the heartwood of the tree, sloping forwards; a tree is said to give as much as 15 gallons.

Dæmonorops (*Calamus*) *Draco*, Bl., in the Malay Archipelago, is the source of Indian Dragon's Blood. The fruit scales, which are coated with a red resin, are shaken in bags till the resin comes off as a powder, which is made into sticks or cakes. It is used in red spirit varnishes, in furniture polish, and in medicine.

Dipterocarpus alatus, Roxb., Assam and Malaya, introduced at Peradeniya in 1880, and other species of *D.* yield Gurjun Oil or Wood Oil (market value about 5d. per lb.), used in medicine and for varnish and lacquer. The method employed to obtain it in Cochin China is to bore holes in the stem and light fires near. One tree is said to yield 50 gallons. *D. glandulosus*, Thw. (Dorana, S.; Fl. Cey., I., 115), rare in wet low-country, yields a blackish resinous oil (Dorana-tel, S.), said to be a good substitute for Gurjun Oil, and used in the Leper Hospital at Colombo (and see Vateria). *D. hispidus*, Thw. (Bu-hora, S.; Fl. Cey., I., 114), found near Ratnapura, yields an aromatic gum-resin from the wood. *D. zeylanicus*, Thw. (Hora, S.; Fl. Cey., I., 114), common in the moist low-country, endemic, gives a grayish-green gum-resin. All of these are worth further investigation.

Doona cordifolia, Thw. (Beraliya, S.; Fl. Cey., I., 122), *D. macrophylla*, Thw. (Honda-beraliya, S.), and *D. ovalifolia*, Thw. (Pini-beraliya, S.), rare in wet low-country, endemic, give good resins, which should be of value for varnish. *D. zeylanica* (Dun, S.; the Doon; Fl. Cey., I., 119), common in wet zone to 4,000 feet, also yields a good colourless resin. All these might be used as substitutes for dammar, and are worth investigation.

Dorema Ammoniacum, Don, in W. Asia, is the source of the medicinal gum-resin Gum Ammoniacum, imported in small quantity.

Erythroxylon monogynum, Roxb. (Devadaram, Chemmanatti, T.; Red Cedar of India; Fl. Cey., I., 190), common in dry zone and in S. India. The heartwood has a pleasant resinous scent, and yields by distillation a kind of tar said to be used by Moormen at Puttalam as a preservative for the wood of their boats (Trimen).

Ferula galbaniflua, Boiss., and *F. Narthex*, Boiss., in W. Asia, are the sources of the gum-resins Gum Galbanum and Asafœtida respectively, used in medicine, and the latter also in food.

Garcinia Cambogia, Desrouss. (Goraka, S.; Korakkaipuli, T.; Fl. Cey., I., 95), frequent in wet zone to 1,500 feet, yields a transparent gum-resin from the bark (Trimen). Its gamboge is of very poor quality. *G. Morella*, Desrouss. (Kanagoraka, Gokatu, Kokatiya, S.), common in wet zone to 2,000 feet, and in India and Malaya, yields abundance of gamboge, which is however little collected in Ceylon (see Gamboge, above).

Guaiacum officinale, L., the Lignum Vitæ of S. America and W. Indies, introduced at Peradeniya in 1882, yields the resin Guaiacum, used in medicine and in chemistry.

Hardwickia pinnata, Roxb., of S. India, introduced at Peradeniya in 1871, gives a dark red resin from deep incisions, like Gurjun Oil or Copaiba, useful in medicine (Watt).

Hymenæa Courbaril, L. (see above, Copal).

Mammea americana, L., the Mammee Apple, introduced from the W. Indies before 1824, yields a resin.

Mastixia tetrandra, Clke. (Maha-tawara, S.; Fl. Cey., II., 287), endemic in wet zone to 4,000 feet, yields a scented resin.

Mesua ferrea, L. (Na, S.; Naka, T.; Ironwood; Fl. Cey., I., 105), common in wet zone, India and Malaya, yields an aromatic resin, which is said to make a good varnish with oil of turpentine (Watt).

Pinus.—Many species of pines yield turpentines (see under *A*, above) by tapping. Ceylon has no native species, but several have been introduced at Hakgala.

Pistacia Lentiscus, L., of the Mediterranean region, is the source of Mastic, a very valuable resin, used in medicine, varnishes, and liqueurs; obtained by tapping the trees, and exported chiefly from Chios.

Schinus terebinthifolius, Raddi, introduced at Peradeniya in 1884, is the source of W. Indian Mastic (*cf.* Pistacia).

Schleichera trijuga, Willd. (Kon, S.; Puvu, Kula, T.; Fl. Cey., I., 304), common to 2,000 feet, and Indo-Malayan, is said to yield a yellow resin.

Semecarpus Anacardium, L. f., the Ink Nut or Marking Nut of Indo-Malaya, introduced at Peradeniya; and *S. Gardneri*, Thw. (Badulla, S.; Fl. Cey., I., 323), common to 3,000 feet in wet zone, yield acrid black resins, which might perhaps afford the basis of black varnishes.

Shorea robusta, Roxb., the Sal of India, introduced at Peradeniya in 1880, yields large quantities of aromatic resin when tapped. Formerly much destroyed in India for the sake of its resin, now conserved, as its timber is very valuable. Ceylon has several species of *S.* (Fl. Cey., I., 116), not recorded as producing resins, but they should be tested.

Styrax Benzoin, Dryand., Malayan, introduced at Peradeniya in 1881, cultivated on the edges of fields in Sumatra, Singapore, &c., is the source of Benzoin or Gum Benjamin, an aromatic resin used in perfumery, varnish, and medicine. The tree yields at seven years old, by tapping, at the rate of about 3 lb. a year; the resin is packed into cubes while soft and exported; its market value is about £6 to £8 per cwt.

Toluifera Balsamum, L. (Balsam of Tolu, introduced at Peradeniya in 1870), and *T. Pereiræ*, Baill. (Balsam of Peru, 1861), S. American trees, yield valuable medicinal and perfumery balsams by tapping.

Trachylobium verrucosum, Oliv., of Tropical Africa, &c., introduced at Peradeniya, is the source of a copal (see above).

Vateria acuminata, Hayne (Hal, S.; Fl. Cey., I., 131), common to 2,000 feet in wet zone, endemic, yields a clear yellowish resin on tapping, of very good quality, occasionally exported as a dammar (*q. v.*). It makes a good varnish with the local Dorana-tel (see Dipterocarpus), and probably would make excellent varnishes in the ordinary solvents.

