HILIPPINE ISLAND

GOVERNMENT

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1903.—No. 7.

DEPARTMENT OF INTERIOR.

BUREAU OF GOVERNMENT LABORATORIES.

CHEMICAL LABORATORY.

THE GUTTA PERCHA AND RUBBER OF THE PHILIPPINE ISLANDS.

By Penoyer L. Sherman, Jr., Ph. D.

MANILA:
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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
BUREAU OF GOVERNMENT LABORATORIES,
Manila, P. I., September 20, 1903.

SIR: I have the honor herewith to transmit for publication as a bulletin a monograph on the gutta percha and rubber of the Philippine Islands, by Penoyer L. Sherman, jr., Ph. D., chemist in the Bureau of Government Laboratories.

I am, very respectfully,

PAUL C. FREER,
Superintendent Government Laboratories.

Hon. JAMES F. SMITH,
Acting Secretary of the Interior.

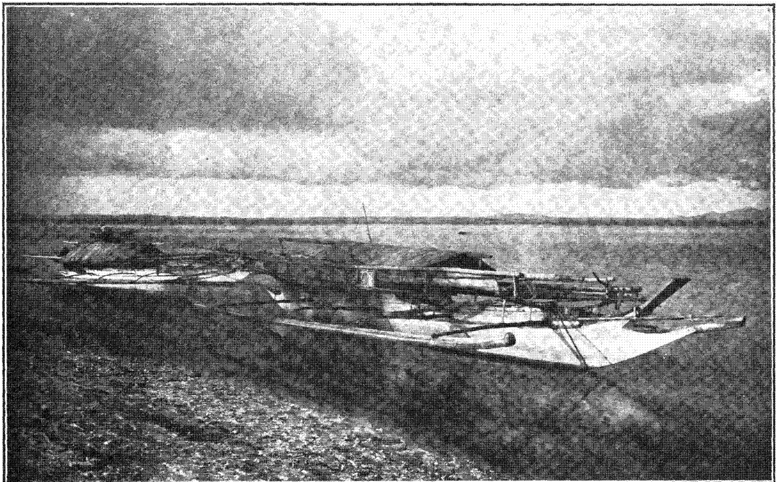


Fig. 1.—MORO SAILBOATS ("VINTA") USED FOR TRAVELING AMONG THE SOUTHERN ISLANDS.

THE GUTTA PERCHA AND RUBBER OF THE PHILIPPINE ISLANDS.

By P. L. Sherman, Jr., Ph. D.

INTRODUCTION.

The material for this bulletin was collected under the direction of the Bureau of Forestry and of the Bureau of Government Laboratories. As early as 1900 the attention of the Government was called to the fact that many of the wild tribes in the southern islands were engaged in cutting down large numbers of forest trees in order to secure the gutta percha and rubber which they contained. These products they bartered to the Chinese, who in turn exported them to Singapore.

The matter was considered important enough to demand investigation, because—

(1) The trees were being cut down in violation of forestry rules.

(2) No forestry dues were paid by those either collecting or exporting these forest products.

(3) Judging from the experience of the English and Dutch in the Malay Peninsula, Sumatra, and Borneo it would only be a question of a short time, if the wild tribes were allowed to have their own way, when there would not be one tree of this class left standing in the Philippines.

Unfortunately there was no information at hand on the subject. In June, 1901, I was sent as a special agent of the Forestry Bureau to Singapore, the Malay Federated States, and Java to study the laws and conditions under which these forest products were grown, collected, and marketed.

Provided with the information thus gathered and which is detailed below, upon my return to Manila four months later I was again sent to the southern Philippines to repeat my investigations and as before, to make collections of herbarium material and samples of the various kinds and grades of gutta percha and rubber found there.

This first southern trip consumed several months, for, while specimens of marketable gutta percha and rubber could be secured in the principal towns, all herbarium material and gums from each tree species had to be taken personally to avoid all sources of error.

The trips along the coasts and rivers of many of the islands were made in small native sail and row boats, and the journeys into the forests of the interior were completed on foot with native guides and carriers. The native gum collectors themselves, their method of felling the trees and vines, securing the gutta percha and rubber, preparing the same for market, the prices they received both in money and barter were thus seen at first hand, and of course opportunity secured for making herbarium collections of the various species of trees and vines yielding gutta percha and rubber. In the principal towns the market conditions of supply, demand, prices, etc., were studied.

Upon my return to Manila I was ordered to be transferred to the Bureau of Government Laboratories, in order that all specimens collected might be tested chemically and physically so as to determine their relative values. This analytical work, as well as several subsequent trips to the southern islands, Paragua, Mindoro, and Culion in search of new material, has been carried out and is here reported.

The identification of the various species of gutta percha and rubber trees and vines was kindly undertaken by Mr. E. D. Merrill, botanist for the Bureau, who also assisted greatly in collecting herbarium material in Mindoro and Culion.

My thanks are also due to Messrs. J. H. Thigpen and Paul Stangl for much assistance in the analytical work. To Capt. George P. Ahern, Chief of the Forestry Bureau, and Dr. Paul C. Freer, Superintendent of Government Laboratories, I wish to express warm appreciation of their many courtesies and valuable suggestions in planning and carrying out the work.

PART I. GUTTA PERCHA.

I. HISTORICAL.

As is the case with many other commercial products coming from Oriental lands, the date of the discovery of gutta percha is lost in Oriental history. The famous Tradescant Brothers in 1656 (1) exhibited in their museum of curiosities in London a piece of gutta percha which they had secured in the Far East. Also in 1822 Dr. William Montgomery (2), an English surgeon, saw whips and other articles of gutta percha in use by the natives of Singapore. It is therefore safe to assume that the real discovery of this remarkable substance was made at some time previous to either of these dates.

The western or commercial discovery of gutta percha was delayed until 1843, when both Drs. Montgomery and D'Almeide sent specimens of the gum and leaves of the tree to London. While the specimens of D'Almeide were neglected, those of Montgomery received enough attention from the scientists of the Royal Society of Arts to demonstrate some of the uses to which the substance might be put. The botanists agreed that the tree belonged to the family *Sapotaceæ*, but as neither flowers nor fruit were at hand they could go no further with the identification.

In 1847 the greatest advance was made toward the utilization of gutta percha. Considerable amounts had from time to time been shipped to London, and experiments were made to determine its physical and chemical characteristics. Luckily a sample fell into the hands of a young German artillery lieutenant, Werner von Siemens, who was then experimenting with insulating material for subterranean and submarine telegraphic cables (3). The ease with which gutta percha lent itself to this object and the high efficiency obtained induced him to construct a machine for insulating cables. The methods he adopted, as well as the kind of machinery, have been with few modifications in use ever since.

The subsequent history of gutta percha runs parallel with that of submarine and subterranean electric cables, for three-fourths of all the gutta percha produced has been used on them. With the construction of the great trans-Atlantic cables in the sixties and seventies of the past century, the demand for gutta percha became enormous, and the details of its value and ready market traveled over all this part of the Orient.

When the Malay Peninsula adjacent to Singapore failed to supply sufficient quantities to meet the demand, the adjacent islands of the Rhio Archipelago and Sumatra were invaded, and rich finds made. Finally Borneo was included in the producing zone, and lastly the Philippines.

At what date the Philippines began to export gutta percha to Singapore, the center of the trade, can not be learned with any degree of certainty. Probably twenty years ago varying quantities were exported, but apparently the trade died out, owing, it is said, to the wholesale adulterations practiced by the Chinese exporters and the prohibitory laws of the Spanish Government. For the last ten years prior to the American occupation of the Islands but little had been shipped, though the collecting and exporting began very soon afterwards and increased at once to large proportions.

II. BOTANICAL.

In the year in which Von Siemens made his great discovery of the insulating value of gutta percha for submarine cables Sir Joseph Hooker, Bentham, and others worked out the status of the gutta percha tree. From the first specimen of leaves which had been sent to England several years previously, it was seen that the tree belonged to the natural family of *Sapotaceæ* (4). The many species of this family are scattered over the tropical and semi-tropical world and are distinguished by the curious property all possess of secreting a milk or latex in the inner layers of the bark. When the bark is cut or bruised and the capillary sacks and tubes which contain the latex are ruptured it flows out with greater or less abundance according to the species of the tree. This milk probably serves in the plant economy as a protection; still it is primarily an excretion, since it is discarded by the tree in its dead leaves and bark and the bark of the live tree can be tapped and the latex removed with no apparent injury to the tree.

As has been stated, it was in 1847 that specimens of the flowers and fruit finally reached London and the complete botanical deter-

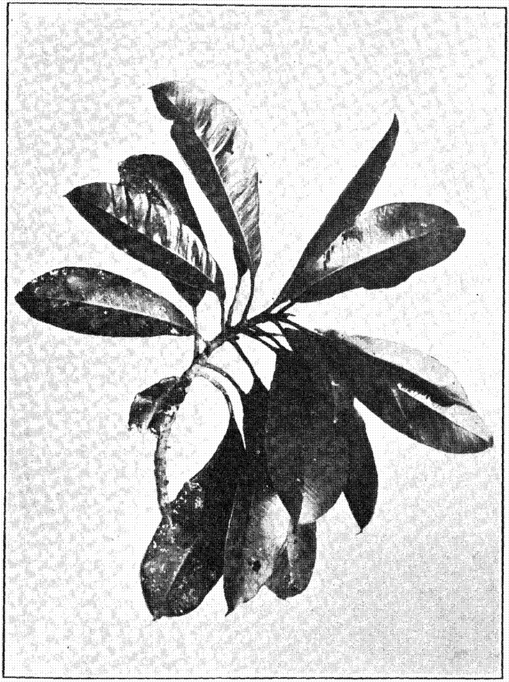


FIG. 2.—LEAVES OF PALAQUIUM GUTTA BURCK, GROWN AT THE BOTANICAL GARDEN AT SINGAPORE, STRAITS SETTLEMENTS. FURNISHES FIRST GRADE GUTTA PERCHA.

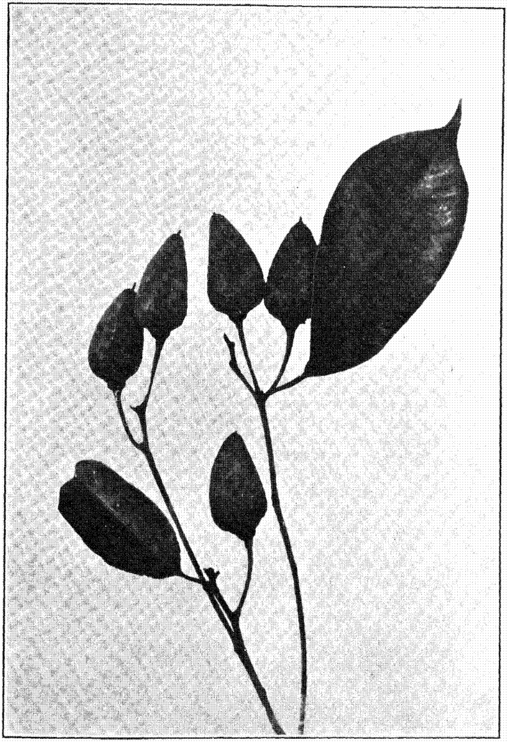


FIG. 3.—LEAVES AND FRUIT OF PAYENA LEERII BENTH. ET HOOK. FROM BUITENZORG, JAVA. FURNISHES SECOND GRADE GUTTA PERCHA.

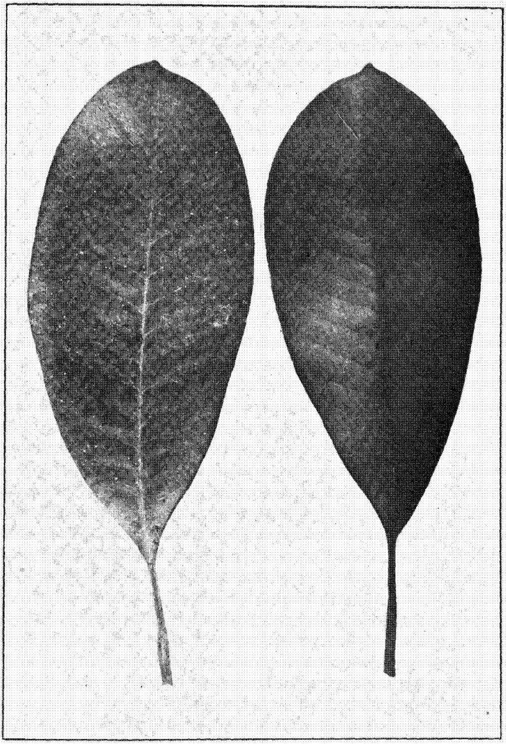


Fig. 4.—Leaves of Palaquium Treubii Burck, grown at Buitenzorg, Java. Furnishes second grade gutta percha.

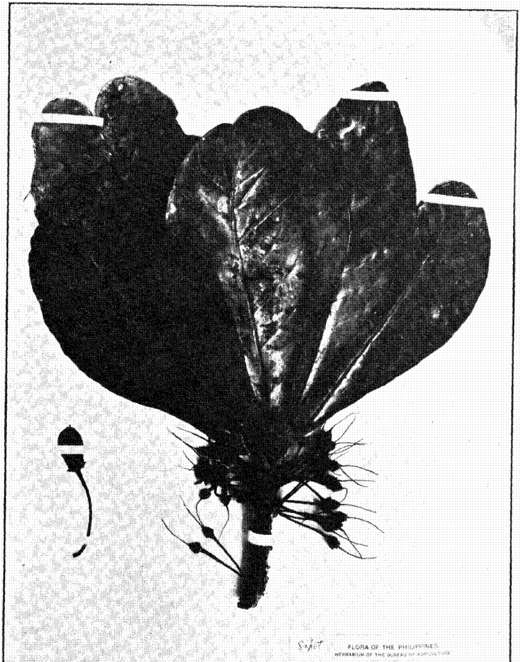


FIG. 5.—PALAQUIUM LATIFOLIUM BLANCO. PROVINCE OF TAYABAS, LUZON.

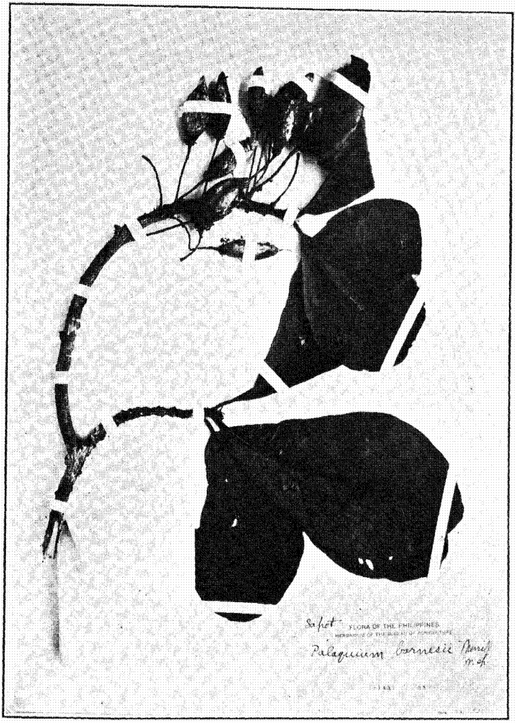


Fig. 6.—PALAQUIUM BARNESI MERRILL. ISLAND OF MASBATE.

