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THE HEVEA RUBBER TREE IN THE AMAZON VALLEY

By

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By Carl D. La Rue,[1] *Specialist in Rubber Investigations, Office of Cotton, Rubber, and Other Tropical Plants, Bureau of Plant Industry*

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INTRODUCTION

The use of rubber for one purpose or another has been known to man for an indefinite length of time; for centuries at least. In 1536 Oviedo y Valdés (*30*)[2] in his Historia general y natural de las Indias, which was published in full at Madrid in 1851–1855, mentions different articles made from the latex of the rubber tree by the Amazonian Indians.

La Condamine (*13*), who went to South America in 1734 to make astronomical observations, sent a small quantity of rubber to the Paris Academy in 1736. Later, in 1745, he described the uses to which rubber is put by the Omagua Indians of the Maranon River, whom he visited on his trip from Quito across the Andes and down the Amazon to its mouth. In this paper he states that this "resin," as he calls it, is called "cahuchu" (pronounced, as he says, "cahoutchou") in the Province of Quito near the sea. It is also very common on the Maranon, where it is used in the same way as in the other region.

Later, in 1751, La Condamine (*14*) tells of his observations in 1736 on rubber in the Province of Esmeraldas. Here he contradicts his former statement as to the name of the product in this region and says

[1] The thanks of the writer are due the members of his own party, of the party from the Department of Commerce, and of the Brazilian Rubber Commission. He is also indebted to the Governors of Para and of the Acre Territory in Brazil, and of the Northwest Territory of Bolivia; to the staff of the Museu Goeldi in Para, to the Commercial Association of Manaos, to Nicholas Suarez, of Suarez Hermanos, and to a number of other officials and private citizens who aided the expedition in many ways.

[2] The serial numbers (*italic*) in parentheses refer to "Literature cited" at the end of this bulletin.

it is called "Hhévé," or "Jévé," according to the Spaniards, but that the Maïnas Indians to the east of the Andes call it "caoutchouc," while the Portuguese call it "Pao de Xiringa." In the same publication La Condamine gives a description and a very poor picture of the rubber tree, which obviously belongs to the Hevea group.

In 1770 Priestley discovered that india rubber would erase pencil marks, and small quantities were soon on the market, offered at a high price, for this purpose. This, however, was really India rubber, since it came from India and not from South America.

Further uses for rubber were not rapidly discovered by civilized man, for it was not until 1823 that Charles McIntosh found that rubber was soluble in benzine and could be used for making waterproof coats. Prior to this garments had been waterproofed by coating them with latex from the rubber tree, and explorers and early travelers in South America found garments and bags so treated very useful. But since the coating had to be put on with latex freshly drawn from the tree the process was of very limited application.

The successful use of this substance by McIntosh stimulated an interest in its application for other purposes. Boots and shoes were made of rubber, and at one time the city of Para, in Brazil, manufactured them in considerable quantities. However, these articles, though waterproof, showed a tendency to freeze in cold weather and to become sticky or tacky in warm weather.

The accidental discovery by Goodyear in 1839 that rubber could be vulcanized by mixing it with sulphur and heating it removed the bar to the successful application of this remarkable substance to a great variety of uses. The demand for rubber rapidly increased, and a great many different plants in various part of the world were exploited for their rubber content. Of all these, the Para rubber tree (*Hevea brasiliensis*) growing in the valley of the Amazon River was found to yield the greatest quantity as well as the highest quality of rubber. Richard Spruce (*40*), the noted plant explorer and collector, records that in 1849 rubber was collected from this tree only in the vicinity of the city of Para, but that by 1854 the industry had become so important that in the State of Para alone it occupied the efforts of 25,000 persons, and the collectors had ascended far up the tributaries of the Amazon.

In the process of collecting rubber many plants could be utilized only by destroying them completely, so that the visible supply of rubber steadily decreased while the consumption of this commodity was ever on the increase. This led to the consideration of the possibility of cultivating rubber-bearing plants, and various species were made the subject of experimental plantings. Most of these were found unsuitable for commercial cultivation, but a few gave promise of success. *Hevea brasiliensis* was introduced into India, Ceylon, the Straits Settlements, and the Dutch East Indies by Wickham (*46*), who took seeds from the Amazon region to Kew in 1876. It soon became apparent that this was one of the most suitable plants, if not the most suitable, for cultivation, though the Central American rubber tree (*Castilla elastica*) was highly, though unwisely, recommended for planting in such places as Trinidad. In certain dry areas the Ceara rubber tree (*Manihot glaziovii*) gave promise of profitable yields, at least while the price of rubber was high.

At this time a combination of circumstances occurred which gave a great stimulus to rubber planting in the Orient. A deadly rust disease of coffee (*Hemileia vastatrix* Berk. and Br.) completely ruined the coffee plantations of that part of the world, and the planters in desperation were seeking a substitute crop. Rubber, as one of the most promising crops, engaged their attention, and soon large acreages were planted with *Hevea brasiliensis*.