Vatica obscura, Trim. (Fl. Cey., I., 129), rare in dry zone, endemic, yields an odorous sticky gum-resin (Trimen). *V. Roxburghiana*, Bl. (Mendora, S.; Swamp Mendora, *l. c.*, 128), frequent in wet low-country, and in W. India, gives a transparent yellow resin.

Sub-section 2a, Lac.

(By E. E. GREEN, Government Entomologist.)

Strictly speaking, lac is not a vegetable economic product, but as it is a resin and collected upon plants it is convenient to include it here.

Lac is not—as sometimes supposed—a resinous exudation from a tree, excited by the punctures of the insect that accompanies it. The juices of the plant first pass through the body of the insect, and reappear as an excretion from the skin. The resinous matter first occurs in the form of separate plates on the dorsal area of each segment of the larval insect. As the insect grows these plates enlarge, coalesce, and thicken ; finally forming a hard compact shell completely enclosing the insect, but perforated by three small holes—known as the spiracular (2) and anal (1) orifices. Where the insects are much crowded on a branch—as usually occurs—the resinous cases become agglomerated, resulting in a continuous incrustation enclosing the branch upon which it is formed. In this condition it is known as "Stick-lac." "Seed-lac" consists of the resinous matter removed from the branches and broken up. "Shell-lac" is the residue after evaporation of an alcoholic solution of the resin.

The lac insect is a Coccid or scale-insect, belonging to the genus *Tachardia.* Many species of Tachardia are known to science, but only a few of them are of any economic value. The principal source of commercial lac is *Tachardia lacca*, a native of India.

THE LAC INDUSTRY IN CEYLON.

Lacwork, or lacquerwork, appears to be a dying industry in Ceylon.

There are two distinct classes of work: one in which the lac-pigments are applied to the wood while it is revolving on a turning-lathe, the heat of friction causing the lac to adhere: and another in which the pigments are heated over a charcoal fire during application. The first class of work is applicable only to articles that can be turned on a lathe. The second can be employed for the decoration of other articles, such as panels, Kandyan walking-sticks, standard handles, and small pieces of furniture. The painted pottery and much of the decorative panel work—often classed as lacwork in Ceylon—have really no connection with that art. The pigments employed in the painting of pottery are mixed with vegetable gums, and applied with paint brushes. Paint brushes are not and—from the nature of the medium—cannot be employed in true lacwork.

As far as I have been able to discover, work of the first class is centred in the small village of Angalmaduwa (situate about 7 miles from Tangalla), and is in the hands of two small families only. I have visited this village and (with the exception of the actual mixing of the pigments, which was reserved as a trade secret) have seen the whole process.

The product of two distinct species of lac insects (*Tachardia albizziæ*, Green; and *T. conchiferata*, Green) is employed by the lac-workers of the Tangalla District. The former, known to the natives as "Kon laccada," occurs on the following trees:—"Keppitiya" (*Croton aromaticus*), "Kon" (*Schleichera trijuga*), "Hinguru" (*Acacia cæsia*), and "Kittipol" (a name which I have been unable to identify). I have found it also on "Hulan-mara" (*Albizzia stipulata*), "Pehimbiya" (*Filicium decipiens*), "Na-imbul" (*Harpullia cupanioides*), and *Nephelium litchi*.

The latter (*T. conchiferata*), known as "Tela-kiriya laccada," is a scarcer species, and is found by the natives only on the "Tela-kiriya" (*Excœcaria Agallocha*), an Euphorbiaceous plant. I have myself taken this lac insect on a species of *Acacia*, in the Kandy District. Though less abundant than the other, this species is preferred by the lacworkers, as it produces lac of a brighter and clearer quality. They also use small quantities of imported Indian lac (the product of *Tachardia lacca*), which they purchase at Galle. It makes a quality similar to that of "Tela-kiriya laccada."

A third species of Tachardia (which has been provisionally named *T. lobata*) occurs in Ceylon on a species of *Flacourtia*. But the insect is so small and the resinous secretion so dense, that it would be of little or no value for lacwork.

The wood employed by the lacworkers of Angalmaduwa is—almost exclusively—"Suriya" (*Thespesia populnea*), which is light and easily worked on a turning lathe. It is seasoned (under cover) for about two months. "Satinwood" (*Chloroxylon Swietenia*) is more rarely used. The work is smoothed with the leaves of the "Sandpaper fig" (*Ficus asperrima*). The objects usually manufactured are small tables, chairs, fancy cups, tom-tom frames, and walking-sticks. But any article, the parts of which can be revolved on a lathe, can be lacquered by this process.

The turning lathes employed are of a very primitive construction. The object is pivoted upon two fixed points, and is revolved independently of the lathe. The operator works in a sitting posture on the ground. The object is revolved by a second man, by means of a piece of rope twisted two or three times round it or round a block to which it is attached.

The lac-pigments are prepared as follows. The freshly collected twigs bearing the lac insects are dried in the sun. The resin is then removed, pounded, and winnowed or sifted. In this condition it is termed simply "laccada." It is then packed into small bolster-shaped bags of thin cotton cloth and roasted over charcoal fires. As the lac melts and oozes through the cloth it is allowed to drip on to a smooth leaf or the smooth surface of a piece of plantain stem, where it cools into a hard brittle mass of a deep brown colour. This is the uncleared lac, locally termed "Kahata ekka." A piece of this uncleared lac is next softened over the fire and attached to the point of a short stick. It is again warmed and a second stick attached to it. The softened lac is then drawn out between the two sticks, worked about, doubled up, and redrawn many times, until it assumes the form of a long stout ribbon of glistening fibrous lac of a bright golden brown colour. It is now known as drawn lac, or "Kahata netta." It only remains to add the pigments,—a process which I was not allowed to see, but it is doubtless effected in much the same manner as described later, in the account of the Matale lacwork.

The pigmented lac finally appears in the form of broad cakes or sticks—resembling coarse sealing-wax—of four colours: red, yellow, green, and black. They are usually shaped so that the edges vary in thickness, to permit of fine lines or broad bands of colour being applied.