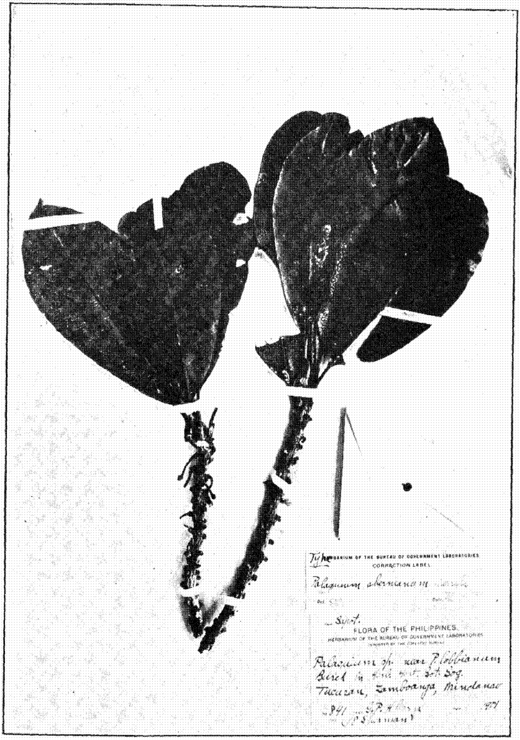


Fig. 7.—PALAQUIUM AHERNIANUM MERRILL. TUCURAN, DISTRICT OF ZAMBOANGA, MINDANAO.

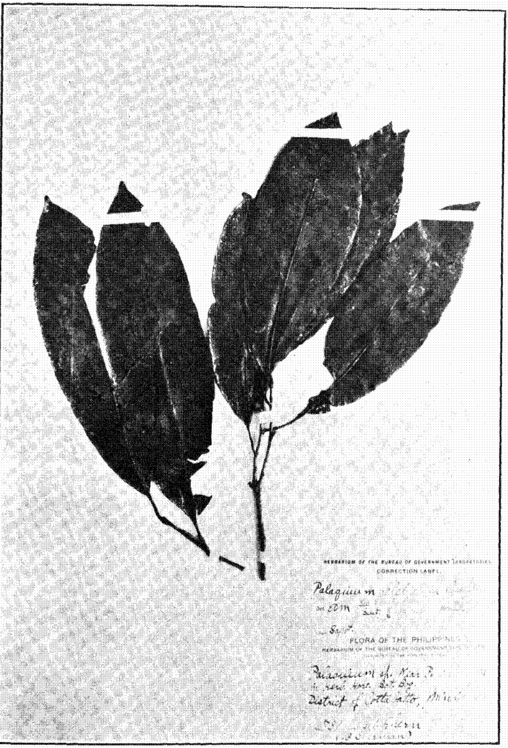


FIG. 8.—PALAQUIUM CELEBICUM BURCK. DISTRICT OF COTTABATO, MINDANAO.

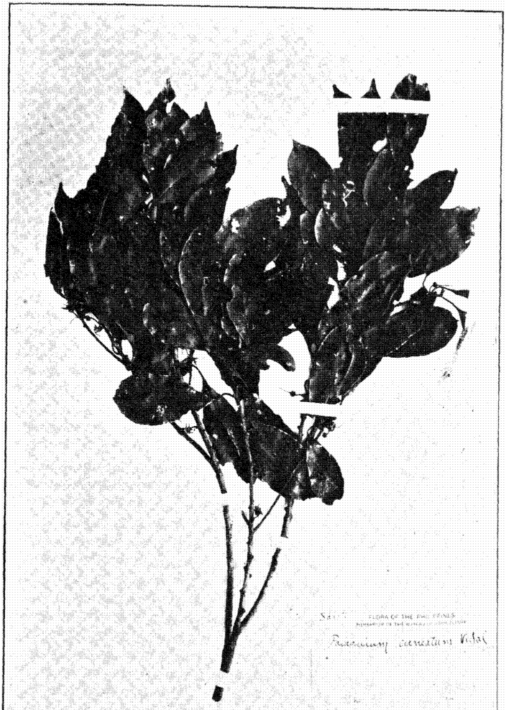


FIG. 9.—PALAQUIUM LANCEOLATUM BLANCO. PROVINCE OF TAYABAS, LUZON.

Fig. 10.—PALAQUIUM GIGANTIFOLIUM MERRILL. PROVINCE OF TAYABAS, LUZON.

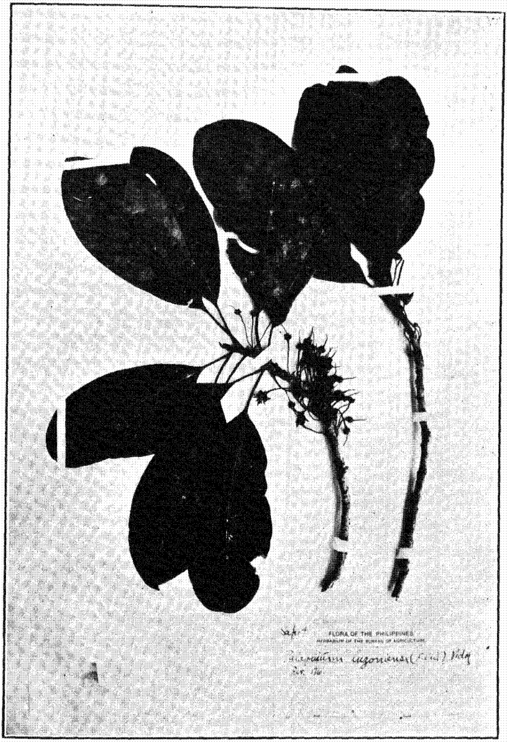


FIG. 11.—PALAQUIUM LUZONIENSE (F. VILL.) VIDAL. PROVINCE OF TAYABAS, LUZON.

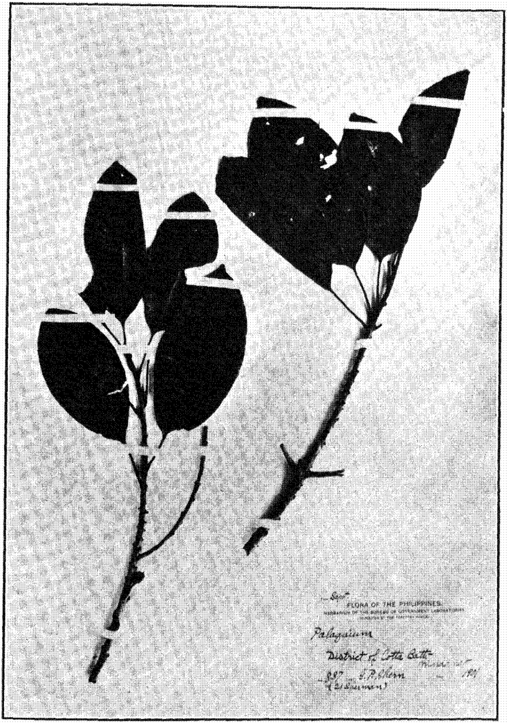


FIG. 12.—PALAQUIUM MINDANAENSE MERRILL. DISTRICT OF COTTABATO, MINDANAO.

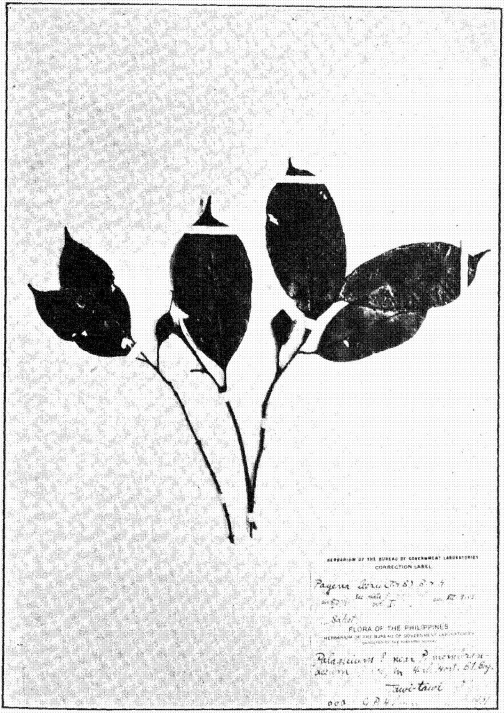
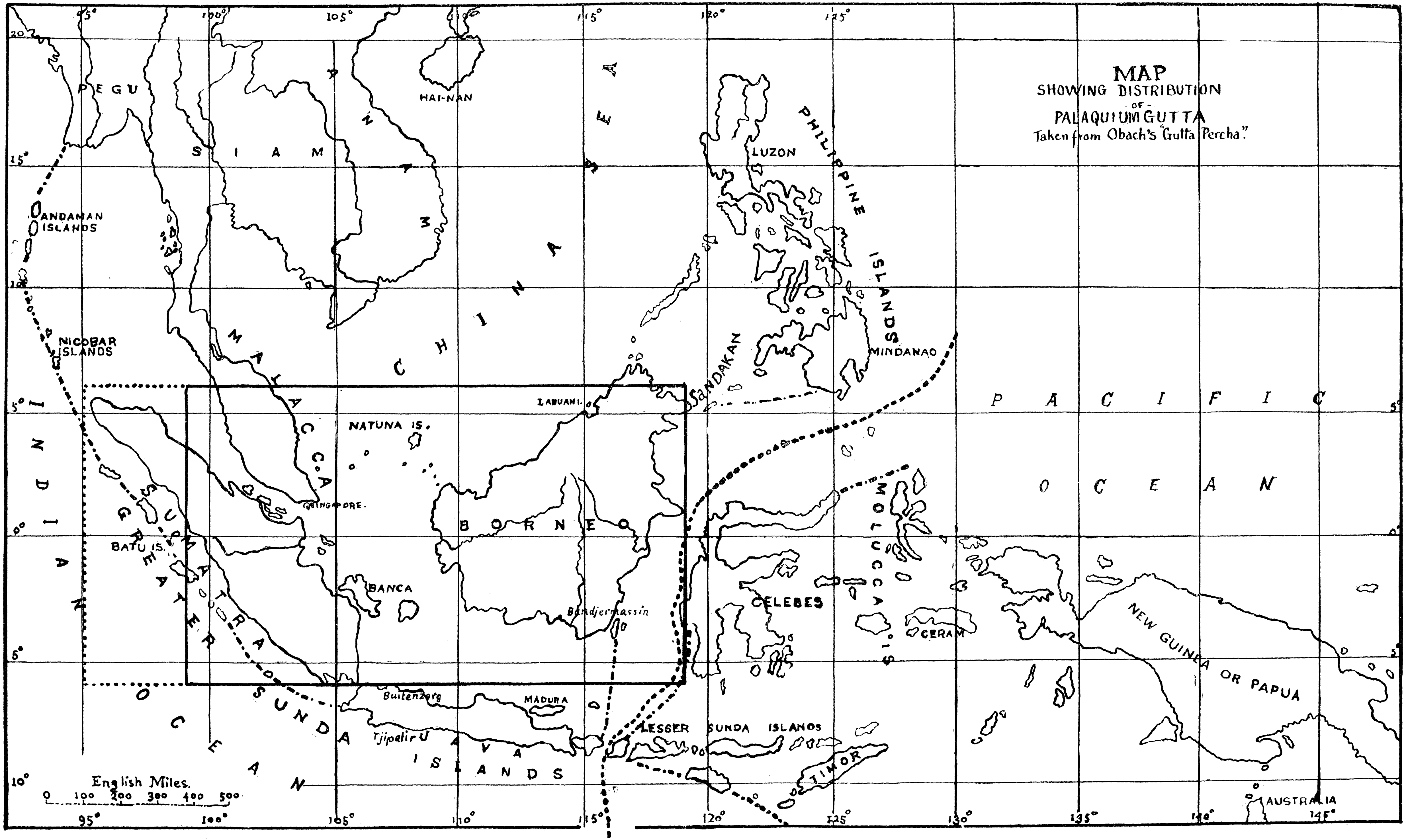
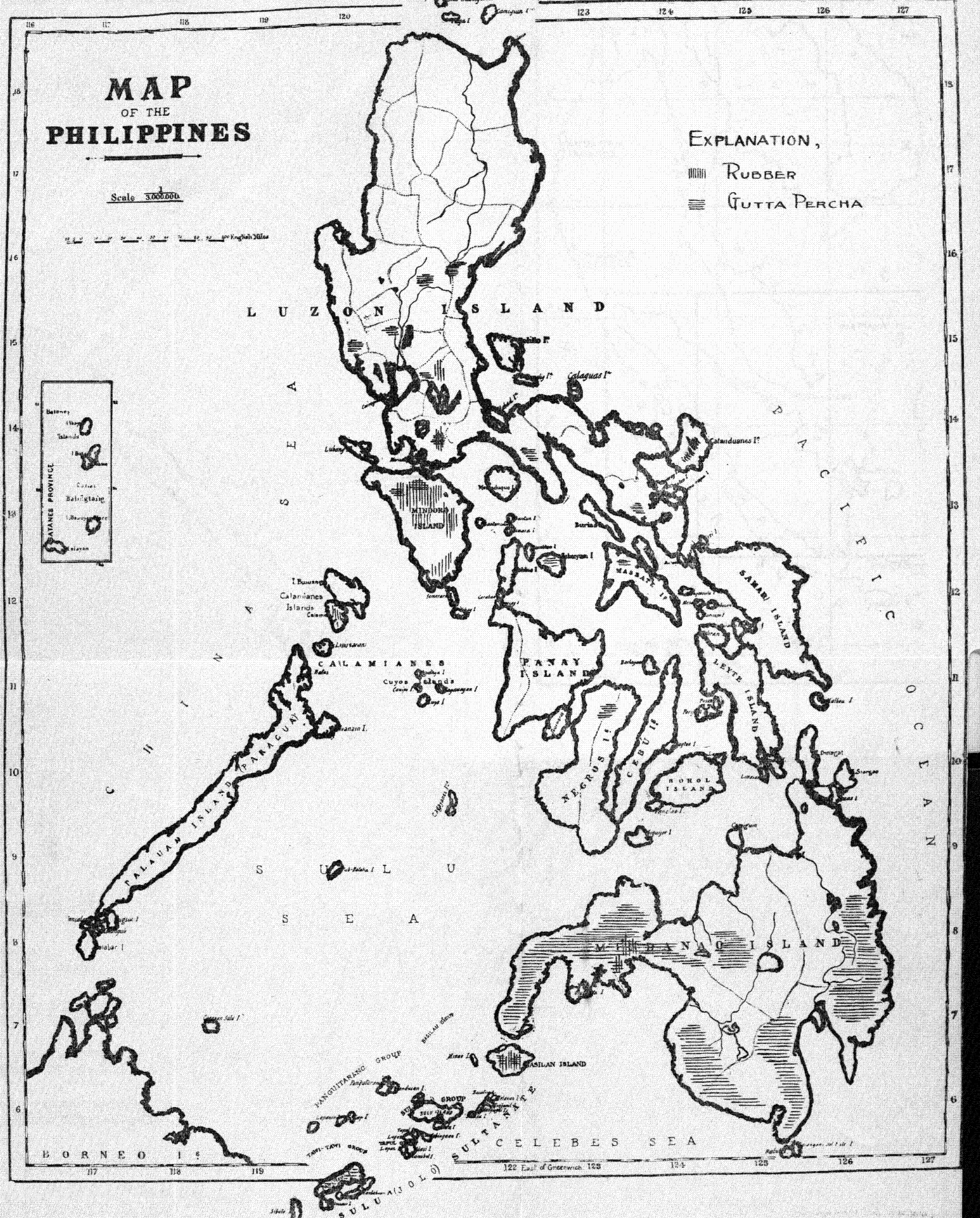


FIG. 13.—PAYENA LEERII (T. ET B.) BENTH. ET HOOK. TAWI-TAWI.