In a few years considerable plantation rubber appeared on the market and, in spite of the early skepticism of the manufacturers, continued to be produced in larger and larger quantities. Improved methods of preparation gradually removed most of the objections to its use, until now it is considered the equal of fine hard Para, long the highest quality of rubber known.

With the passage of years many types of rubber disappeared completely, either because of the exhaustion of their sources or the decline in price which made their production unprofitable. Plantation rubber has constantly assumed larger proportions in the world's markets, while wild rubber has steadily become of less importance, until plantation rubber has come to control the situation completely. Wild rubber is now obtained from relatively few plants, and unless certain special uses demand certain types the exploitation of the wild product must soon cease altogether.

The United States is now the largest consumer of rubber, while the plantation-rubber industry is centered in the Orient, in India, Ceylon, Burma, the Federated Malay States, the Straits Settlements, Sumatra, Java, and Borneo. This wide separation of consumer from source of supply has given concern to many, who have pointed out the need of sources of supply nearer home which could be drawn upon in case the more distant sources were cut off by war.

In addition to this, the control of this raw product, so vastly important in our transportation system, by foreign powers was emphasized by a recent restriction act which aims at the control of the price of rubber. These and other considerations led to the initiation in 1923 of a series of investigations of the sources of crude-rubber supply undertaken by the United States Department of Agriculture and the United States Department of Commerce. This report embodies the results of one of the investigations conducted by the United States Department of Agriculture.

PURPOSE OF THE EXPEDITION

An expedition was sent to Para, Brazil, in July, 1923, to make a study of the botanical phases of the rubber industry on the banks of the Amazon and its tributaries. The problems to be investigated may be stated as follows:

(1) The general status of the rubber industry in the Amazon region at the present time, including a study of present methods of production and the possibility of improving them.

(2) The rubber resources of the region available in case of a crisis and the means of making such resources available.

(3) The suitability of the region for the cultivation of rubber, especially as determined by the growth and development of the trees.

(4) The types of Hevea and the possibility of securing more desirable strains for plantation use in the Amazon Valley or elsewhere.

(5) The prevalence of diseases of Hevea and plant pathological conditions generally.

PERSONNEL OF THE EXPEDITION

The expedition from the United States Department of Agriculture was composed of Carl D. La Rue, specialist in rubber investigations, in charge of the party; James R. Weir, pathologist in rubber investigations; and E. L. Prizer, field assistant, and Morris K. Jessup, field assistant, who did the photographic work for the party.

In Para the party joined forces with another from the United States Department of Commerce, and to collaborate with these American investigators the Brazilian Government appointed a commission consisting of Hannibal Porto, chief; Avellino Olivera, geologist and later chief of the commission; Gerardo A. Kuhlman, botanist; Raymundo Monteiro da Costa, rubber specialist; and Fernando Solidade, physician.

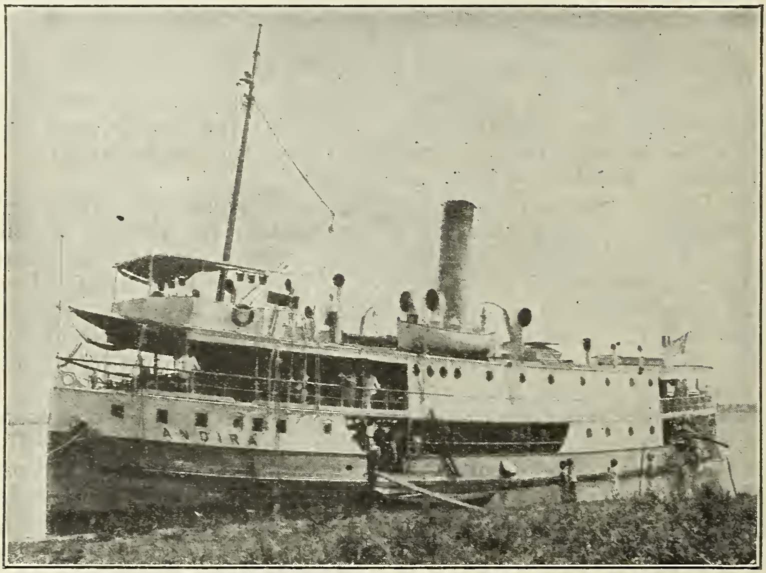

FIG. 1.—The *Andirá*, the boat which was chartered and equipped by the Brazilian Government for the use of the three expeditionary parties. The *Andirá* is a fine example of the type of boat common on the Amazon and its tributaries

ITINERARY

The Brazilian Government had chartered and equipped a commodious and comfortable river boat, the *Andirá* (fig. 1), for the use of the American and Brazilian investigators, and on this they proceeded to Manaos and later to Porto Velho, the limit of navigation on the Madeira River. From this point the Madeira-Mamore Railway carried the travelers to Guajara Mirim, on the Mamore River, whence they proceeded by batelaões (broad-bottomed strongly built river boats) and canoes up the Mamore to the Pacanova River, thence up this to the Ouro Preto River, and finally for a distance up the Ouro Preto into the jungles of Matto Grosso. From Matto Grosso the party returned to Villa Murtinho at the mouth of the Rio Beni, which stream they ascended to Riberalta and from that point continued up the Madre de Dios to Sena. When the party returned by river and rail to Abuna at the mouth of the river of that name a division of the party was made; the Brazilian and Commerce parties ascended the Abuna into the Acre Territory and crossed overland to the Rio Acre, while the Agriculture party came back to the *Andirá* at Porto Velho and returned on that boat to Manaos and later to Para.