The object to be ornamented is now attached to the lathe and revolved as described above. The pattern is in the form of bands of colour of varying breadth; the width of the several bands being first marked out by holding the thin edge of one of the cakes of pigment against the revolving wood at the measured intervals. Where large surfaces are to be covered, narrow lines of one colour are often superposed over a ground of another colour. A favourite combination—especially for the decoration of small tables—is a black ground with concentric rings of yellow or yellow and red.

As mentioned above, the pigment is applied by pressing the cakes of coloured lac against the revolving wood, to which it adheres by the heat of friction. After the surface has been roughly covered in this manner the colour is evenly distributed (while the object is still revolving) by means of small pieces of cane with blunt chisel-shaped ends. The application of colour is repeated several times, and the work is finally polished by holding against it a piece of fresh Pandanus leaf, assisted at intervals by the application of the operator's finger.

The work is now complete, and the pigmented lac forms a dense waterproof covering, which can be affected only by heat or alcohol.

The natural crimson pigment of the lac insect—from which a separate dye is manufactured in India, and which gives its name to the artist's colour "crimson lake"—does not appear to be utilized in any way in Ceylon. It is noticeable that a certain proportion of the insects—even in a single colony—are of a gamboge-yellow instead of crimson colour, and yield correspondingly a yellow pigment.

The second class of lacwork is known as "niya-pothen" (finger-nail) work. The principal examples of this work are coloured walking-sticks and native ceremonial staffs. The headquarters of this branch of the industry is at a village named Hapuwida, in South Matale. It is confined to about five families. The name of this class of work is derived from the fact that the pattern is manipulated chiefly by the finger (or thumb) nail of the operator.

The lac employed is that from *Tachardia albizziæ*, and is here called "Keppitiya laccada," being collected principally from the "Keppitiya" tree (*Croton aromaticus* var. *lacciferus*). The insect occurs on a number of other trees, but the lacworkers state that the lac grown on the croton is of a superior quality, and that lac from other trees is darker and more opaque.

The preparation of the lac is, in most particulars, similar to that employed by the Tangalla workers. The crushed lac is enclosed in narrow bolster-shaped bags of thin cloth. It is heated over a charcoal fire, and the bag twisted until the melted lac oozes through the cloth. This melted lac is then scraped off with the back of a knife, and is drawn in the manner already described. Vermillion ("Sodilingam") is the base of the red pigment. Dhobies' blue ("Nilu") is employed for the blue tints. Orpiment (or Sulphide of Arsenic), locally known as "Hirial," forms the yellow and buff colours. Black is produced by burning rags soaked in oil, and catching the soot on the bottom of an earthenware chatty. The greens are compounded from the blue and yellow pigments.

The pigment is mixed into the drawn lac by softening the latter and pounding the coloured powders into it. This mixing is done by repeated blows with a blunt knife, which drives the colouring matter into the lac, the compound being kneaded and folded again and again during the process.

From the nature of the appliances, this form of lacwork seems to be principally confined to the ornamentation of wooden sticks, or of such pieces of furniture and other articles as are composed of rod-like pieces of wood joined together. It will be convenient to follow the process in its simplest form, namely, in the decoration of a walking-stick.

The wood, having been fashioned into the requisite form and carefully smoothed, is first coated with the ground colour (usually red).

The only tools employed are small round tapered sticks, about 8 inches long, of some hard wood. The specimens in the Museum collection are cut from some kind of palm. The lac pigment is softened over glowing charcoal and a portion transferred to the point of this distributing tool, and worked about until it thickly covers about an inch of the extremity. This, in its turn, is again heated over the charcoal, and when sufficiently soft is spread evenly over the surface of the object by means of the same wooden tool. The object that is being coloured is itself repeatedly warmed to ensure the even distribution of the colour. The coating of pigment is then smoothed and polished with a strip of "ola" (Talipot leaf), a final polishing being given with a piece of soft rag. Upon this groundwork all the other colours that form the pattern are overlaid in the manner described below. For this purpose the lac pigments are drawn out into threads of varying fineness in the following manner. A small piece of the requisite colour is attached to the point of the wooden tool. It is repeatedly heated and kneaded upon the piece of palm leaf, to the smooth surface of which it does not adhere. When sufficiently ductile, the tool being held in the left hand, a piece of the softened mass is taken between the finger and thumb of the right hand and drawn out into a thread which, as it extends, is wound off round the bare knee and left hand of the operator, forming a short skein ; the thread being finally pinched off with the thumb nail. The thickness of the thread depends upon the rapidity of the drawing action ; the fine threads being produced by a rapid movement, while the broader ribbon-like threads are formed by a slower action.

To make the pattern—which is usually in thin lines of a lighter colour on the dark background—a thread of lac pigment of suitable thickness and tint is selected. The object is warmed, the end of the thread attached at the desired point and held in position with the thumb of the left hand. The thread is then applied, being made to follow any curves required by the pattern, and is finally cut off at the right spot with the finger nail. That portion of the object is then again warmed, and the filament of colour pressed firmly into the substance of the groundwork by means of the strip of palm leaf. Broader bands of colour are formed by applying many threads side by side. When warmed and pressed into position, the several threads coalesce, losing all trace of their composite origin. Dots are formed by applying the end of the thread and cutting off a minute piece with the thumb nail. Such dots are consequently square-or diamond-shaped.

In this manner the most intricate patterns are traced on the coloured ground, and great artistic taste is displayed in the execution. To ensure symmetry, the distances are carefully measured with thin strips of the palm leaf. The work is finally polished with a piece of soft cotton cloth, apparently without the assistance of any oil or other lubricant.

The outturn of local lacwork is completely absorbed in the Island. It is very small, and the artificers do not seem at all enterprising or anxious to extend their operations or to find new markets.

There seems no reason why the Indian lac insect, which secretes the resinous matter in much greater abundance, should not be established in Ceylon. Its plentiful occurrence here might give a healthy impulse to the local trade in lacwork. I have made several attempts to introduce the Indian insect; but owing to delay in postage and unsuitable packing, the insects have invariably died during transit.

Chemical Analysis of Ceylon Lacs.

The following analyses have been prepared by Mr. M. Kelway Bamber, Analytical Chemist to the Ceylon Government.

For convenience of comparison, the analysis has been conducted by the method employed by Mr. Hooper in his analyses of the Indian lacs. (See "The Agricultural Ledger," 1901, No. 9, "Lac and the Lac Industries," by George Watt.)

Composition of "Keppitiya laccada" (*T. albizziæ*, Green).