MAP
SHOWING DISTRIBUTION
OF
PALAQUIUM GUTTA
Taken from Obach's "Gutta Percha."
PEGU
SIAM
ANNAM
HAI-NAN
CHINA SEA
LUZON
PHILIPPINE ISLANDS
MINDANAO
SANDAKAN
ANDAMAN ISLANDS
NICOBAR ISLANDS
MALACCA
NATUNA IS.
LABUAN I.
SINGAPORE
BORNEO
PACIFIC
OCEAN
INDIAN OCEAN
SUMATRA
BATU IS.
GREATER SUNDA ISLANDS
BANCA
Bandjermassin
CELEBES
MOLUCCAS
CERAM
NEW GUINEA OR PAPUA
Buitenzorg
MADURA
Tjipatir
JAVA
LESSER SUNDA ISLANDS
TIMOR
AUSTRALIA
English Miles
0 100 200 300 400 500

MAP No. 1.


MAP
OF THE
PHILIPPINES
Scale 1/3.000.000
English Miles
EXPLANATION,
RUBBER
GUTTA PERCHA
LUZON ISLAND
MINDORO ISLAND
PANAY ISLAND
NEGROS Iª
CEBÚ Iª
BOHOL ISLAND
LEYTE ISLAND
SAMAR ISLAND
MASBATE Iª
MINDANAO ISLAND
BASILAN ISLAND
PALAUAN ISLAND (PARAGUA)
CALAMIANES
Calamianes Islands
Cuyos Islands
BATANES PROVINCE
Catanduanes Iª
Calaguas Iª
CHINA SEA
SULU SEA
CELEBES SEA
PACIFIC OCEAN
BORNEO Iª
PANGUITARANG GROUP
SULU GROUP
TAPUL GROUP
TAWI-TAWI GROUP
SULU (JOLO) SULTANATE
East of Greenwich

MAP No. 2.

mination of them made, which resulted in giving to the tree the name of *Dichopsis gutta* Benth et Hook. fils. A few years later the Dutch botanist, Burck, pointed out the fact that as early as 1837 Padre Blanco (5) had given the name of *Palaquium* to this genus of *Sapotaceæ*, and accordingly most botanists have adopted the generic name *Palaquium* for these wonderful species[1] of forest trees which produce the bulk of all the gutta percha of commerce.

As the demand for gutta increased and the trees of the species *Pal. gutta* became scarcer and more difficult to reach, the native collectors were not slow in finding other species that produced gutta percha, though of an inferior quality. Among these *Pal. treubii* Burck, *Payena leerii* Benth. et Hook. fils, and *Mimusops balata* Gaertner, fils, are the best known. Many other species have been found in Sumatra, Borneo, Celebes, and the Malay Peninsula, but what part they play in the production of the gutta percha of commerce has not yet been determined.

The accompanying figures will show some of the resemblances and differences between the species above mentioned. The trees of the genus *Palaquium* are among the largest of the tropical forest and are generally to be noted by the brilliant green color of their leaves above and the golden to copper-brown shimmer below.

The following general description of the botanical characteristics of *Palaquium* is made by Mr. Merrill:

PALAQUIUM, BLANCO 1837 (DICHOPSIS THWAITES).

Usually large trees with rusty-tomentose branchlets. Leaves obovate or oblong, acute or obtuse, petioled, coriaceous, glabrous beneath, or densely rusty-tomentose. Flowers fascicled, axillary on the naked branches below the terminal leaves. Calyx lobes 6, in two series, corolla lobes 6. Stamens 12 to 18, attached near the base of the corolla. Ovary 6-celled. Fruit fleshy, ellipsoid or ovoid, 1 to 2 seeded. Seeds exalbuminous, cotyledons large, fleshy.

In regard to the species *Mimusops balata* mentioned above, it

[1] Of late years the Dutch and English botanists in the Orient have been inclined to divide *Pal. gutta*, the most valuable of the gutta percha producing species, into three species, viz, *Pal. gutta*, *Pal. oblongifolium*, and *Pal. borneense*, but as no certainty of differentiation yet exists, while the gutta percha from all is the same, they may for the present be all classed under *Pal. gutta*.

is to be noted that it is the only representative so far known of gutta percha producing trees in the Western Hemisphere. It was discovered in the Guianas in 1857 and contains a fairly good grade of gutta percha. Obach (6) designates it in his description as a substitute for gutta percha in all its chemical and physical characteristics. Though of an inferior grade to that coming from *Palaquium gutta*, it may well be classed among the rest of the *Palaquium* and *Payena* species furnishing second and third grade gutta percha.

The gutta percha trees of the Philippines embrace both *Palaquium* and *Payena* species, and while their complete determination or identification is still unfinished, those which produce the gutta percha of commerce have been located, and their final identification is only a matter of collecting more complete herbarium material.

The following table (No. 1) gives the species at present known. Those marked (*) probably furnish the largest part of the gutta percha exported from the southern islands:

TABLE No. 1.—*Present known species of gutta percha.*

Species.	Local name.	Locality.	Botanical description.
Leaves rusty tomentose beneath:			
Pal. latifolium Blanco.	Palacpalac or Alacap.	Luzon to Mindanao.	Leaves obovate, obtuse, 10 to 30 c. m. long, 5 to 15 c. m. wide; nerves, about 15 pairs.
Pal. oleiferum Blanco.	Alacap or Baracan.	Luzon	Leaves obovate-lanceolate, 10 to 25 c. m. long, 6 to 10 c. m. wide, acute; nerves, about 15 pairs; closely related to the preceding.
Pal. barnesii Merrill.	Nato	Masbate	Leaves obovate, obtuse, thin, 12 to 15 c. m. long, 7 to 8 c. m. wide; nerves, 11 pairs.
*Pal. ahernianum Merrill.	Calapia	Mindanao	Leaves ovate or obovate, obtuse or acute, 12 to 14 c. m. long, 5 to 6 c. m. wide; nerves, 15 pairs.
Leaves glabrous beneath:			
*Pal. celebicum Burck.	do	do	Leaves lanceolate, acute, 15 to 20 c. m. long, 5 to 6 c. m. wide; nerves, 12 to 14 pairs.
Pal. cuneatum Vidal.	Dulitan	Luzon	Leaves ovate, lanceolate or obovate, acute or obtuse, 5 to 7 c. m. long, 2 to 3 c. m. wide: nerves, 11 to 12 pairs; indistinct.
Pal. gigantifolium Merrill.		Tayabas	Leaves obovate, 50 c. m. long, 20 c. m. wide; nerves, 20 to 24 pairs.
Pal. luzoniense Vidal.	Bagalañgit	Luzon	Leaves ovate, acute or obtuse, 10 to 14 c. m. long, 4 to 6 c. m. wide; nerves, 12 pairs.
*Pal. mindanaense Merrill.	Calapia	Mindanao	Leaves ovate, acute, 9 to 12 c. m. long, 4 to 5 c. m. wide; petioles 3 c. m. long; nerves, 14 to 16 pairs.
*Payena leerii Benth. and Hook.	do	Tawi-Tawi	Leaves ovate or ovate oblong, 5 to 10 c. m. long, 2.5 to 4 c. m. wide, cuneate at the base; short acuminate at the apex.

III. GEOGRAPHIC DISTRIBUTION.

As previously stated the first gutta percha trees were reported from the island of Singapore, and in fact within a few miles of the city itself. When the substance became a marketable article these trees were the first to fall and all of the island was soon devastated. The explorations from Singapore as a center were made in all directions and with remarkable success. All of the forest of the southern half of the Malay Peninsula gave large yields, as well as the islands of the Rhio Archipelago, Borneo, and most of Sumatra. However, from all of the data which have been gathered from native sources, as well as from the information collected by many Dutch, English, and French explorers, it appears that the area of distribution of *Palaquium gutta* is sharply defined. Beyond the sixth degree north on the Malay Peninsula the trees become scarce or cease altogether; on the northern end of Sumatra they are likewise lacking. Java, bordering close on Sumatra, contains none, and Celebes to the east of Borneo has been found to be equally destitute. Reference to map (No. 1) will show the area of distribution of the *Palaquium* gutta which is practically included in a parallelogram inclosing the above-mentioned peninsula and islands. This area include some 450,000 square miles of land, of which only a very small per cent is or ever was covered by gutta percha trees.

Obach, in his celebrated book on gutta percha, practically limits the area of gutta percha production for the entire world to this small territory (7). While this statement is probably true so far as the gutta percha from *Palaquium gutta* is concerned, we have already seen that the area of distribution of the other or inferior species is extended eastward so as to take in the Philippines, and the same is also true of Celebes, Java, and the northern half of the Malay Peninsula.

The number of gutta percha producing species in the Philippines has already been listed, and some of the localities given where they have been found. Attention is again called to the distribution of these localities, extending so far north as well as south, and it can be confidently expected that when the forest surveys are completed nearly all of the islands will be found to contain some species in more or less abundance.

Owing to the limited extent of the areas where gutta percha trees have so far been found on most of the islands, the regions which produce gutta percha for the market at the present time are confined to the Islands of Mindanao and Tawi-Tawi. The accompanying map (No. 2) is arranged to show the places where gutta percha species have been found as well as to give some idea of the size of the districts producing the gutta percha now being exported. The exact or even approximate extent of these areas is difficult to calculate. Much has not yet been explored, and the information derived from the natives is vague and contradictory. The areas on the map are given conservatively and are known to produce gutta percha at the present time. Other territories will probably become known as our intercourse with the wild tribes inhabiting these regions grows more friendly and open.

List of towns and forest regions from which gutta percha is exported to Singapore.

Central point for collection and exportation of gutta percha.	Point of collection of gutta percha from the various forest regions.	Name of forest regions from which gutta percha is collected.
Cottabato	Tukuran and Dinas	Dinas-Subano Camalarang, Labangas, Tukuran.
	Malabang	Laguna de Lanao, Baras, Liangan, Segayan.
	Clán, Sarangani, and Binang	Tagabuli, Manobo, Bilan, Binang.
	Reina Regente and Salaya	Dama Balao, Matingananan, Talayan.
Zamboanga	Baluan, Curuan, Taluesangi, Puerta Santa Maria, Dapitan, Misamis.	Western and northern Subano.
Joló (Sulu)	Transshipped from Davao Cottabato, Zamboanga, or Siassi.	Tawi-Tawi.
Bongao	Siassi, Balambing, Buan, Dajapatan.	Do.

The Islands of Paragua (Palawan) and Balabac were found destitute of either gutta percha or rubber-producing trees, although long and careful search was made for them in many localities. Owing to their close proximity to Borneo, and the fact that botanically and geologically these islands are supposed to be more closely allied to Borneo than to the rest of the Philippines, it was confidently expected that both gutta percha and rubber would be found there. The absence of these forest products is probably due to the uneven distribution of the rainfall with a long drought in January, February, and March.

FIG. 14.—GUTTA PERCHA LEAF (PALAQUIUM GUTTA) ENLARGED, SHOWING THE FIBERS OF GUTTA PERCHA PERMEATING THE LEAF INTERIOR.

FIG. 15.—READY TO FELL A LARGE GUTTA PERCHA TREE FOR EXPERIMENTAL PURPOSES. DISTRICT OF ZAMBOANGA, MINDANAO.

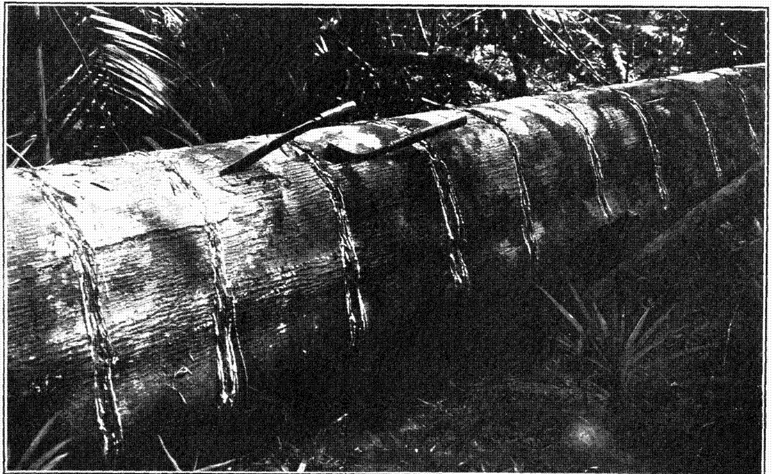


Fig. 16.—A LARGE GUTTA PERCHA TREE TAPPED IN SUCH A MANNER THAT THE FLOWING MILK IS ALL ABSORBED BY THE CHOPPED-UP BARK AND NONE ESCAPES. TIRURAY DISTRICT, MINDANAO.

Fig. 17.—Tapping a gutta percha tree in such a manner that all the milk is collected in shells beneath and none lost. Done by Moros in Tawi-Tawi.

FIG. 18.—A GUTTA PERCHA TREE FELLED AND RINGED BY THE SUBANOS NEAR CURUAN, DISTRICT OF ZAMBOANGA, MINDANAO.

IV. METHODS OF COLLECTING AND MARKETING.

(*a*) COLLECTING.

The question of what is the best method for collecting gutta percha has troubled owners and dealers from the beginning, and a satisfactory answer is still lacking. The trees are in the tropical forest regions of the Malay Archipelago, Borneo, and the Philippines, which are inhabited by the wildest pagan tribes only. These natives are the natural gutta percha collectors and as a matter of fact have done all the collecting since the beginning. They evolved a method which answered their requirements very satisfactorily. As might be inferred, they wished the maximum yield of gutta percha from each tree with the minimum expenditure of work or time. That the method was extremely wasteful did not concern them nor were they bothered over the prospect of a bankrupt future.

The method, which is still in vogue from the westernmost part of Sumatra to the easternmost point of Mindanao, is, with various minor modifications, practically as follows: The tree is first cut down and the larger branches at once lopped off, the collectors say to prevent the gutta percha milk from flowing back into the small branches and leaves. As has been previously stated the milk or latex is contained in the inner layers of the bark and leaves, in small capillary tubes or ducts. (See fig. 14.) To open these so as to permit the maximum amount of the milk to escape, the natives cut rings in the bark about two feet apart along the entire length of the trunk. The milk as it flows out is collected in gourds, cocoanut shells, large leaves, or in some districts in the chopped-up bark itself, which is left adhering to the tree for the purpose of acting as a sort of sponge. (See fig. 16.) After one or two hours, when the milk has ceased to flow, the contents of the receptacles are united and boiled over a fire for the purpose of finishing the partial coagulation. The warm, soft mass is then worked with cold water until a considerable amount of the liquid is mechanically inclosed. To further increase the weight, chopped bark, stones, etc., are added and the whole mass worked into the required shape with most of the dirt on the inside.

The gutta percha gathered in this way well repays the amount of work expended. The two vital defects of the method are—

(1) The method is very wasteful, the yield from each tree being

a small proportion to the total amount. What this per cent is has been investigated by scientists with the result that the figures differ widely. Remembering that the gutta percha milk is contained in capillary ducts and tubes, it will be seen that a considerable amount can not flow out on account of capillary attraction, no matter how much cutting is done. It very seldom happens also that a tree falls in such a way that all its trunk is exposed so as to admit of ringing on all sides. As a general thing from one-third to one-half of it is inaccessible to the process of ringing, and all the milk within this portion is consequently lost. Even the larger limbs are not deemed worth ringing and consequently all the milk in them and in the leaves also goes to waste; to this must be added the considerable quantity spilled on the ground through carelessness and lack of enough receptacles for every cut or bruise from which the milk flows. (See fig. 19.)

The method employed to find what percentage of gutta percha has been removed from a tree by the native collectors was to determine the per cent of gutta percha remaining in a given area of the bark, multiplying this by the total bark area of the tree and adding 15 per cent of this amount for that contained in the bark of the branches and in the leaves.

The amount which the native collectors secure from the average full-grown tree apparently varies according to the species, season, personnel of collectors, etc. Most authorities place the amount per tree at one-fourth of a pound. The director of the botanical garden in Penang (8) secured 1½ pounds of clear gutta percha from a large tree (*Pal. gutta*) estimated to be 60 years old. Wray (9) obtained somewhat over 2 pounds from a *Palaquium gutta* tree at least 100 years old, and 2½ pounds from one of an inferior species.

Burck (10) made some extended experiments in Sumatra and secured an average of less than 1 pound from full-grown trees, while Serullas (11) in Sumatra obtained almost 1 pound from a giant tree. Trees of inferior grade have been found to give as high as 8 pounds. Probably the best average obtainable is 3 pounds. In the Tiruray District of Mindanao I secured 1 pound of clean gutta percha from a tree 135 feet high and 5 feet 4 inches in circumference at the base. The work was carefully done by the natives. Taking a measured amount of the bark of this tree after no more gutta percha could be collected by the native method, and extracting all of the gutta percha which it still contained, it was estimated that

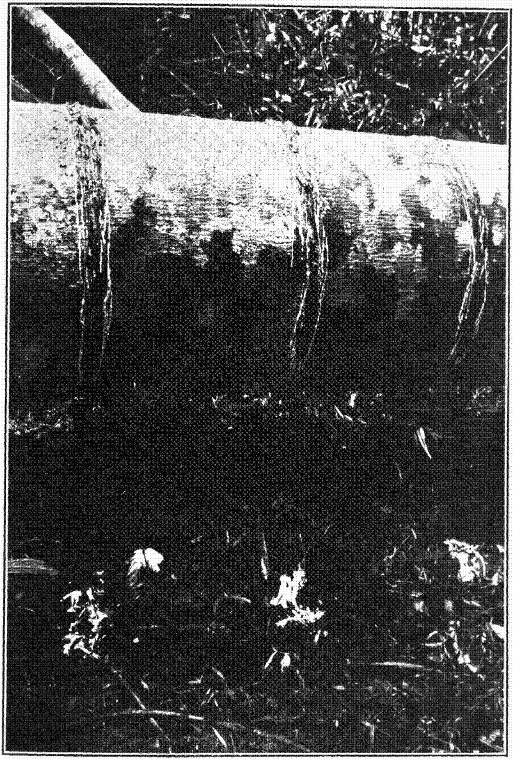


FIG. 19.—A GUTTA PERCHA TREE TAPPED IN SUCH A MANNER THAT THE FLOWING MILK IS NOT ALL ABSORBED BY THE CHOPPED-UP BARK, BUT MUCH OF IT IS LOST ON THE GROUND BELOW. TUCURAN, DISTRICT OF ZAMBOANGA, MINDANAO.

FIG. 20.—A LARGE GUTTA PERCHA TREE FELLED AND RINGED. NO OTHER GUTTA PERCHA TREES WERE FOUND GROWING WITHIN A LARGE RADIUS, AND NO SAPLINGS WERE OBSERVED. DISTRICT OF ZAMBOANGA, MINDANAO.

FIG. 21.—STEM OF GUTTA PERCHA TREE, SHOWING SCAFFOLDING ERECTED BY SUBANOS FOR THE PURPOSE OF FELLING THE TREE. SOME ROOTS WERE STILL ALIVE, BUT NO STOOLING WAS APPARENT. DISTRICT OF ZAMBOANGA, MINDANAO.

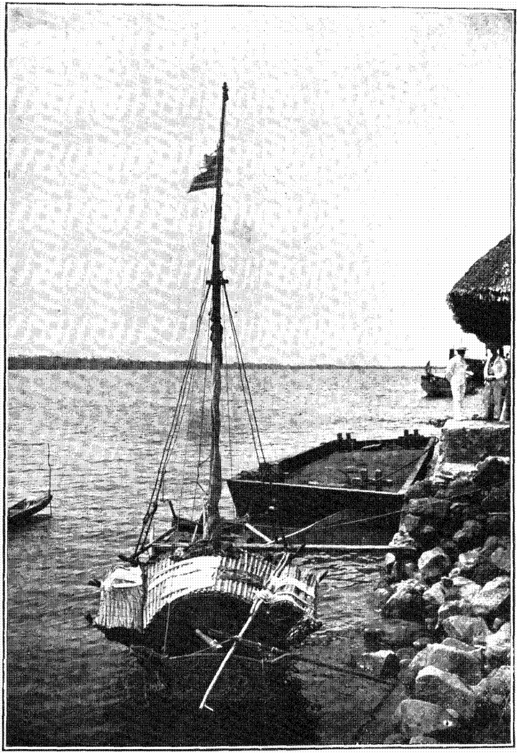


Fig. 22.—A CHINESE MORO TRADING BOAT STOPPING AT PARANG PARANG, MINDANAO, FOR THE PURPOSE OF BUYING GUTTA PERCHA AND TAKING IT TO COTTABATO FOR EXPORTATION.

after collection there still remained $6\frac{1}{2}$ pounds of gutta percha. Taking into consideration the fact that had the tree not fallen in such a way as to leave almost all of the trunk propped high enough above the ground to allow the milk to be extracted from the bark on the under side, the amount extracted would undoubtedly have been much less, or in other words ten times more gutta percha would have been left to rot with the tree than was taken from it by the natives. Other investigators have secured figures as large as these and some found that forty times more gutta percha was left behind than was secured by the careless collectors.

(2) It leaves the future unprovided for. It has been seen that the invariable practice of the native collectors is to fell the tree in order to extract the gutta percha. (See fig. 20.) In some cases it has been reported that the stumps stool afterwards, and in course of time produce new trees, but it can be safely asserted that this is the exception and not the rule. Of those I have found cut down in the Philippines, none have ever stooled, though in one case I saw some of the roots of the stump alive long after the felled tree was well advanced toward decay. (See fig. 21.)

It is fortunate that only the full-grown trees contain enough gutta percha to repay the work of felling, ringing, etc.; otherwise the complete extermination of the gutta percha forest would only be a matter of a year or so. On the other hand the felling of all the trees old enough to bear seed works to the same end with a somewhat longer time limit.

(*b*) MARKETING.

Having been collected and put in marketable shape, the gutta percha is carried in baskets on the back of the collectors to the nearest waterway and thence by boat (see fig. 22) to the most accessible town, where, applying the description to the Philippines, it is exchanged for barter to some Moro, Chinese, or Filipino merchant (comerciante) living there for the purpose of dealing in all kinds of native products. From here it is shipped to one of the ports doing an export trade with Borneo and Singapore. The entire gutta percha trade is practically in the hands of the Chinese in the latter city, and they guard the secrets of boiling, working over, mixing, adulterating, and coloring the gutta percha for European markets most zealously. All who have tried to investigate their methods agree that there is no connection between the various grades and the different tree species, and that pure gutta percha from the species *Palaquium gutta* is no longer found on the market unmixed with inferior grades.

Strangely enough, I was unable to find in Singapore any statistics regarding the importation of Philippine gutta percha. The Chinese dealers denied receiving any, and beyond a few piculs noted in the annual import statistics, no mention of it was found anywhere. I afterwards ascertained that the gutta percha first goes to Sandakan and Labuan, in British North Borneo, and is there transshipped to Singapore, entering as North Borneo gutta percha.

Unfortunately the amount collected for exportation can not be given with any degree of accuracy, as the export statistics (12) include gutta percha with all other gums. It is known, however, that the amount reaches into tens of thousands of pounds.

V. LAWS REGULATING COLLECTING AND SHIPPING.

Considering the almost lawless way in which gutta percha is collected and marketed, it is pertinent to review briefly the few steps taken toward legislating on the subject. The English long ago realized that the gutta percha forests of the Malay Peninsula were doomed to destruction unless radical measures were taken to change the method of collecting. The first law passed was to prohibit the felling of trees in order to collect the gutta percha. As the law never penetrated to the wild tribes of the interior where the collecting was done, it was not effective. As a surer method of stopping the destruction, a second law was passed which prohibited the exportation of gutta percha from coast towns in the Federated Malay States in which the English could, of course, exercise personal supervision. The result was that the exportation from those places ceased promptly, but the felling of trees did not stop, the export simply traveling northward by overland routes until it was outside of English jurisdiction, and from there it was shipped to Singapore. I can not find that anything effectual has been accomplished by the English or by the Dutch authorities in Sumatra and Borneo toward remedying the difficulty. It seems to be generally realized at last that wild natives can not be prohibited from doing things where there is no law nor show of authority. Certainly they will not cease felling gutta percha trees until some one can show them an easier method for collecting the same amount or more of the material, so long as gutta percha has a market value.

The English had the true idea when they took away its market value through prohibiting exportation. The only trouble was that the Malay States are on a peninsula and not an island. This law, if applied to the Philippines, might succeed better by reason of their geographical situation, but so far nothing of this kind has been tried here. As soon as the Forestry Bureau was established in 1899, the felling of gutta percha trees was prohibited (13). Rules and regulations were provided for tapping the bark of the tree with a bolo in such a manner as to allow the milk to be secured without killing the tree. As the amount of gutta percha obtained by this process was much less than that secured from felling the tree, while the labor was fully as great and was dangerous besides (some trees being 70 feet to the first limb) the wild natives never practiced this method, nor did they ever hear of it, and all the gutta percha so far exported has been at the expense of so many trees killed.

Islands such as Mindanao and Tawi-Tawi can not stand this for any length of time and already the gutta percha trees have entirely disappeared from the vicinity of the coast regions and of the large rivers. According to the forest surveys made so far in the Islands the average number of trees of 1 foot in diameter is between forty and fifty per acre, and considering the large number of species found in the forests the number of trees of any one species is generally placed at four or five. With this liberal allowance the forest acreage of the southern islands will probably supply gutta percha at the present rate of cutting for three or four years longer, but not for more than that.

It must not be supposed that scientific investigation has not been directed toward solving this vexed question of securing gutta percha in paying quantities without killing the trees, but before describing the results of this work, the chemical and physical characteristics of gutta percha as well as the prices to be realized for it must be considered in order to demonstrate the difficulties to be overcome.

VI. GRADES AND PRICES.

The prices governing the sales of all grades and kinds of gutta percha in Singapore, the chief market of the world, seem to be most arbitrary and uncertain. As a general thing they have increased continuously and steadily since the beginning of the industry.

Formerly the different grades of gutta percha were named from the well-known districts or shipping ports from which they came. An attempt was also made to designate the species of tree furnishing the product, and a further distinction was given as to quality. For instance "Koatei guta merah No. 1" was first grade of gutta percha from *Palaquium gutta* coming from Koatei, while "Pahang white soondi No. 1" was first-grade gutta percha from *Payena leerii* from the Pahang district.

These names and gradings are still kept up as a matter of convenience for cable codes, etc., but the significance of the names is almost entirely lost, certainly as far as any indication of the tree species is concerned, and often as regards the district of production as well. The Philippine gutta percha for example has neither grading nor price in Singapore, and probably comes in under Sarawak white, red, etc.

As has been stated previously, the secrets governing the selection boiling, adulteration, coloring, etc., of the various grades are closed and known to the Chinese exclusively. This is also true in the Philippines, though very little except boiling and cleaning is attempted before shipping to Sandakan.

Most of the Philippine gutta percha passes through three hands and the rise in price is quick and decided. My experiences in the gutta percha districts of Mindanao and Tawi-Tawi were to the effect that the wild native collector had to take about what he could get, which was on an average of $10, Mexican, for a picul of 162½ pounds. Money was seldom paid, the usual thing being barter in rice, cloth, copper wire, cheap jewelry, beads, etc. It is needless to remark that the middleman realized a good profit on his merchandise. He in turn carried the gutta percha to the export towns and sold it to the Chinese at the rate of $40 to $80, Mexican, per picul of 137½ pounds. As this latter amount was the legal weight for a picul, his profits were increased by the additional pounds which he deliberately stole from the ignorant natives. The Chinese exporter pays $5 to $7, Mexican, per picul forestry dues (he being the only one of the three with a fixed residence and amenable to Forestry regulations) and exports the gutta percha to Sandakan or Singapore, where it probably brings $100 to $150, Mexican, per picul of 133½ pounds. There is no definite information on this subject, however, as Philippine gutta percha, as has been stated, is neither rated nor graded in Singapore. A year and a half ago when the best grade of gutta percha in the Philippines was said by the Chinese of Cottabato to be worth $80 per picul, the following analyses of Singapore gutta perchas were made by Van Romburgh and Tromp de Haas (14):

Grade.	Dirt.	Water.	Resins.	Gutta.	Price per picul.[1]
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	
Bila (red) soondi	33.6	7.0	31.4	28.0	$150
Sarawak soondi No. 2	37.1	6.8	25.5	29.6	135
Penang gutta Palelo No. 1	2.1	5.8	53.8	38.3	180
Sarawak red soondi No. 1	19.0	3.9	35.5	41.6	350
Bagan white soondi No. 1	0.7	8.6	36.5	54.2	350
Koatei guta merah No. 2	21.7	5.1	28.5	44.7	360
Indragiri white soondi	2.0	4.1	46.2	47.7	370
Sambas white soondi	1.0	4.4	53.6	41.0	380
Koatei guta merah No. 1	14.8	3.8	34.8	46.6	500
Pahang white soondi No. 1	4.2	0.5	12.8	82.5	500

[1] Mexican currency.

According to these analyses the best grades of Philippine gutta percha may well rank with any of the first four on the list, especially as my chemical and physical tests show the high grade of the gutta in them.

Another example of the difficulty in dealing with the Chinese gutta percha merchants in Singapore is the experience of an American merchant of Manila, who, about this time, took a considerable quantity of the best grade of gutta percha from Mindanao over to Singapore by way of speculation. He was only offered $8 per picul by the leading merchants there, and it was not until they found out he was not anxious to sell at all but would ship the product to America, that they finally closed with him at $70 per picul. How much the gutta percha was really worth he never found out.

The evidence then all goes to show that the price of Philippine gutta percha jumps from about $8 a picul in the mountains where it is gathered by the wild tribes, to $150 in Singapore. Thus the native collectors get almost nothing, the Government about as much, and the Chinese the rest. The Chinese might possibly get even higher prices by exporting direct to London or America, though apparently that has not yet been tried.

It is stated on good authority that the Chinese in all their manipulations for preparing the gutta percha for the European market go solely by smell, color, toughness, and the softening and hardening test in hot, then cold, water. At any rate they are certainly very skillful in the work, although careful inspection of the above table, as Van Romburgh points out, would tend to show that their prices were not at all warranted by the analyses. So long as the collecting of the gutta percha is all in the hands of wild natives and the manipulating and marketing controlled by the Chinese, we can not hope to have the gutta percha trade on a fair business basis. However, as the supply steadily decreases while the demand and prices increase, the attention of Governments and manufacturers will more than ever before be directed to the subject and perhaps the hoped-for relief will come through scientific propagation of gutta percha trees and scientific collecting of the gutta percha.