	Per cent.
Moisture	3·50
Colouring matter	8·50
Resin	74·72
Bark, fragments, &c.	7·25
Ash	6·03
	100·00

Composition of "Tela-kiriya laccada" (*T. conchiferata*, Green).

	Per cent.
Moisture	2·45
Colouring matter	7·00
Resin	85·81
Insoluble	4·40
Ash	·34
	100·00

Sub-section 3, Caoutchoucs or Indiarubbers, Guttaperchas, &c.

These substances are contained in the milky juice or latex of a large number of plants, more especially of those belonging to the families Euphorbiaceæ, Moraceæ (included in Urticaceæ by English authors), Apocynaceæ, Asclepiadaceæ, and Sapotaceæ. The rubber-yielding plants are almost confined to the tropical zone, though the families to which they belong are not. The caoutchoucs or guttas are contained in the latex in the form of minute globules in the watery fluid, and when exposed to the air or treated with various chemical compounds they coagulate or clot, finally forming a tough more or less elastic mass, the rubber or gutta of commerce. The latex-containing or laticiferous vessels are most commonly in the inner bark of the tree, near to the cambium, and when the tree is wounded the latex flows out. These substances have been known for a long time to the natives of the tropics, and within the last fifty years have become indispensable in the arts. Until lately the supply was entirely from wild trees, but of recent years their cultivation has been taken up in Ceylon and elsewhere, and now bids fair to become an important industry.

1.—Indiarubber or Caoutchouc.

Indiarubber is imported into Europe and America in enormous quantity, more than 100,000,000 lb. being consumed annually. The chief sources of supply are the Amazon valley (Para rubber, the product of *Hevea brasiliensis*), the Ceara Province of Brazil (Ceara rubber, *Manihot Glaziovii*), Central America (Columbian, Panama, Mexican, Nicaragua, Centrals, &c., *Castilloa elastica*), West Africa and Congo (Senegal, Sierra Leone, Gaboon, Angola, &c., species of *Landolphia*, *Funtumia elastica*, &c.), Madagascar (*Landolphia*), Assam (*Ficus elastica*), Borneo (*Willughbeia firma*), and other islands of the Malay Archipelago.

Rubber appears on the market in many forms, known as slabs, balls, lumps, tongues, biscuits, sheets, twists, strips, negrohead, niggers, scrap, &c. The qualities first named are in general the best, being more homogeneous and less intermixed with bark, sand, or other impurities. The price varies from about 4*s*. 6*d*. per lb., which is obtained at present by the biscuits of the finest Ceylon-grown Hevea rubber, down to about 1*s*. 6*d*. for poor scrap rubbers. The standard rubber quality is "Fine Para, up-river, hard cure," which appears as large very uniform slabs, at present valued at about 4*s.* per lb.

Pure caoutchouc, freshly prepared, is almost colourless, but rubber as it appears on the market is of all kinds of colours, blackish, blueish, greyish, yellowish. A good rubber should be uniform in texture and colour.

Caoutchouc appears to be a compound of carbon and hydrogen, expressed by the formula $(C_{10} H_{16})_n$. It is slightly lighter than water, having a specific gravity of about 0·92. It is a non-conductor of heat and electricity, and becomes electrical on rubbing. It is insoluble in water and alcohol, but absorbs them, and swells up in so doing. In oil of turpentine, carbon bisulphide, ether, benzine, chloroform, &c., rubber forms a clear homogeneous sticky fluid, usually known as rubber solution, but which is rather a solution of the so-called solvent in the rubber than of the rubber in the solvent.

Rubber alters in air and is injured by oils. When heated, *e.g.*, by standing in the sun while drying, it melts to a sticky mass, which does not become firm again on cooling, and which is almost valueless. Crude rubbers contain more or less resin, which lowers their value; the smallest proportions, about 1¼–7 per cent., are found in the best rubbers, *e.g.*, in Para. Rubber is used in innumerable ways in the arts. The crude product goes through various preliminary processes. It is first boiled in water for twelve or more hours to soften it, then torn to fragments in a machine on the principle of the coffee-pulper, and then passed in small quantities between grooved rollers moving in opposite directions, which are continually washed by a stream of water. The rubber emerges as thin sheets with a peculiarly pitted surface, and cleaned of its coarser impurities such as bark, sand, &c. It is then dried and masticated between heated grooved rollers, pressed together into sheets or blocks and left in a cool place for some months to become homogeneous, and is then cut into sheets for manufacturing purposes.

For the majority of its uses rubber is vulcanized, a certain proportion of sulphur being added to it during mastication and the rubber heated for some time to a considerable temperature. It thus becomes tougher and more resistent, and is less easily melted. A larger proportion of sulphur (20–40 per cent.) produces vulcanite or ebonite.

A.—STAPLE RUBBERS.

CASTILLOA OR PANAMA RUBBER.— *Castilloa* is a genus of the family *Moraceæ* (often included in *Urticaceæ*), and belongs to that section of the family which includes the jak and breadfruit (*Artocarpus*), the milk tree (*Brosimum*), and the many species of *Ficus*, *e.g.*, the Bo and the Assam rubber (*F. elastica*). The genus has two or more species. Of these, the most important is *C. elastica*, Cervantes, the Ulé of the Spaniards, which is found wild in Mexico from lat. 21° southwards, in Guatemala, Honduras, San Salvador, Costa Rica, and Nicaragua; it also appears to occur in North-Western South America. *C. tunu* Hemsl., the Tunu, occurs in Honduras and Costa Rica. *Castilloa* rubber was introduced into the Colony about the same time as the Para and through the same agency. A Wardian case of plants arrived in 1876 from the Royal Gardens, Kew, and the plants were put out at Henaratgoda and Peradeniya. They grew well at both places, but especially at Henaratgoda, and were increased by cuttings. They began to flower in 1881, and in the following year a few seeds were ripened. About 1886 the growth became less rapid, and since then has been very slight, the soil in the gardens being shallow, and at Henaratgoda not well drained. *C. elastica* is usually described as a large tree of rapid growth, reaching 180 feet in height and 15 feet in girth. The Ceylon plants show no sign of such growth. There has been some doubt as to whether they are the true *C. elastica;* they were brought by Cross from Darien (Panama), where they were locally known as Caucho, and have been described by some as a different species, *C.*

Markhamiana Markham (not Collins). Recent research seems to show that this form cannot be specifically separated from *C. elastica*, but at the same time it is not improbable that the latter occurs in several different varieties. Koschny describes three in Costa Rica, the white, black, and red (Ule blanco, negro, colorado), recognized chiefly by the colour of the bark. As this is partly due to lichens, these colours are probably not reliable tests out of Costa Rica. The white form is described as the best, the others giving a poor yield and being easily injured by tapping.

A considerable number of plants were distributed from the gardens, and the tree is now common in Ceylon, especially in the Matale District. In recent years some seed has been imported direct from Mexico and elsewhere, and may prove to be different from the originally imported form.

When young the tree grows rapidly upwards, and forms a number of short lateral branches, which after a time drop off, being detached from the trunk by a peculiar joint, whose surface resembles a piece of coral. The bark is rather soft and thick. The leaves are large and oblong. The flowers are borne when the tree has reached some considerable size (in the fifth year or later) and has begun to form permanent branches. They are monœcious, male and female on the same branch, enclosed or embedded in a top-like common receptacle, which is covered externally with small leaves. This subsequently forms a somewhat fleshy fruit, containing numerous small seeds about $\frac{1}{4}$ inch in diameter, with white papery seed-coats. About 800–1,000 seeds weigh a pound. They do not keep well, and should be sown as soon as possible.

Cultivation.—The seeds are sown an inch deep, and about 8 inches apart, in a well prepared nursery and lightly covered with a little vegetable mould. They are kept lightly shaded, and watered when the surface of the ground is dry. They germinate in about three weeks. In ten or twelve months the young plants are 2 feet high and ready for planting out.

Cuttings (at least 3 inches long, with a basal portion of old wood) may also be taken; those from lateral branches have a tendency to grow more or less horizontally, so that main shoots must be used.

The tree in its native country inhabits a warm, steamy climate, like that of the low-country of South-West Ceylon, and is rarely found above 1,500 feet. The most common situations are in alluvial soil at the sides of valleys or on low ridges. It needs deep, warm, loamy soil, with plenty of water, but does not thrive where the soil is swampy, nor in places where there is not good drainage at the roots. It grows best where the temperature never falls below 60°, and in a district with a well distributed rainfall of at least 70 inches. The most promising localities in Ceylon are the lower mountain districts, such as Matale, Rambukkana, Balangoda, Passara.

The young plants are planted out during rainy weather in holes filled with well prepared sandy, loamy soil. If the plantation is of *Castilloa* only, they are usually put at about 12–15 feet apart. The young trees are shaded for a time; possibly it would be best if they were always lightly shaded like cacao, *Castilloa* being a forest tree. It is sometimes itself used as a shade for cacao or for other crops. The ground is kept clear of weeds and the trees watered in dry weather until they reach sufficient size to take care of themselves.

The tree grows fairly rapidly at first, and soon reaches a height of 10 or more feet. The largest of the original trees at Henaratgoda at six years old was 46 feet high and 26 inches in girth at a yard above the soil; at ten years old its girth was 36 inches, but afterwards it grew more slowly.

Tapping, &c.—The tree may be tapped when it reaches a girth of at least 2 feet or 2 feet 6 inches. After the eighth year there will probably be a number of trees in the plantation ready for tapping.

The milk flows much more freely than that of *Hevea*, so that one cut seems to drain a much larger area of the stem. The native American methods of tapping are wasteful, and often cause the death of the trees. The method described under Para rubber, by cutting V incisions at frequent intervals, seems to be the only one used in Ceylon. The milk here runs so freely that a simple sloping cut is sufficient, and there is no need to make the V. A sharp knife should be used, as the milk flows more readily and the wound is less ragged. The cuts need not be so close together as in *Hevea* ; they may be 3 or 4 feet apart instead of 1. A large quantity of milk flows from an incision, so that tins holding 150 c.c., or 4 ounces, must be used. The incisions are about an inch long, and should be confined to one side of the tree, or to not more than three-fourths of its circumference at a time. The milk is placed in a glass churn or other receptacle (machines for the purpose are occasionally used) in which it can be shaken. On standing, the caoutchouc floats to the top as a cream. The beery fluid below is run off by the tap. The cream is mixed with water, churned, left to stand, and the process repeated. The rubber is thus obtained almost pure in three creamings, and the cream is poured out to dry on a porous surface, when a thin sheet of perfectly dry and almost pure caoutchouc is obtained in a short time. Good results are obtained with less trouble by the use of the centrifugal machine, first applied to rubber separation by Biffen.

Samples of Ceylon *Castilloa* rubber, prepared by Mr. Parkin by the creaming method, were submitted to MM. Michelin et Cie, who reported that they were "rubber in very clean sheets, unusually fine for Castilloa." On washing and drying the rubber lost nothing in weight. The film contained 91·78 per cent. of pure caoutchouc, 7·54 per cent. of resins.

Till further experience has been gained we do not know how much tapping is advisable in *Castilloa*, nor how much it will stand. A few trees of about 3 feet girth gave an average of 5 ounces of rubber each from one day's tapping. Probably three or four tappings might be done every year without serious injury, but this remains to be investigated. The tree is not very resistent, and in some cases at Henaratgoda has died back completely, apparently as the result of a number of tappings carried on four years ago. Trees in the Matale District, about twelve years old, have yielded 1½ to 2 pounds of rubber a year.

It is sometimes stated that rubber may be obtained from saplings or from the young twigs, thus saving many years in obtaining a return, but Parkin's experiments showed that in Ceylon at any rate the latex in young stems contains no caoutchouc, but a sticky substance like bird-lime, which he terms viscin.

The best Castilloa rubbers appear on the market as sheets, and are valued next to fine Para. Ceylon samples have obtained 3*s.* 6½*d.* per lb. at a time when fine Para was valued at 4*s.* 2*d.*

CEARÁ RUBBER.—*Manihot* is a genus of the family *Euphorbiaceæ*, to which belong also several other rubber-yielding plants. It comprises about eighty species, natives of S. America ; among others is the manioca, tapioca, or cassava (*M. utilissima*, Pohl.), so largely grown in Ceylon (see chapter VI.). *M. Glaziovii*, Müll.-Arg., the Ceará rubber, is a native of Brazil, and is especially common in the Province of Ceará. Plants and seeds were collected there by Cross, and arrived at Kew in the end of 1876. On 15th September, 1877, 50 plants were sent to Peradeniya, and put out there and at Henaratgoda. These came on rapidly, so that in the following year seeds from them were sent to Burma, Calcutta, and Madras. In 1879 a few seeds were distributed to planters in Ceylon, and in 1880 24,550 seeds and 1,879 plants were thus disposed of. By the end of the following year the demand for seed from the gardens had almost ceased, planters having large supplies of their own. Some seeds were also imported privately direct from Brazil. In 1883 about 1,000 acres were said to be occupied by this product. Early results as to yield were, however, disappointing, and with the rush into tea rubber was soon neglected in favour of this more profitable cultivation. The export in 1892 was 7,280 lb., in 1895 1,753 lb., and in 1896 17,591 lb., decreasing subsequently to 2,792 lb. in 1898. After this date the export figures do not distinguish between this product and the newly commencing export of Para rubber, but there is no reason to suppose that any increase has occurred. At the present time probably not more than 500 acres are cultivated in Ceará rubber, though it is everywhere common as a hedge in native compounds.