VII. CHEMICAL PROPERTIES.

A chemical examination of the milk or latex above referred to as coming from the gutta percha trees upon wounding the bark shows it to be composed of an emulsion of water and oil in a finely divided state. According to the species of tree the water varies from a small (best species) to a very large percentage (poor species). A drop of the milk caught on the finger undergoes no apparent change for a few minutes, but by the end of this time a thin rubbery scum can be observed to have formed on the surface. If this be removed a second film will form, and so on until the entire drop has become a small piece of a tough, leathery substance. When a fresh drop is worked between the fingers the hardening process or coagulation takes place very quickly, and by boiling or adding certain chemicals, such as mineral or vegetable acids, alum, salt, etc., it takes place almost instantaneously. What the nature of this hardening process is, appears to be unknown. The subject will be investigated in this laboratory.

After coagulation sets in (see below), the oily portion becomes hard and tough while most of the water separates or is inclosed mechanically. Subjecting this hard and tough mass, taken for example from the *Palaquium gutta* species, to further examination, it proves to be insoluble in water and very stable against the action of either dilute acids or alkalies. In chloroform or carbon bisulphide it is easily soluble, while ether, petroleum ether, and alcohol dissolve it only in part. By subjecting it to the action of cold alcohol, a yellow amorphous resinous powder can be extracted. Hot alcohol further extracts a white crystalline resin, leaving a tough horn-like residue, which is easily soluble in chloroform and carbon bisulphide and can be precipitated from these solutions by alcohol as a white flocculent mass, which by warming or through pressure quickly returns to its original appearance. Taking the three constituents of gutta percha in the order described above, the names Fluavil, Alban, and Gutta were given them by Payen (15) in 1852. Besides these constituents, all gutta percha was found to contain more or less dirt, coloring matter, and water inclosed mechanically.

TABLE No. 2.—*Analyses of representative samples of gutta percha from Singapore and Philippine markets, as well as from different species of gutta percha trees, to show composition and comparisons.*

Source of specimen.	Appearance.	Gutta.	Resins.	Water.	Dirt.	Grade.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	
1. Collected from Pal. gutta trees in experiment garden, Buitenzorg, Java.	Close, compact, tough, whitish to pink and brown.	74.77	20.74	2.49	1.99	Superior, but not on Singapore market.
2. Sample analysis of product of Pal. gutta made by Van Romburgh.	----------------	85.15	11.02	2.08	1.75	Do.
3. Product from two trees of Pal. leerii, Tawi-Tawi.	White, somewhat elastic, very tough.	48.19	41.38	6.59	2.05	Superior in Philippines.[1]
4. Product from tree of Pal. mindanaense; in mountains southeast of Cottabato.	Somewhat tough, white, pinkish, and brown.	38.42	49.08	9.76	2.72	First.
5 Brought into Cottabato by Moros from Subano region, northwest of Tucuran.	Clean, pinkish balls; tough.	32.49	54.08	7.61	5.76	Do.
6. Purchased from Moros at Bongao.	Tough, compact slab.	28.37	37.42	18.32	15.83	Second.
7. Product from tree of Pal. celebicum; in mountains southeast of Cottabato.	Inclined to crumble; white to brownish.	31.30	51.86	.04	16.79	Do.
8. Brought into Cottabato by Moros from Binang region; botanical origin unknown.	Long coils on piece of bamboo; dirty and dark colored.	30.20	57.40	7.80	4.60	Do.
9. Product from unknown species; in mountains southeast of Cottabato.	Dark brown, hard, and crumbling.	23.64	53.99	13.87	8.48	Third.
10. Product from Pal. ahernianum; in mountains north of Tucuran, Mindanao.	Heavy, compact mass, crumbling easily; light reddish brown.	24.55	43.21	15.19	17.04	Fourth.

[1] The grading of the Philippine gutta percha is done by the Chinese exporters.

The method adopted for making the above analyses is a modification of those used by Obach (16) and Van Romburgh. The former determined first the per cent of water by drying a weighed sample to constant weight on a water bath or desiccator, determining the water by difference. The resins were then extracted with ether and weighed after the solvent had been completely evaporated.

The gutta and dirt were thus left and were separated by chloroform, which dissolved the gutta, leaving the dirt to be filtered, dried, and weighed. The chloroform was then evaporated and the gutta weighed.

Van Romburgh (17) in his latest analytical work uses the following scheme: The weighed and finely divided substance is dried to constant weight in an atmosphere of dry carbondioxide gas, which fulfills the double purpose of drying and at the same time preventing oxidation. The sample is then dissolved in hot chloroform, thus allowing the undissolved dirt to be filtered off, washed, dried, and weighed. The chloroform solution containing the gutta and resins in diluted with chloroform to 100 c. c. and an aliquot portion taken, evaporated, and dried to constant weight as above. By extracting the residue with hot alcohol or acetone the resins are removed, when the remaining gutta is dried and weighed. The resins are then estimated by difference. Van Romburgh points out that the largest source of error in using this method is due to the evaporation of the chloroform. To avoid this loss and save time the following modifications were adopted by me:

DIRT.

A fair sample of the gutta percha to be analyzed was finely divided and quartered down to a small amount. Of this 0.3 to 0.5 gram was taken in a weighed thimble filter and extracted hot in a Soxhlett apparatus, chloroform being used as the solvent. When all was dissolved but the dirt the latter was dried on the filter and weighed.

RESINS AND GUTTA.

The chloroform solution is then evaporated to dryness in the flask (previously tared) attached to the extractor and dried to constant weight on the water bath in a stream of dry carbon dioxide gas. After weighing, the contents are extracted with hot alcohol or acetone, when the flask is again dried as before and weighed. The loss in weight equals the weight of resins and gain of the flask the weight of gutta. The water is estimated by difference.

Analyses of samples taken from several trees of one species show the percentages of the constituents to vary considerably, they being influenced, probably, by the age of the tree, the conditions of its growth (soil, moisture, shade, etc.), as well as by the season at which the sample was taken. For illustration of this, two analyses of gutta percha known to have been taken from different trees of *Palaquium gutta* are given to show the large variation in the percentage of gutta. It must, therefore, be understood that the figures obtained from the analyses of the gutta percha taken from any one tree will not necessarily represent the exact values for that species. An average from a number of trees is necessary to secure true values. In the same way, samples from any commercial grade of gutta percha may vary quite a little in their percentage composition, the differences, however, generally falling within a well-defined limit.

The "dirt" found in all commercial gutta percha, as has been stated, may be there unintentionally, or have been added with intent to defraud. In either case it generally consists of finely chopped bark, leaves, small sticks, etc. From 2 to 6 per cent of dirt is not only admissible but generally unavoidable, while more than that is looked upon with suspicion. So intimately is some of the dirt mixed with the gutta percha that even the best machines fail to eliminate the last one or two per cent.

A certain amount of coloring matter which exudes from the bark when it is cut is also mixed with the gutta percha milk and colors the resulting product. Certain species give a distinctive color to the material taken from them, so it has become a practice of the Chinese in Singapore to boil inferior grades with the bark of the best species in order to give them the correct color.

Under "resins" are considered the resinous-like substances which with gutta go to form the substance gutta percha. These resins vary greatly in appearance. In gutta percha from *Palaquium gutta* for example, as has already been stated, one is a white crystalline mass while the other a yellow amorphous powder. In other species they may be oily or brittle, colored or white. Judging from the formulas $C_{10}H_{16}O$ and $(C_{10}H_{16}O)_x$ which have been given to alban and fluavil respectively, it might be inferred that these resins are oxidation of products of gutta $(C_{10}H_{16})_x$. Sufficient work has not yet been done on these bodies, however, to make this anything more than conjecture.

Again taking the gutta percha from *Palaquium gutta*, for illustration, it is found that the 10 to 20 per cent of resins which it contains is not a detriment but rather a decided advantage. Besides adding much to the bulk, these substances are insoluble in water, poor conductors of electricity and quite stable against the action of air and moisture. In fact, gutta percha at present prepared for the insulation of submarine cables is composed of one part of resins to every two parts of gutta. When the amount of resin passes this percentage, however, the toughness of the gutta percha is lessened and other objectionable qualities become apparent. The necessity, then, of knowing the percentage of resin in a given quality of gutta percha before using it for manufacturing purposes is plainly apparent.

As might be inferred from the preceding, the "gutta" is the principal constituent in gutta percha. The methods of separating it from the other constituents have been given and its indifference toward dilute acids and alkalies noted. Concentrated nitric acid causes violent oxidation while sulphuric acid carbonizes it in a short time. Alkalies, even when concentrated, have practically no action on it. The best solvents for gutta are chloroform, carbon bisulphide, and carbon tetrachloride. From all of these solutions it may be reprecipitated by the addition of alcohol.

If gutta be subjected to dry distillation isopren C_5H_8 and kautchin $C_{10}H_{16}$ (18) distill over as the chief decomposition products, and are identical with the isopren and kautchin (19) recovered from the dry distillation of rubber. Tilden (20) succeeded in changing isopren back again into a rubber-like substance through the action of concentrated hydrochloric acid. Isopren, according to Ipatiew and Wittorf (21), is methly divinyl $CH_2{=}C(CH_3){-}CH{=}CH_2$, so that both gutta and rubber will perhaps be found to be polimerization products of isopren.

The discussion has so far been of the gutta found in the species *Palaquium gutta*. Dr. Eugene Obach (22), as chemist for a large cable insulating company, made analyses of specimens of gutta percha from different species of trees as well as from many grades of commercial gutta percha. In his table of analyses he puts under the name of "gutta" the substance found in each sample, which was insoluble in boiling alcohol but soluble in chloroform. The "guttas" thus found were variously colored from white to dark brown, and possessed different tensile strength, from "elastic" and "very strong" to "brittle." Obach thus used certain slight chemical similarities as his criterion of a gutta and neglected, apparently, the wide physical differences, which, as will be shown later, these bodies display. Provided there are many kinds of guttas, it is easily understood why a chemical analysis alone of a gutta percha will give almost no insight into its value unless accompanied by physical tests of the gutta contained in it.

VIII. PHYSICAL TESTS OF GUTTA.

Before going further with the discussion as to whether chemical or physical tests should decide what is or is not "gutta," attention is called to the various physical properties of these bodies. To provide material for these physical tests, they were isolated in considerable quantities from various representative Singapore and Philippine gutta perchas by means of solvents, and after evaporation were dried in a stream of dry carbondioxide gas to prevent any possible oxidation. When heated to the temperature of boiling water they could be easily cut or molded into the necessary shape for performing the following experiments:

Gutta	Color.	Action toward light.		Heat, soft-ening tem-pera-ture.	Stress, tensile strength (pounds).
		Refractive index.	Rotation, in 0.5 per cent solution.		
		70° C.		° C.	*Sq. inch.*
No. 1	Light brown	1.5093	6.75	62	5262.4
No. 3	Cream white	1.5088	6.50	60	6668.15
No. 4	Yellowish white	1.5089	7.50	61	5134.7
No. 5	Very light chocolate	1.5093	6.50	61	6451.45
No. 10	Cream white	1.5076	4.75	56	([1])

[1] Brittle. (The numbers in this table refer to Table No. 2.)

EXPLANATION OF TABLE.[1]

The "color" of the guttas undoubtedly comes from the bark of the tree when cut to secure the gutta percha, for, by repeated solution and precipitation, the color may be almost entirely eliminated, leaving the gutta only slightly tinted from a cream color to light pink, and pure white when finely divided. It is my opinion that all variations of color are only incidental and not connected with the chemical structure of the gutta itself. The amount of color in the above samples was a minimum and not sufficient to have any material effect on the physical properties. The experiments

[1] The results given in this table and some of the explanations appeared in the previous annual report of the Superintendent of Government Laboratories, but as subsequent experience and the completion of botanical data has led me to take up the subject from a different standpoint, they are again appended for the sake of completeness.

with light, namely, those given under refractive index and rotation are employed with great success in the commercial analysis of sugars, oils, fats, butters, etc. This is due to the fact that each chemical individual, providing it is capable of transmitting light, has an index of refraction peculiar to itself, which, for purposes of comparison, must be taken under constant conditions and, provided it is able to rotate the plane of polarized light, a degree of rotation which is also constant. While two chemical individuals may show identity in some one physical property, they can not continue this identity in two or more, so that more than one method was necessary to determine the relationship of the guttas examined by me. Substitution, adulteration, or variation in chemical structure can in this way be easily discovered and determined. Owing to certain mechanical and chemical difficulties encountered in making these determinations on the guttas, the limits of error of experimentation are outside of the differences found between Nos. 1, 3, 4, and 5, but do not include the marked difference displayed by No. 10. In determining the refractive index, an Abbe-Zeiss refractometer was employed, a small amount of a concentrated solution of pure gutta in chloroform placed on each of the prisms and allowed to stand until the odor of chloroform had entirely disappeared. The prisms were then closed, and kept at a temperature of 70° C. until the readings became constant, showing that all chloroform had evaporated. The above figures are the results of many determinations made with carefully prepared samples.

The rotation was determined in chloroform, 0.5 per cent solution being used, because, when more concentrated, the absorption of light was too great to admit of accurate readings.

The physical tests given in the above tables are so diversified as to bring out clearly the extent of resemblance between the various samples of gutta submitted to them. The results show little variation between Nos. 1, 3, 4, and 5. Indeed, these samples may be regarded as practically identical in composition. The physical constants appear to be those of a single chemical individual, the refractive index varies only in the third decimal place, the rotation is the same within the limits of only 1°, and the softening points vary only from 60° to 62°. The small amount of resins in the specimens, which it was impossible to remove, would be sufficient to account for even greater variations. No. 1, however, is the best sample, used for a standard and taken from *Dichopsis gutta*; Nos.

3, 4, and 5 are from the Philippine Islands. It would appear from this that gutta is a chemical individual, identical in all cases, and any substance, such as No. 10, for example, which varies from the properties recorded above, should not be designated as such. This opinion is, however, advanced, subject to further confirmation by extended chemical investigation looking toward the determination of the chemical constitution of gutta. In the case of sample No. 10 the substance designated as gutta, and the real gutta of No. 3 are very similar in appearance and chemical behavior. In tensile strength, however, they are widely divergent, and this difference is accentuated and not lessened by the other physical tests, for while these latter differences are not so marked, yet they clearly show that all the physical constants of No. 10 differ more or less from all the others, and hence this substance must certainly be different in chemical constitution.

The action of heat in softening gutta percha and making it plastic has previously been used as a test of value. It has been found that the best grades require a higher temperature to soften them than the lower grades. According to the results obtained by me, the inferior grade of gutta (No. 10) also possesses the property of softening at a lower temperature than the superior gutta. The softening point was determined by molding a piece of gutta into the bottom of a glass tube sealed below, placing a sharp pointed glass rod in contact with the surface, and gradually heating in a bath of sulphuric acid until the point of the glass rod just began to enter the gutta.

The tensile strength, or toughness, possessed by gutta, next to its resistance to sea water is undoubtedly its greatest merit commercially. Even the inferior grades of gutta percha are used for objects requiring toughness combined with pliability and strength. In the insulation of a submarine cable great toughness is imperative, for during the laying of the cable it is constantly subjected to great strains from kinking, pulling, rubbing, etc., and when it has reached to the ocean bottom where the pressure is often three and a half tons to the square inch, it must not have sustained a fracture even as large as the diameter of a fine hair for otherwise the moisture would slowly penetrate to the wires, the insulation would not be complete, and the cable would have to be pulled up and repaired.

In order that the measurements made might be within the limits of the instruments at hand, only small strands of gutta could be used for testing. To make these strands free from minute air bubbles was well nigh impossible, in consequence of which the breaking was in most cases brought about by weakness due to this source. The figures, while thus only approximate, are below and not above the true values and show clearly the enormous tensile strength of my samples. Obach (23) gives a tensile strength of 5,000 pounds for the best gutta percha while for the gutta from it he found about 6,500, which closely corresponds to results given above. This also brings out most clearly the excellent quality of the best Philippine gutta percha.