The tree grows rapidly, often reaching a height of 30 feet and a girth of 20 inches within two years. It has a smooth silvery bark, not unlike that of the birch, which readily peels off. The leaves are palmately lobed, with 5–7 points. The flowers are produced at the age of eighteen months or later. They are of separate sexes, but both male and female occur on the same tree. The fruit is a capsule containing three seeds, and splits open explosively, scattering the seed to some little distance. The seed, like those of many other plants of this family, is not unlike a beetle in appearance, and has a little wart or caruncle at the end from which the root emerges in germination. The shell of the seed is extremely hard, and in consequence seeds may lie dormant in the soil for some time, springing up when the conditions are favourable. About 700 seeds weigh a pound.

Cultivation.—The seeds have so hard a coat that if not filed they do not germinate in a reasonable time. The caruncle end is filed on either side with a rasp. The seeds may be sown in a nursery or at stake. They germinate in about twenty days. They are planted out at distances of about 15 feet by 15 feet; sometimes the tree has been employed as shade for cacao or other crops, but it has not proved very satisfactory for this purpose. The tree also grows readily from cuttings about a foot long.

The Ceará Province has a gravelly or sandy soil, and a climate rather like that of the Badulla District in Ceylon in the matter of rainy seasons. The tree grows luxuriantly in most of the lower hill districts in Ceylon, up to about 3,000 feet above sea level. It also thrives when properly started in the dry regions of the north and east.

The tree reaches its full height rapidly; it rarely grows much above 40 feet high, but continues to branch out and grow in thickness. It drops its leaves in the dry weather.

Tapping, &c.—Mr. Cross, in his original report, mentions that in Brazil the trees are tapped when they reach a diameter of about 5 inches, *i.e.*, at about two to three years old, judging by the growth in Ceylon. "The collector takes with him a stout knife and a handful of twigs to serve as a broom. Arriving at a tree, any loose stones or dust are swept from the ground around the base, and some large leaves are laid down to receive the droppings of milk which trickle down. Some do not go to the trouble.........for which reason the milk adheres to sand, dust, decayed leaves, and other impurities. The outer surface of the bark of the trunk is pared or sliced off to a height of 4 or 5 feet. The milk then exudes and runs down in many tortuous courses, some of it ultimately falling on the ground. After several days the juice becomes dry and solid, and is then pulled off in strings and rolled up in balls or put in bags in loose masses. Only a thin paring should be taken off, just deep enough to reach the milk vessels; but this is not always attended to."

A later account, by Mr. Biffen (*Kew Bulletin*, 1898, p. 14), states that "the rubber is exported in three forms:—(*a*) In pale yellow-brown threads, $\frac{1}{4}$ inch in diameter and several inches in length, obtained by peeling off the thin layer of old bark and making a slight incision with a narrow-bladed axe. A small quantity of latex flows and coagulates on the trunk. (*b*) In small flat cakes prepared by tapping the base of the tree and allowing the latex to flow on the ground and coagulate there. Hence the rubber contains large quantities of dirt on its lower surface, which is removed to a certain extent by rubbing in coarse-meshed sieves. (*c*) By smoking with the vapour from the burning nuts of a palm, in a similar manner to Para rubber. So prepared, it contains a large quantity of water, which partially sweats out on exposure to the heat of the sun. The exudation on evaporation leaves a brown resinous substance. This last method is becoming very general.

"To collect the latex small tin cups are used; each tree is tapped eighty days, divided by an interval of about three months into two periods of forty each. Under this system the tree is said to live for fifteen to twenty years.

"The tapping is always done in the dry season, from July to December.

"The average yield per tree is from ½ to 1½ kilos (1 to 3 lb.) per year; coagulation may be effected by churning or by the addition of an excess of water or salt solution. In the former case the rubber particles, which are unprotected by any film (as the fat particles of milk are), simply adhere to form a mass.

"In the case of the addition of excess of water, salt, or smoking, coagulation is brought about by means of the globulin present. This coagulates at 74–76° C. or on dilution, &c., and tangles up the rubber particles in its meshes, much as white of egg gathers up particles in suspension when used for clearing jellies."

The first important trial in Ceylon was made at Peradeniya in dry weather at the end of April, 1882, when the trees were five years old. The dry bark was peeled off, and sloping cuts were made with a knife. The milk mostly dried on the stem, and was pulled off and rolled into balls (sample 1), but some fell on the ground and became mixed with sand, and was also more sticky than the rest (sample 2). The milk was found to flow most freely in the early morning.

Nine or ten trees gave a total yield of 20 ounces of dry rubber, the largest quantity from one tree being 4 ounces. The samples were submitted through Kew to Mr. S. W. Silver, who reported that sample 1 was dry and compact, free from extraneous impurities, and agreeing in all respects with Ceara rubber of good and sound quality. When washed and dried it gave a loss of 8 per cent., *i.e.*, less than is met with in Ceara rubber of the finest quality. Its valuation was 2*s*. 9*d*. to 3*s*. a pound. Sample 2 was valued at 1*s*. 3*d*. only.