The results of the combined chemical and physical tests on various samples of so-called "guttas" extracted from gutta perchas of different origin seem to show that the gutta from the gutta percha of *Palaquium gutta* has certain well-defined chemical and physical properties, and they also demonstrate that some so-called gutta perchas contain a substance which chemically resembles to a certain extent the above-mentioned guttas, but differs widely from it in many of its physical properties. As the gutta from the species *Palaquium gutta* has stood the test of usage for fifty years, it is only fair that its chemical and physical constants should be used as the standard of comparison. Until more is known chemically of such substances as I found in No. 10, a chemical analysis will not be sufficient to determine the value of a gutta percha, but it must be supplemented by physical tests. This laboratory will undertake the task of so determining the chemical properties of gutta and its allied bodies in the hope of discovering a method of chemical analysis which alone can be used to determine the value of any gutta percha.

IX. SCIENTIFIC PROPAGATION.

As soon as the native collectors made such heavy inroads on gutta percha forests as to make certain of their serious decimation if not entire destruction, the various governments having tropical possessions in the East began to take note and make inquiries, but it was not until the last four or five years that the notes became serious or the inquiries anxious. Both explorations and inquiries revealed that the greater part of the Malay Peninsula had lost most of its trees, and that the portions of Sumatra and Borneo which were still productive were in the most inaccessible mountain forests of the interior. So thoroughly had the seed-bearing trees been cleared out of the Malay States that a standing reward by govern-

Fig. 23.—THE ENGLISH METHOD OF STARTING A GUTTA PERCHA PLANTATION. THE SEEDLINGS ARE PLANTED IN IRREGULAR ROWS. BUKIT TIMAH, ISLAND OF SINGAPORE.

Fig. 24.—PLANTATION OF GUTTA PERCHA TREES (PALAQUIUM GUTTA) OF VARIOUS AGES. BUITENZORG, JAVA.

ment officials for seeds of the species *Palaquium gutta* was not claimed, though the offer stood for a long time. Van Romburgh (24) in a very extensive tour of Sumatra and Borneo, made for the purpose of reporting to the Dutch Government the condition of the gutta percha regions, saw but a few seed-bearing trees, and these in almost all cases had been protected by native chiefs.

In the botanical gardens of Singapore, Bukit, Tiniah, Penang, and Buitenzorg, *Palaquium gutta* trees were growing which had either been protected from destruction or had been planted for a sufficient length of time to be seed bearing. These formed the nucleus of the gutta percha nurseries now being planted by the English and Dutch governments, with the purpose of obtaining reliable information as to methods of propagation, the rapidity of growth, the time necessary for maturing, and above all to furnish material for testing scientific methods for extracting gutta percha without killing the trees. Owing to the scarcity of seeds everywhere the government botanists were obliged to resort to various methods for securing young plants, and their experiments have been along the following lines:

(*a*) PLANTING FROM SEEDS.

The fresh seeds are laid in beds of rich earth and allowed to germinate and grow under partial shade. When about a foot high they are transplanted to the future plantation, where the soil may be entirely free from trees, shrubs, or other vegetation (Dutch method) or where small patches of earth have been cleaned and loosened for their reception in a forest of secondary growth, heavy enough only to furnish a light shade (English method). By the Dutch method a light shade is required around each seedling until a vigorous growth is secured. The seedlings are set out about 5 by 5 yards apart, though where it is desired to obtain the largest amount of leaves per acre the space allotted is 4 by 4 yards. No special care seems necessary except to keep them free from weeds. Too much stress, however, can not be laid on the care which should be taken not to break or injure the long tap root of the young plant during the process of transplanting, for any injury to it stunts the growth materially or even causes death. Mr. Curtis, director of the Penang Botanical Gardens, has modified the manner of starting the germination and first growth, by placing each seed in a separate bamboo joint filled with earth. This joint is made long enough to allow the tap root to strike downwards undisturbed, and when the time comes for transplanting it can be transferred, joint and all, without any fear of injury, to the place made ready for it. The bamboo is then cracked open and the plant inserted in the ground with almost no disturbance of its roots.

The Dutch Government in Java, having many seed-bearing trees, is now deeply engaged in carrying out a programme which contemplates the planting of some 150,000 seeds annually until at least 1,000,000 trees are growing. This will be done on extensive government plantations at Tjipitir, Java. The entire management is intrusted to Dr. van Romburgh, director of the Government Chemical Laboratory at Buitenzorg, who has a corps of assistants intrusted with testing the gutta percha contained in the seed-producing trees in order that none but the best stock may be used.

(*b*) PLANTING FROM SELF-SOWN SEEDLINGS.

In the forests both of Sumatra and Borneo the natives are still able to find comparatively large numbers of self-sown seedlings of the *Palaquium gutta* species. These, when carefully taken up and transplanted into air-tight boxes provided with glass covers and rich earth, can be packed in large numbers in a comparatively small space and shipped to almost any desired distance. For instance, 60,000 such seedlings were shipped two years ago from Southern Borneo to the French Congo, via Antwerp. The plants transported from Borneo to Singapore in this manner are doing well in the gardens at the latter place. The German Government is planning a nursery of such seedlings in its tropical possessions in New Guinea.

(*c*) PROPAGATION BY MEANS OF MARCOTTAGE.

As neither direct slipping nor grafting has ever succeeded with gutta percha trees, the method called marcottage was tried in Java and the Malay States with some success. This consists in selecting a young straight limb from a large tree and at the point where the roots are to grow the bark is removed for the length of an inch around the entire limb. The denuded spot is then packed with rich mud, which is held in by a coating of cocoanut or other fiber. (See fig. 25.) If the mud is kept moist, and only if this is the case can good results be secured, small roots will generally appear in three to nine months, when the limb can be cut off and planted.

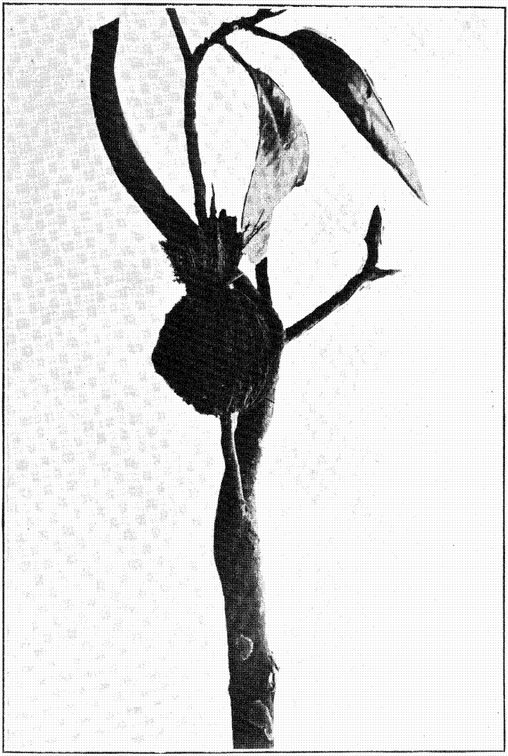


Fig. 25.—SHOWING THE METHOD OF PROPAGATING GUTTA PERCHA TREES BY MEANS OF MARCOTTAGE. BUITENZORG, JAVA.

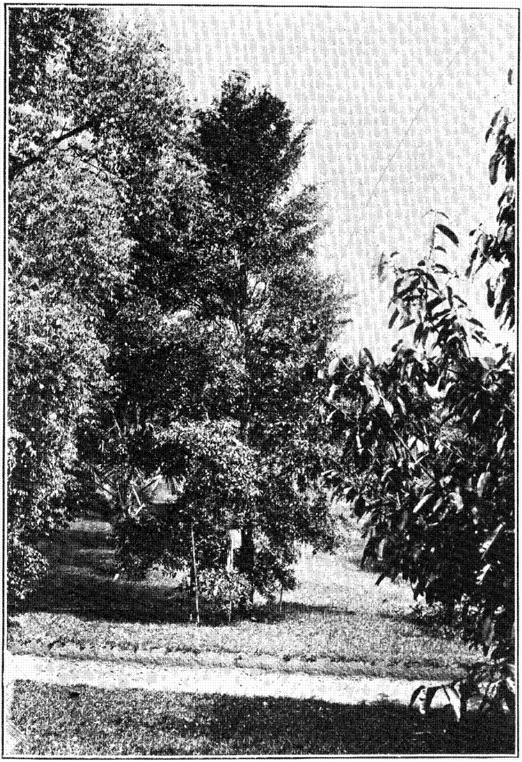


Fig. 26.—A PALAQUIUM GUTTA TREE GROWN IN THE OPEN, SHOWING THE TENDENCY TO BUSH. BOTANICAL GARDEN, SINGAPORE, STRAITS SETTLEMENTS.

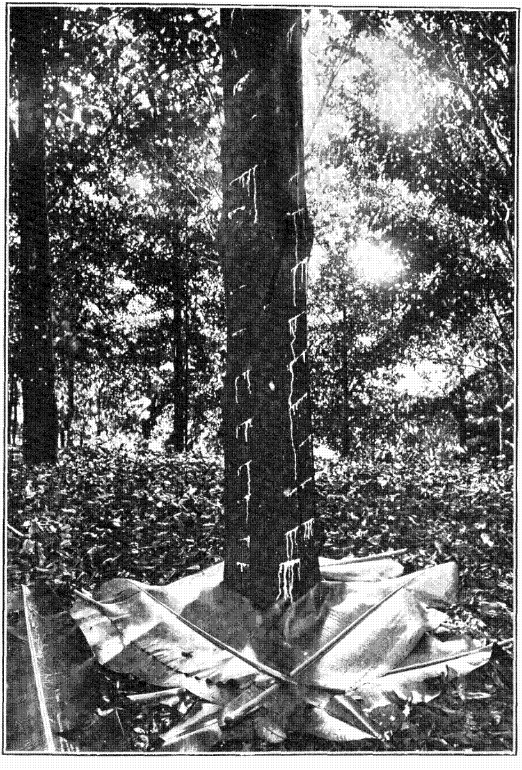


Fig. 27.—A TREE OF PALAQUIUM GUTTA JUST TAPPED. THE FLOW OF MILK IS QUICKLY STOPPED BY THE BEGINNING OF COAGULATION. TJIPITIR, JAVA.

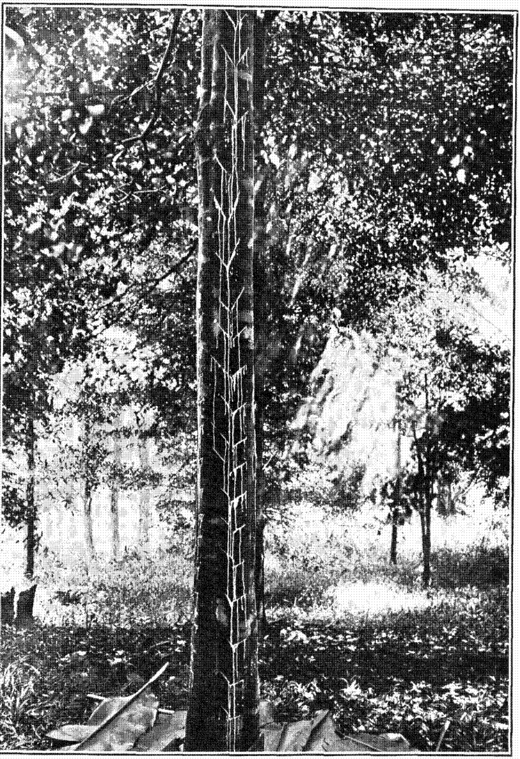


FIG. 28.—A TREE OF PALAQUIUM TREUBII JUST TAPPED. THE MILK HAS A GREATER TENDENCY TO RUN THAN IN PALAQUIUM GUTTA. TJIPITIR, JAVA.

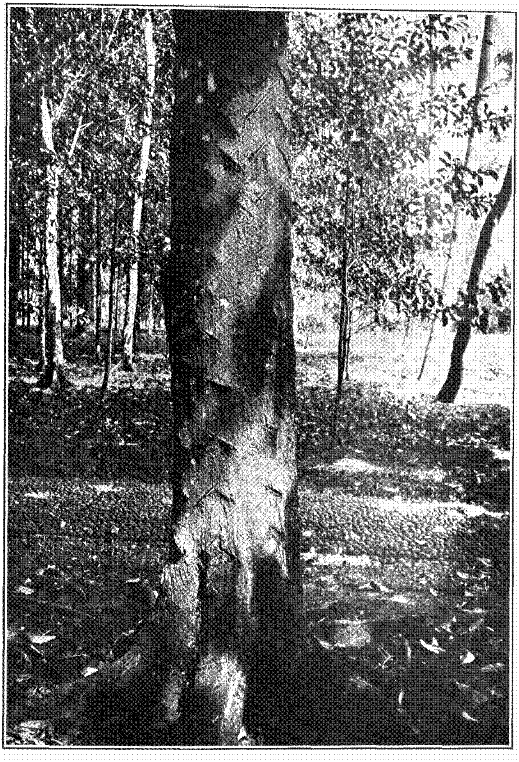


Fig. 29.—ABSENCE OF DEEP SCARS OR ANY TENDENCY TO DECAY OF A PALAQUIUM GUTTA TREE, AFTER SEVERAL YEARS OF TAPPING. BUITENZORG, JAVA.

The principal gutta percha plantations now under cultivation and in which much useful and desired experimenting is being done, are located at Tjipitir and Buitenzorg in Java, on Rhio Island at Singapore and Bukit Timah on Singapore Island, on Penang Island, and at one or two places in the Federated Malay States. Enough time and work have been spent to demonstrate most conclusively that gutta percha trees can be raised not only successfully but also without much trouble or great outlay of money, and all the nations having tropical possessions in the East, except the United States, have made a start toward gutta percha plantations, but the Dutch are the only ones so far who have gone into it on a grand scale, and unless appearances are deceitful they will have a monopoly on the plantations of the gutta percha of the future, as sure as they have on the forest gutta percha of the present day.

X. SCIENTIFIC METHODS OF COLLECTING.

Modern methods of collecting gutta percha have advanced along two lines. Needless to say they were not proposed nor carried out by the wild native collectors who are unwilling to discontinue present gains in favor of future returns. It was previously remarked that the gutta percha is all contained in the bark of the tree and in the leaves. The problem resolved itself into either—

(*a*) Extracting some of the gutta percha from the bark and leaves without injuring the tree, or

(*b*) Felling the tree and securing the gutta percha from all of the bark and leaves.

To carry out the first proposition a method was devised similar to that used in South America for extracting rubber milk, by which incisions were made in the bark in a slanting direction up and down the trunk (see fig. 27), so cut that the gutta percha ducts were opened but no injury done to the inside wood of the tree. The milk flowed out to a greater or less extent, and coagulated in strings on the bark. After the flow had ceased and complete coagulation had set in (one day) the strings of gutta percha were pulled off by hand, washed in hot water, and pressed into cakes. The advantage of this method was that no injury was done the tree although it was tapped repeatedly. (See fig. 29.) The disadvantage lay in the fact that only a small per cent of the total gutta percha in the tree could be extracted at any one time. According to Van Romburgh's (25) latest experiments with plantation trees (*Palaquium gutta*) about

15 to 17 years old, the yield was 100 grams (nearly one-fifth of a pound) per tree. The gutta percha thus secured was of the very best.

In addition to the amount thus taken the leaves both from the living and dead trees contain 8 to 10 per cent by weight of gutta percha calculated to the dry leaf. To extract this gutta percha two processes have been devised:

(1) The mechanical one, in which the leaf is ground to a powder and then treated with hot water in such a way that the gutta percha is gradually worked into a compact mass while the pulp of the leaf is washed away. Up to the present the process has not been perfected, for although the gutta percha contained is of a good quality the percentage of recovery is smaller than it should be. The largest factory of this kind is being erected near Singapore and it proposes to use the leaves from a plantation of 100,000 trees on the Island of Rhio, some five hours from Singapore.

(2) The chemical process is carried out on the same lines as the mechanical one so far as the grinding of the leaves is concerned. The powder is then extracted with solvents and the dissolved gutta percha recovered either through precipitation or through evaporation of the solvent. The details of the process, as well as the solvents used, are kept secret and no patents for this or the mechanical process have been taken out.

The largest factory producing gutta percha for the market is located at Sarawak, North Borneo, and is very advantageously situated as regards securing leaves from the surrounding gutta percha forests. It has been claimed, however, that the factory defeated its avowed object of preventing the destruction of the trees, for the native collectors employed would never risk their lives trying to collect leaves from forest trees over 100 feet high when they could gather them much easier by felling the tree and collecting a goodly amount of gutta percha in addition. It thus appears that the supply of leaves must come from a plantation where supervision can be exercised.

The plan of felling the gutta percha trees of the forest and securing all of the material from the bark and leaves is worthy of serious consideration. In the first place the trees are surely doomed as long as present conditions obtain. If the native can sell the entire bark and leaves for more than he could get for the gutta percha which he could extract, he will be tempted to bring then in.

A second inducement for this method is the fact that many gutta percha trees cut down even years previously have still much perfectly sound gutta percha in the rotting bark, which could also be secured. The process of recovering the substance from the bark is practically the same as from the leaves, and about the same per cent is found there as well. With a yield of from ten to fifteen times the present amount recovered from each tree the gutta percha market would be relieved at once and the extermination of the trees put off many years, long enough at any rate to allow plantation trees to take their place.

A large amount of work has been done in this laboratory with the purpose of finding a practical method for extracting the gutta percha from the bark and leaves of the gutta percha trees. The process calls for a solvent for the gutta percha which will dissolve it easily, can be recovered and again used, and above all has no deleterious effects on the substance.

The result of the experimentation led to a modification of the Obach (26) hardening method for gutta percha. The process consists in extracting the gutta percha bark and leaves by means of hot gasoline, the apparatus being provided with reflux condensers. When the gutta percha has entirely dissolved the solution is allowed to stand until all of the dirt and most of the coloring matter has settled. The clear supernatent liquid is then poured off and cooled to 10° or 15° below freezing. The gutta, with a small amount of resin, is thereby precipitated and can be filtered off through cloth bags and dried. The resulting gutta can be further purified by redissolving in distilled gasoline and reprecipitating. The filtrate containing the dissolved resins is redistilled and the recovered gasoline used for effecting further solution of gutta percha, thus making the process continuous.

The gutta so secured, on being warmed, can be pressed into any desired form for experimentation. The gutta used in the above experiments was so prepared, and the results of the physical and chemical tests showed it to be unaffected by the process to any appreciable extent. A year's exposure to laboratory fumes has not changed the substance in any way. The accompanying figure (No. 30) shows some of pressed cakes prepared in the laboratory.

It is to be noted that the process gives practically pure gutta and not gutta percha, the resins remaining dissolved in the gasoline.

This is in itself a great advantage, as the gutta could be used directly for bringing up the percentage in inferior grades of gutta percha, and so make them suitable for cable insulation. The commercial value of this gutta has not been determined, but should be rated at about $600, Mexican, per picul, judging from the price of the best gutta percha. In this way three piculs of Philippine gutta percha at $210, Mexican, will produce 1 picul of pure gutta valued at $600, Mexican, or a gain of $390 for every three piculs of gutta percha (or the equivalent in bark and leaves) handled.

XI. PESTS AND PARASITES.

An instructive bulletin has been issued by Dr. Zimmerman (27) of the 's Lands Plantentuin at Buitenzorg, Java. His field of observation covered the large experimental gardens of Buitenzorg and at Tjipitir, where many thousands of gutta percha trees of various species are now growing. While the same conditions do not obtain there as are encountered in the forest, it is certain that they are as badly if not worse off on account of the multitude of insects of all kinds which are attracted by the other plants of the gardens. In fact he considers the test a severe one, and his conclusions that there are practically no insect pests which might be considered dangerous is very gratifying. Cattle and goats eat the leaves greedily and young trees must therefore be protected until high enough to be out of reach.

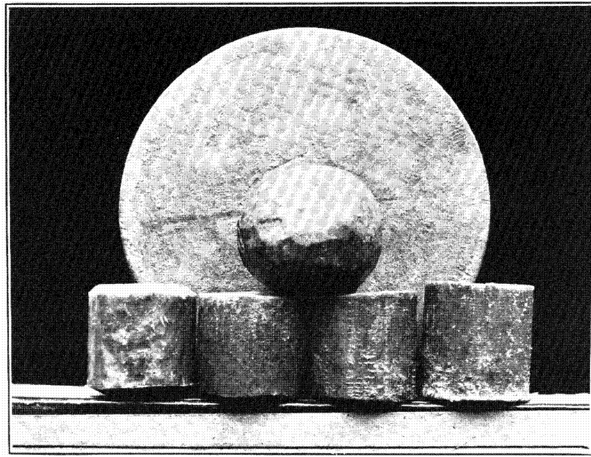


Fig. 30.—SAMPLES OF PURE GUTTA PREPARED IN THE LABORATORY FOR TESTING AND EXPERIMENTAL PURPOSES.

PART II. RUBBER.

I. HISTORICAL AND DESCRIPTIVE.

Even the shortest outline presenting the subject of rubber in its historical, geographical, botanical, and commercial aspects would be beyond the scope of this report, nor does the part which the Philippines have taken in its production or are likely to take for several years to come, warrant anything more than a brief explanation of the present state of the rubber industry, in order to better understand the present conditions here and the possibility of these islands becoming a new center of the ever-increasing rubber industry.

Rubber, or India rubber, as it seems best known in the United States, was discovered by the Spaniards in the second voyage of Columbus. The Indians of Haiti were found playing with rubber balls which they said were formed from the hardened milk of certain forest trees on the island. In 1755 Dom José, King of Portugal, sent several pairs of his boots to South America to be coated with rubber milk. They must have been made satisfactorily waterproof, for the rubber industry has increased from that day to this.

Not alone was the valley of the Amazon found stocked with rubber trees and vines, but new species were discovered in Central America and Mexico as well. In 1798 rubber-producing vines and trees were encountered in Southern Asia, later on in Central Africa, and by the middle of the nineteenth century almost every tropical country of the world had been searched, and the search had not been in vain.

The number of genera and species—even the families representing the rubber plants—is very large, especially because the production is not confined to trees alone nor to any one country, as is the case with gutta percha, but includes a large number of vines as well, and its area of production is practically that of the tropical world. While rubber trees predominate in tropical America, Africa and Asia apparently draw their greatest supply from vines. Borneo especially is rich in them to the exclusion of trees. The Philippines were said to contain more trees than vines, but systematic search has so far revealed only vines.

Not until the middle of the last century were the manifold uses to which rubber could be applied well understood and the rubber industry thoroughly established. Statistics show that London imported in 1830 some 46,400 pounds of rubber, and by 1870 this had increased to the enormous amount of 15,211,800 pounds for that one year alone. Since then the consumption has steadily increased, the statistics reading by tons and not pounds, and for 1902 amounted to some 62,650 long tons. London, the former chief center of the rubber trade, has retired in favor of New York. While tropical America in the beginning produced nine-tenths of the rubber supply, it now exports but very little more than one-half of the total amount, India, Burmah, Borneo, and Central Africa especially having made giant strides in rubber production. Last year's production for the Malay States, Java, and Borneo was about 1,000 tons. In this was included the amount exported from the Philippines. How much that amount was there is no way of finding out, nor for how long this exportation of rubber has been going on. My investigations in the southern islands convinced me that whatever collecting and exporting has been done concerns the island of Tawi-Tawi alone, and in all probability the latter amount was small. This conclusion is reached because the natives only of Tawi-Tawi know of the commercial value of rubber, and also because I found rubber vines very near the coast on Tawi-Tawi, a sure indication that the search for rubber has not been very careful nor for a long time.

The Philippine Islands are then practically a new field for the development of a rubber industry. It will be my purpose, therefore, to show—

(1) The species of rubber-producing plants indigenous to the islands and the amount of territory covered.

(2) The grade of rubber produced.

(3) The Philippines as a rubber-producing country: (*a*) Through utilization of natural supply; (*b*) through introduction of foreign species.

Reference to figs. 31, 32, and 33 will show the two species of vines now known to be well distributed over the islands, both of which produce a good grade of rubber. Owing to my inability to

Fig. 31.—A RUBBER VINE (PARAMERIA PHILIPPINENSIS RADLK.) GROWING IN THE FOREST, WESTERN MINDORO.

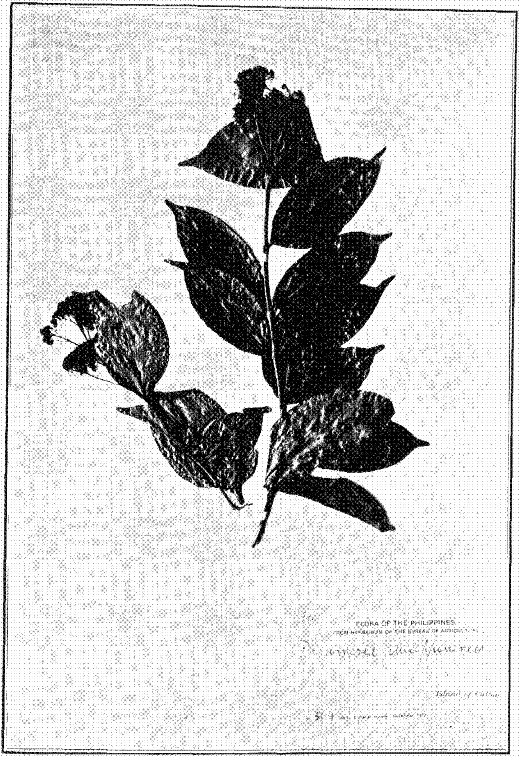


FIG. 32.—RUBBER VINE (PARAMERIA PHILIPPINENSIS RADLK.) GROWING IN GREAT ABUNDANCE ON THE ISLANDS OF MINDORO AND CULION.

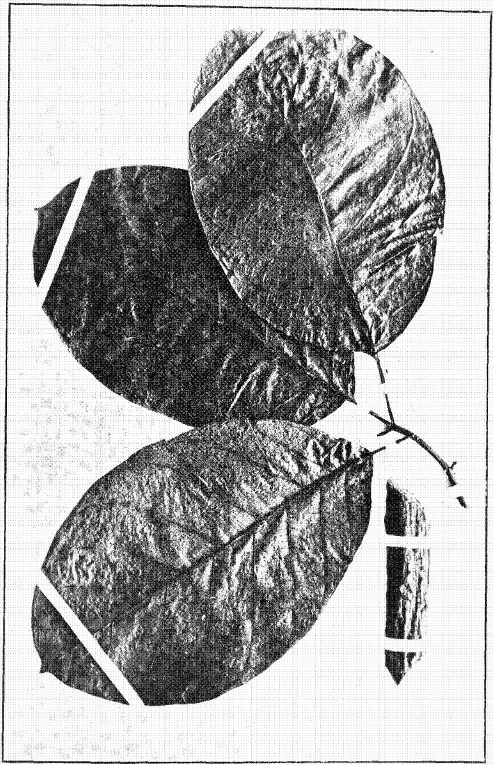


FIG. 33.—RUBBER VINE FOUND IN TAWI-TAWI, BASILAN, AND MINDANAO. SPECIES UNDETERMINED.

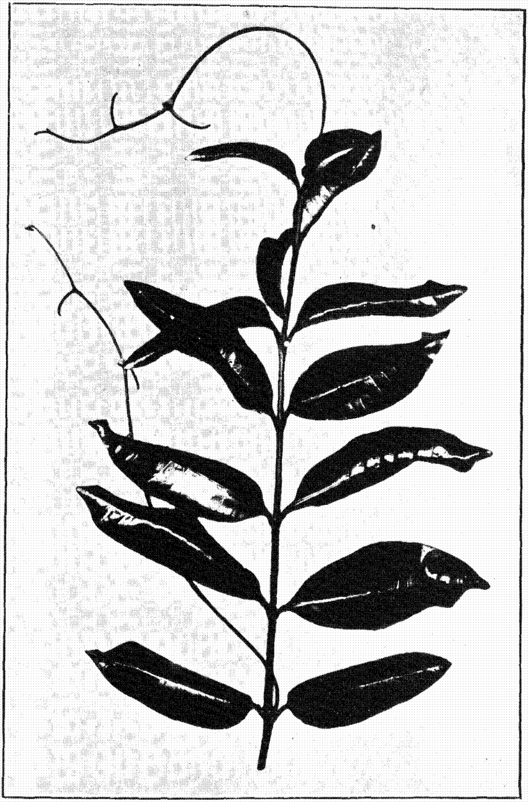


Fig. 34.—Rubber vine (Willughbeia firma Blume). This species supplies most of the rubber produced in Borneo. Botanical Garden, Singapore, Straits Settlements.

find a vine in fruit or flower, one of them has not yet been determined botanically. Mr Merrill contributes the following botanical descriptions:

Parameria philippinensis Radlk. (Apocinaceæ).

An evergreen woody vine, reaching a height of 40 or 50 feet and a diameter of 1 inch or more. Bark gray, with an abundant milky sap. Leaves opposite, ovate, acute or somewhat acuminate, glabrous, 2 to 3 inches long; nerves four pairs; petioles short. Flowers small, white, fragrant, in terminal panicles. Fruit a long, slender, distinctly torulose follicle, 10 to 12 inches long, the swellings over the seeds an inch apart. Seeds one-half inch long, brown, coma white, about twice as long as the seed.

(*Apocinaceæ.*) Genus undetermined, specimen with leaves only, from the Island of Basilan.

A very large vine 150 to 200 feet in length, with a diameter of 6 to 8 inches, the bark somewhat rough, greenish. Leaves broadly ovate or orbicular, 8 to 10 inches long, abruptly very shortly acuminate, the acumen less than one-half inch long, glabrous above, pubescent on the nerves beneath, the nerves prominent, about 10 pairs.

It has already been stated that no rubber-producing trees have been found. That is to say a great many species of trees have been discovered which are known to produce a milk or latex, and while none so far studied contain rubber, it is scarcely to be supposed that when material from all has been collected some at least will not be found to yield a good product.

The extent of territory covered by these two rubber vines is given by map No. 2 (facing page 9). While the *Parameria* is found in Mindoro, Culion, and the other northern islands, the indetermined species is found on Tawi-Tawi, Basilan, and Mindanao. The extent of territory covered in these various places was estimated after extensive personal investigations when all available data had been secured from natives, merchants, etc. In the northern islands, excepting Mindoro, the area covered is given as reported by those who found specimens of the vine. There is every reason to believe, however, that careful investigations would show much larger areas. In Mindoro the natives in all the coast towns knew the rubber vine as "Dactang Ahas" (medicine for snakes), and many of them brought us samples from the neighboring forest. They all reported large numbers of vines in the interior of the island, and the three expeditions made there from the north, west, and south sides confirmed their statements.