Interest in this product was at its height in 1883, and numerous experiments were tried to determine the best and cheapest methods of obtaining the rubber. Several instruments were invented for tapping the trees, *e.g.*, a knife with two parallel blades ¼ inch apart, which was drawn down the bark, the strip of bark thus separated being taken out. This was afterwards modified into a V-shaped knife, the point of the V being placed at the cambium. Another tool was a spur-like double wheel with sharp points provided with guards. This was run along the bark, making numerous pricks in it. The object of all these tools was partly to avoid the necessity of removing the outer bark, as it was now being realized that the yield was too small to allow of any expense in collecting. On some estates the system adopted was to go round daily, bleeding the trees with the pricker, the little tears of rubber being afterwards collected into balls. Others made long cuts down the bark from about 5 feet above the soil, and collected the milk in tins, coagulating it by simple standing or by adding a little alcohol or by heating. Others removed the outer bark in strips, so that the inner bark should bleed, and so on. None of these methods, however, gave satisfactory results, and with the growing rush into tea interest in Ceara rubber died out from 1884, and in many places the trees were cut down to make room for tea. The general opinion of the planters was, and is, that this product pays to harvest, but not to cultivate.

A cooly working with one of the tools mentioned can collect from ½ to 1½ lb. of rubber a day.

In 1898 some samples of Ceylon Ceara rubber obtained as much as 3*s*. 4*d*. a pound in London, and a few estates, which have old trees, continue to harvest this rubber in small quantity. About 1 lb. of dry rubber per tree per annum is a good yield. It is by no means impossible that it may yet pay to grow Ceara rubber in waste land in the drier parts of the hills. Though the yield is hardly great enough to tempt a European planter, it is not quite clear why natives have not taken it up; they commonly use the tree as a hedge, and the tapping is easy.

To sum up the chief facts bearing on the profitable harvesting of this product. The tree should be at least four years old; it yields best in the dry season, and the milk runs most readily in the morning. The outer bark is to be stripped off, and the tree tapped either by making V incisions, as in the case of Para rubber, or by pricking it. The milk rarely runs sufficiently freely to be collected in tins, and may be allowed to dry on the tree, when the tears or strings are removed and made into balls or slabs. The tree does not stand tapping as well as Para rubber, and one series of tappings lasting over six weeks in the year is as much as is wise, a few V's only being made on each occasion, so that by the end of the tapping the cuts are at least six inches apart.

It has yet to be properly investigated whether this tree show any wound response like the Para rubber; if this were the case it would alter the question of its profitableness, though it is improbable that the response, if any, is a large one, or it would have been noticed. If sufficient milk would flow to be conveniently collected in tins, the centrifugal treatment, invented by Biffen, could be applied with excellent results, or the milk, as suggested by Parkin, could be gently heated to boiling point. Some samples prepared in this way by Mr. Parkin from fairly large trees at Peradeniya were reported on by MM. Michelin et Cie. The samples consisted of scraps packed together, clear brown in colour, with no nitrogenous odour such as is found with many Ceara rubbers of Brazilian origin. The rubber after washing and drying in sheets lost 19 per cent. of its weight; the sheets contained 93·74 per cent. of caoutchouc, 4·38 per cent. of resins.

PARA RUBBER.—Para rubber is obtained from *Hevea brasiliensis*, a species belonging to the Euphorbiaceæ and indigenous to the Amazon valley. Plants were introduced into Ceylon, through Kew, in 1876, the Indian Government paying all the expenses incurred by Messrs. Wickham and Cross (who collected seeds and plants) and by Mr. W. Chapman, who brought the seeds over from Kew. Most of the plants were sent to Henaratgoda, but a few were planted at Peradeniya. The plants were first propagated from cuttings, the twigs from two to three-year-old trees being used for this purpose. The plants at Henaratgoda flowered for the first time in 1881 when they were five years old, while those at Peradeniya did not flower until 1884. In 1883 a crop of 260 seeds was produced at Henaratgoda, and from that year the trees have regularly seeded, the annual crop from about 500 trees now being about 200,000.

Plants were sent to India and the Straits in 1878, and in subsequent years seeds or plants have been distributed to Jamaica, Buitenzorg, Queensland, German East Africa, Borneo, Sumatra, Seychelles, Fiji, Gold Coast, Australia, and many other places. The acreage in Para rubber has increased very rapidly in Ceylon, the Straits, India, and other countries, especially Java, Borneo, Sumatra, &c., where large areas are being planted with this product. During the last six years the acreage has increased in Ceylon from 1,750 acres in 1900 to 40,000 in 1905, whilst a slightly larger area has been planted in the Straits. The prospects for the industry are bright on account of the increase in value of the prepared rubber to over 6*s*. per pound and the improvement in yields and methods of collecting the latex.

The tree grows rapidly, and in the first few years has a tendency to produce long slender stems, with whorls of foliage at regular distances. By pruning the young buds the growth in the vertical direction can be checked and lateral shoots encouraged. The increase in circumference takes place at varying rates according to soil, climate, &c., the usual range being between 4 to 6 inches each year. The leaves are trifid, large, and lanceolate, and after the tree is two to three years old are shed regularly each year. The lateral roots form a very compact mass, growing radially at rates varying between 6–9–12 inches per year according to local conditions ; the tap root may grow to a great length. The flowers appear regularly each year ; they are small, green, and scented. The inflorescence is a panicle of small cymes, and possesses male and female flowers.

The fruit consists of a three-lobed capsule, and when ripe bursts with a loud report, throwing the seeds a considerable distance. The seeds are speckled brown on the surface and shiny ; the compact substance of the seed is very rich in oil. The trees produce seeds from the fifth year, the average per mature tree being about 500 each year. About 200,000 seeds weigh one ton.

Cultivation.—According to many observers Para rubber in Brazil grows in a climate which is fairly uniform, the range in temperature being from 74° to 95° F., and in rainfall from 80 to 120 inches. In the Amazon district there are two chief seasons, a dry and a wet. The driest months are from July to September ; the rain begins in October and lasts till March. This product is now being cultivated in many parts of the tropics, but it is practically confined to the equatorial zone, a few degrees on either side of the equator. In Ceylon, the Straits, and India, it is being grown from sea-level to over 3,000 feet, where the average annual mean temperature varies from about 75° to 81° F. It is being grown in parts of Ceylon and in the Gold Coast, where the rainfall is only about 50 inches per year, and in Ceylon, Straits, and India appears to be doing well, where the rainfall ranges between 50 and 200 inches. It is a hardy plant, and experimental cultivations in dry hot districts with irrigation have already been commenced in Ceylon and elsewhere.