In Mindanao the two areas given between Dinas and Tucuran in the mountains near the south coast are the only ones known so far, and even these were only found by accident. The natives knew nothing of rubber, but they had a vine which contained a milky substance, good either as a medicine or for making the heads of their drum sticks. On securing a piece of this peculiar substance from the latter it was found to be a good sample of rubber. Further explorations to the west and east will probably prove that this vine covers about the same area as that occupied by the gutta percha trees.

In Basilan and Tawi-Tawi the vine grows abundantly and to a large size. In the latter island the Moros understand its commercial value, and those engaged in collecting gutta percha gather rubber at the same time, sometimes mixing the rubber and gutta milk.

II. THE GRADE OF RUBBER PRODUCED.

Rubber milk or latex is contained in the bark of certain vines and trees in exactly the same manner as is gutta percha. (See fig. 35.) When made to flow, the same phenomenon of coagulation apparently sets in quickly or slowly, according to the species of the plant. In many species of trees the coagulation is very slow and the flow of milk more abundant than with gutta percha trees. As a result the natives have evolved the method of tapping the trees similar to that shown in fig. 36. The milk thus secured is coagulated in a manner similar to that employed with gutta percha.

Another method, which seems to give the best results and which is employed in the preparation of Para rubber, consists in subjecting thin layers of the milk, placed on the broad end of a paddle, to the coagulating action of smoke produced by burning certain husks which are similar to those of cocoanuts. The smoke contains creosote and acid fumes, which quickly destroy all fungus growths and bacteria which might tend to cause decomposition of the rubber, while the heat removes the greater part of the moisture at the same time.

A chemical analysis of many grades of rubber coming from different species of trees and vines shows them, with the exception of variable amounts of water and dirt, to be composed almost entirely of rubber, with a small per cent of resins. The rubber in all has apparently the same chemical composition, an ultimate analysis

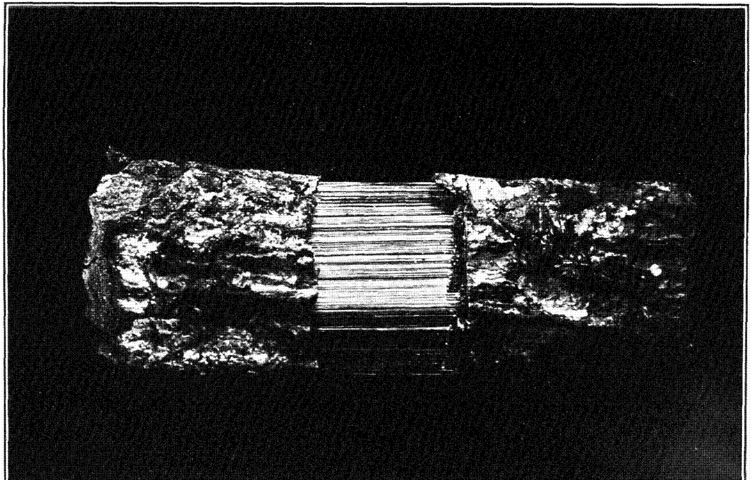


FIG. 35.—A PIECE OF DRY BARK FROM A RUBBER VINE (PARAMERIA PHILIPPINENSIS RADLK.) BROKEN AND PULLED APART, SHOWING THE IMMENSE NUMBER OF RUBBER FIBERS PERMEATING THE INTERIOR OF THE BARK.

giving the formula $C_{10}H_{16}$. Chemically then, there appears to be only one rubber, while physically certain differences are to be found between samples from different species. Whether the superiority of Para rubber is due, therefore, to the excellency of the rubber itself or to the above-mentioned method of coagulation has not yet been determined. However, it is a fact that Para rubber from the tree species *Hevea brasiliensis* Muell. Arg., is recognized as the standard for grading rubber commercially.

It will be noted that the method before mentioned is one requiring skill, judgment, and the expenditure of considerable labor. In most rubber countries the native collectors possess none of these requisites and are content to employ the crudest methods. In consequence, the rubber obtained is of a low grade even though the species of tree is of the best.

The Philippine rubber collectors are Samal and Joloano Moros living in Tawi-Tawi and the adjacent coral islands. The method of coagulation used by them was undoubtedly learned from the Moros of North Borneo, who with the Dyaks collect much of the rubber in that island. It consists in first pulling the vine down to the ground so as to be better able to tap it along its entire length. The milk is caught in cocoanut shells or leaves, and coagulated by pouring into sea water. The coagulation is almost instantaneous, and when properly manipulated a large amount of water can be mechanically inclosed inside the large balls along with plenty of chopped-up bark. The resulting rubber, of which I secured many samples, is white, tough, and very elastic so long as it is kept in sea water. On exposure to the air it blackens and decomposition slowly sets in.

The chemical analysis of a sample of this rubber, after much of the dirt and water had been removed, resulted as follows:

	Per cent.
Dirt	3.76
Rubber	81.57
Resins	3.16
Water	11.51

Judging from this analysis the rubber in Singapore would be rated as Borneo No. 1, which sells for $125, Mexican, per picul of 133⅓ pounds.

The vines generally die after being pulled down and tapped, probably because of their inability to again reach light and sunshine.

The rubber from the Mindoro species has never apparently been gathered in any quantities even by the natives. When the bark is cut the milk flows readily and coagulates quickly. In appearance it is very similar to the Tawi-Tawi rubber. As yet no chemical analysis has been made. In order to get a valuation of it, a sample was submitted to the Goodyear Rubber Company, of Akron, Ohio, who placed it at about 60 cents per pound after allowance is made for the percentage of water. Larger samples of both kinds of rubber are now being prepared in the laboratory in order that they may be submitted simultaneously to rubber experts.

III. THE PHILIPPINES AS A RUBBER-PRODUCING COUNTRY.

(*a*) THROUGH UTILIZATION OF THE NATURAL SUPPLY.

Judging from the way the natives of Tawi-Tawi gathered rubber when left to their own devices, I was convinced that they wasted as large amounts of the milk as they did when they collected gutta percha, that is, ten to forty times more than they took away. It is evident then that under present conditions the history of the rubber vines will be the same as that of the gutta percha trees, only on a smaller scale. It is useless, in my opinion, to think of tapping them only, for an inspection of their tortuous windings up and around the high forest trees (see fig. 37) will show the impossibility of ever collecting the milk, no matter how carefully the tapping were done.

To get the full value from the vine the rubber must be extracted from the entire bark. Experiments along that line are now in progress in the laboratory and so far promise well. If the entire vine be cut into pieces and dried, the bark easily separates from the wood, and forms 44 per cent of the entire plant. By grinding the bark in any ordinary mill, the rubber separates in the form of small balls while the bark passes off as powder. The dried bark contains 9 to 10 per cent by weight of pure rubber, which shows this substance to be about 4 per cent of the entire vine. The other conditions and details will be investigated by the laboratory with a view of determining methods which will make possible the investment of American capital.

It is true that the method of collecting rubber given above kills the vine. The answer to this objection is found in the fact that

FIG. 37.—A RUBBER VINE GROWING IN THE FOREST. TO SECURE A GOOD YIELD OF RUBBER THE VINE SHOULD BE PULLED DOWN, ALL THE BARK REMOVED, AND TREATED FOR THE EXTRACTION OF THE RUBBER. WESTERN MINDORO.

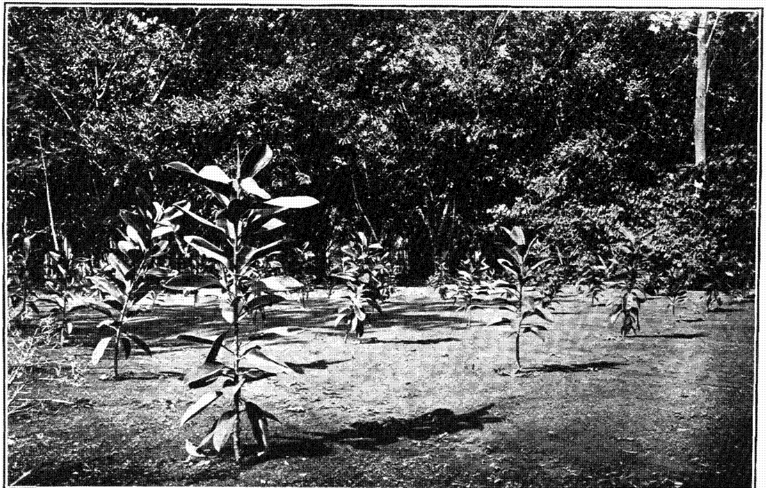


Fig. 38.—PLANTATION OF OLD AND YOUNG INDIA RUBBER TREES (FICUS ELASTICA), THE YOUNG TREES STARTED BY MARCOTTAGE. BUITENZORG, JAVA.

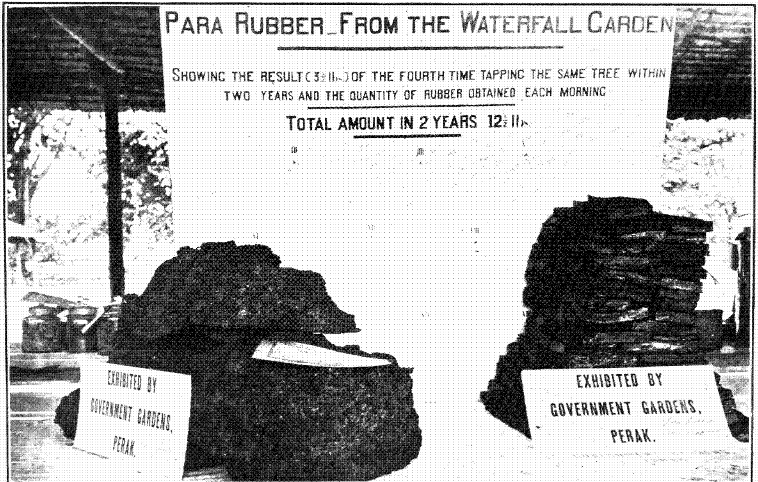


FIG. 39.—EXHIBIT OF PARA RUBBER, SHOWING THE YIELD OF TREES AND DIFFERENT METHODS OF PREPARING THE RUBBER FOR MARKET. PERAK PROVINCE, FEDERATED MALAY STATES.

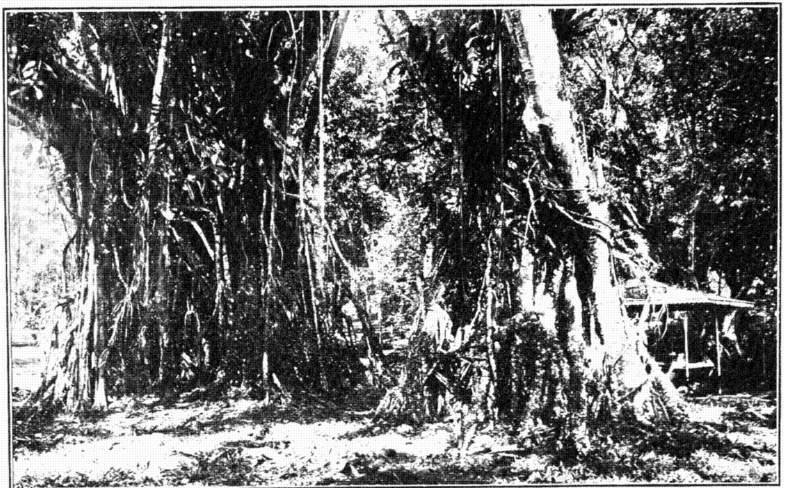


Fig. 40.—LARGE INDIA RUBBER TREES (FICUS ELASTICA L.). BUITENZORG, JAVA.

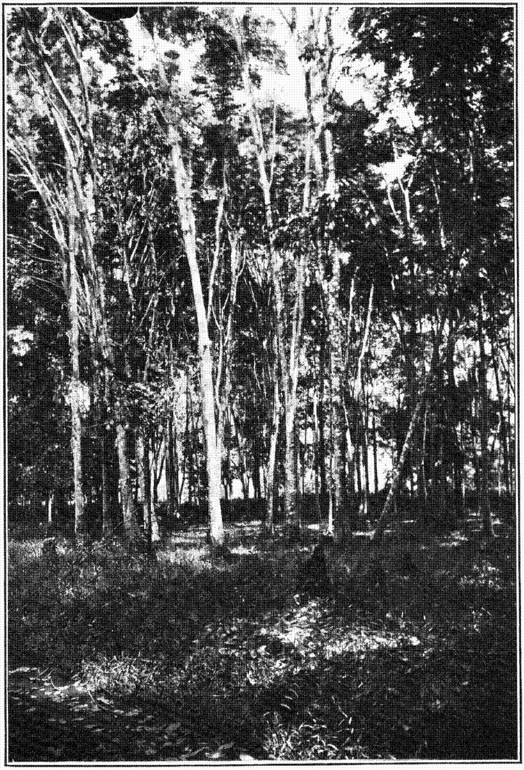


FIG. 41.—PLANTATION OF PARA RUBBER TREES (HEVEA BRAZILIENSIS) PRODUCING SEED.
BOTANICAL GARDEN, SINGAPORE, STRAITS SETTLEMENTS.

when the vine has been cut off, the roots stool again quickly. On a hillside in Mindoro where the natives had burned the forest for the purpose of planting rice, scores of stools from rubber vines were counted while the fire was yet smouldering in some of the old stumps and roots of the large trees.

(*b*) THROUGH INTRODUCTION OF FOREIGN SPECIES.

It was stated previously that no rubber trees were found in the Islands. Exception should be made to the beautiful specimens of the India Rubber tree (*Ficus elastica* Linn.) which were introduced throughout the Archipelago by the Spanish years ago as ornamental shade trees rather than as rubber producers. They are excellent examples of the way foreign species of rubber trees will grow here, and may also serve the still better purpose, that of furnishing seeds and slips to start rubber plantations. Many plantations of this tree have been begun in Java, the reasons for the selection of this species being: (1) The seeds are numerous and the plants grow well; (2) the method of starting new plants by marcottage (see fig. 25) succeeds admirably and the plants have vigorous growth (see fig. 38); (3) the method of coagulation best suited for this milk is the simplest of all. It consists of making many small cuts in the bark of the trunk, and allowing the flowing milk to coagulate in strings. When dry and hard they are pulled off and pressed into a compact mass (see mass of rubber on the left, fig. 39) for shipment. The work can be done by even ignorant workmen and with no damage to the tree.

In the Malay States a great many plantations are now being started with Para rubber trees, the seeds of which are secured from the various government botanical gardens as well as from private plantations. (See fig. 41.) One of this species of trees is now growing in Manila, and apparently the climate is suitable. The Bureau of Agriculture has distributed many Ceara rubber seeds during the past year, and the growth of the seedlings is marvelous.

In general the climatic conditions of most of the islands seem very favorable for the rubber industry. Mindoro and the southern islands especially are advantageous on account of the abundant rainfall distributed throughout the year, with no long season of drought.

What pests and parasites the rubber trees would be troubled with can only be conjectured by reference to the experiences of Java, etc.

Dr. Zimmerman (28) extended his work on parasites to include rubber trees, and has found one or two species of insects that may cause damage. Cattle and goats must also be guarded against.

It is needless to dwell on the commercial side of rubber plantations. They are now flourishing in all tropical countries and as an agricultural investment are highly considered. However, in all new countries a certain amount of experimental work must be done before large capital can be safely invested. In India, Burmah, the Malay States, and Java this has been accomplished by the respective governments. As soon as methods were perfected and seed supplies provided, private capital began operations at once. From the number of inquiries already made about rubber planting in these Islands, it would look as if some movements in this direction are contemplated here, investors only waiting for the Government to pave the way. By profiting from the extensive experience of our neighboring countries the experimental era should be short and inexpensive, as a great deal of the pioneer work has been done.

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