The trees grow from 6 to 10 feet in height every year for the first few years and attain a height of 80 to 90 feet within thirty years. During the first few years the growth is mainly in length, and the rapid increase in girth, varying from 4 to 6 inches per year, is most noticeable after the trees are a few years old. Young trees, which have had their terminal buds removed by thumb-nail pruning or by the knife, have a tendency to throw out lateral branches and thus give rise to an increase in foliage; the growth in height is thereby checked and that in circumference increased. The plant is propagated mainly from seeds, though cuttings can be used. The seeds or plants are planted at from 10 to 20 feet apart according to local conditions and the objects in view. They are frequently interplanted with shade or wind belt trees, the most popular species for these purposes being Erythrina lithosperma and Albizzia moluccana. Each of the young rubber plants or the whole estate must be protected by fencing, otherwise they may suffer from the attacks of rats, hares, porcupines, pigs, deer, cattle, &c.

Draining is very essential in the swampy patches and is, of course, beneficial on all estates. Holing on as liberal a scale as possible is practised. The Para rubber tree is cultivated as a single product or in association with cocoa, tea, and coffee; subsidiary catch crops, such as bananas, lemongrass, citronella, ground nuts, cassava, chillies, &c., are also cultivated in various countries. Though the plant grows best in good soils it is a noteworthy fact that this species thrives in soils relatively poor in physical and chemical properties. The leaves are very rich in potash, nitrogen, and lime, and may be turned into the soil for manurial purposes.

Tapping.—The latex is obtained from the trunk of the tree by making incisions and conducting the exudations to a receptacle. Over a dozen forms of patent tapping knives have been recently described, many of which are constructed so as to avoid wasteful excision of the cortical tissues or penetration to the cambium. The incisions may take the form of single oblique cuts, V-shaped incisions, the half or full herring-bone, or the half or full spiral; the latter methods have come into prominence during the last year. Before incisions are made the areas to be tapped are cleaned and carefully defined. During collecting operations various appliances and chemicals are in use to aid the flow of the latex and prevent the closing of the latex tubes until they are more or less empty, and though good results have already been obtained, the methods of collecting the latex over large acreages are likely to be greatly improved in the near future. The trees are usually tapped from the base up to six or ten feet; large trees can be tapped to a much greater height. The latex usually increases up to the 3rd or even the 14th tapping; Parkin's results show a rise in yield from 61 c.c. for the first tapping to 449 c.c. for the 14th tapping. The rubber prepared from latex obtained from different levels of thirty-year-old trees, from the base to fifty feet, is quite good, but high tapping is not anticipated for the rubber trees which are now being planted.

The trees are tapped according to size or age. In the Amazon district the Para rubber trees are said to require 15 years to come to tapping maturity in open plantations and 25 years in the forest, and in Para the trees are sometimes tapped for the first time when they have a circumference of 18 to 24 inches. The rubber obtained from Para rubber trees two, four, six, eight, ten-twelve, and thirty years old does not differ conspicuously in chemical composition, though the samples from the young trees usually show a tendency to become sticky and lose their good qualities. In most countries the age of the trees when they can first be tapped is of minor importance, and a circumference of 20 to 24 inches, a yard from the ground, is commonly accepted as a safe size when the trees may be tapped for the first time. Tapping is usually done in the early morning and evening when the temperature is low, and is carried on throughout most months of the year. The frequency of tapping varies, some trees being tapped every day, others only during alternate months and others only during certain seasons.

The yield shows a considerable variation, according to the extent of the tapping area per tree, and the methods employed. Individual trees have given from 2 to 25 lb. of dry rubber per tree in twelve months, but large acreages have yielded quantities varying from ¾ lb. to 5½ lb. of dry rubber per tree, per year, for one or more years.

The latex is white or pale yellow in colour, and is slightly alkaline or neutral when it issues from the tree. Mechanical impurities, such as pieces of bark, sand, &c., are usually present, but can be removed by straining. The latex shows a great variation in its composition, particularly in the percentage of water; it is usually estimated to possess from 52 to 56% of water, 32 to 41% of caoutchouc, 1 to 3% of proteids or albuminoids, and varying quantities of resins, sugars, salts, &c. It readily mixes with water or any alkaline solutions such as ammonia, ammonium sulphide, &c., and is not coagulated by freezing or boiling, though acids readily bring about this change.

Coagulation.—The pure rubber is obtained from the latex by processes of straining, coagulating, washing, rolling, and drying. Coagulation is possible owing to the presence of the proteid matters in the latex; these remain in solution so long as the mixture is neutral or alkaline, but are precipitated when the solution becomes acid. If latex is allowed to stand for some time, the proteid matter decomposes and acidity sufficient to lead to coagulation is developed, but this may be delayed by the use of formalin or ammonia. The coagulated proteid is considered to act as a clarifier and to carry with it the suspended globules of caoutchouc and other bodies. On estates where the daily quantity of latex is small, it is usually put into shallow pans and allowed to set with or without the addition of acid. The cake of rubber obtained by such a process is then washed, rolled, and dried, and finally placed on the market as "biscuit" or "sheet" rubber. The addition of certain chemical reagents to the latex, hot or cold, brings about coagulation; dilute mineral acids, acetic acid, and tannic acid are particularly active. Coagulation may also be hastened by exposing the latex to heat and the products of combustion of a fire, the latex being coagulated fractionally by such a process and the finished product, when properly manufactured, is said to be less liable to putrefaction than the rubber prepared by many other methods. The smoke from burning palm nuts (Attalea excelsa, Mart., and Maximiliana regia, Mart.) contains, among other substances, small quantities of acetic acid, acetone, and creosote. The acetic acid is probably the agent responsible for effecting the coagulation; the other substances, particularly the creosote, are absorbed, the latter acting as an antiseptic. The decomposition of the albuminous or proteid substances in the latex may be prevented by the addition of suitable antiseptic reagents to the latex when the rubber is prepared in other ways, though quickness in drying and complete extraction of the moisture from freshly-coagulated rubber is often sufficient to bring about the same result.

Coagulation by chemical reagents is commonly adopted on estates. Many compounds such as picric acid would rapidly coagulate the proteids, but the effect on the resulting rubber would be bad. It has been shown that many acids may be used in the coagulating process, but it is unnecessary to do more than mention those which have, from practical experience, been proved more or less acceptable to producers in the tropics and manufacturers in Europe.

Acetic acid.—This is cheap, always procurable, is not dangerous to handle and is as effective as formic acid. It is not as powerful as tannic acid, though it is effective in bringing about the coagulation of the latex while cold. The commercial article varies in strength, and the quality should be noted by the purchaser.