At Para Doctor Weir was transferred from the rubber investigations to other work and proceeded to Rio de Janeiro and Buenos Aires before returning to New York. Prizer and Jessup returned to Washington, while the writer sailed for Cobija, in the Acre Territory of Bolivia, by way of the Amazon, Purus, and Acre Rivers. The return journey was made over the same route.

THE GENUS HEVEA

Mention has already been made of the fact that La Condamine (*13*) was the first scientist to take note of the rubber tree and its strange product and that he published (*14*) the description and drawings of a Hevea tree submitted to him by Fresneau, which are the earliest extant. It is most likely that the rubber which La Condamine first saw in the Province of Esmeraldas did not come from a tree of Hevea but from some species of Castilla, but Fresneau's drawings and descriptions, imperfect as they are, undoubtedly refer to some species of Hevea.

Fusée Aublet (*4*) in 1775 established the genus Hevea with *Hevea guianensis* as the type species. The name "Hevea" he derived from Hevé, which he says is the Carib name for the tree. Plate 335 of Aublet's work is labeled *Hevea peruviana* for some reason, but is really *H. guianensis*.

Since the time of Aublet certain species of the genus have been known by a number of different generic names, such as Siphonia, Caoutschoua, Siphonanthus, Jatropha, and Micrandra; but Hevea has finally been firmly established as the proper generic designation.

Spruce (*41*) in his long sojourn on the Amazon assembled a considerable number of species of Hevea, among which are found *Hevea spruceana* Muell. Arg., *H. discolor* Muell. Arg., *H. membranacea* Muell. Arg., *H. pauciflora* Muell. Arg., *H. rigidifolia* Muell. Arg., *H. benthamiana* Muell. Arg., *H. lutea* Muell. Arg., and *H. brasiliensis* Muell. Arg.

Martius (*27*) and Richard Schomburgk (*36*) also collected species of this genus; in more recent times Ule (*42*), Huber (*9, 10, 11*), and Ducke have been active in this work.

In 1873–74 volume 11 of Flora Brasiliensis by Martius (*27*) appeared, consisting of the Euphorbiaceæ treated by Mueller Argoviensis. In this the following 11 species of Hevea were recognized:

Hevea spruceana Muell. Arg.
    Siphonia spruceana Benth.
H. discolor Muell. Arg.
    Micrandra ternata R. Brown.
    Siphonia discolor Benth.
H. membranacea Muell. Arg.
H. pauciflora Muell. Arg.
    Siphonia pauciflora Benth.
H. rigidifolia Muell. Arg.
    Siphonia rigidifolia Benth.
H. nitida Muell. Arg.
H. benthamiana Muell. Arg.
H. lutea Muell. Arg.
    Siphonia lutea Benth.
H. brasiliensis Muell. Arg.
    Siphonia brasiliensis Kunth.
H. janeirensis Muell. Arg.
H. guianensis Aubl.
    Jatropha elastica Linn.
    Siphonia elastica Pers.
    Siphonia cahuchu Willd.

Pax (*31*), in Engler's Pflanzenreich, recognized the following species:

Hevea benthamiana Muell. Arg.
  H. discolor Spruce.
H. duckei Huber.
H. nitida Muell. Arg.
H. paludosa Ule.
H. brasiliensis (H. B. K.) Muell.
  var. *janeirensis* (Muell. Arg.) Pax.
    H. janeirensis Muell. Arg.
    H. sieberi Warburg.
    Siphonia brasiliensis H. B. K.
  var. *stylosa* Huber.
  var. *cuneata* (Huber) Pax.
    H. lutea var. *cuneata* Huber.
    H. cuneata Huber.
    H. sp. "*itauba*" Ule.
    H. peruviana Lechler ex Huber.
  var. *randiana* (Huber) Pax.
H. lutea (Benth.) Muell. Arg.
  H. apiculata Baill.
  H. lutea var. *apiculata* Muell. Arg.
  H. peruviana Lechler ex Benth.
  Siphonia lutea Benth.
  Siphonia apiculata Spruce ex Baill.
H. rigidifolia (Benth.) Muell. Arg.
  Siphonia rigidifolia Spruce.
H. spruceana (Benth.) Muell. Arg.
  Siphonia spruceana Benth.
H. similis Hemsl.
H. discolor (Benth.) Muell. Arg.
  H. paraensis Baill.
  Siphonia discolor Benth.
  Micrandra ternata R. Brown.
H. minor.
H. microphylla.
  var. *typica* Pax.
  var. *major* Pax.
H. pauciflora (Benth.) Muell. Arg.
  H. confusa Hemsl.
  H. spruceana Oliv.
  Siphonia pauciflora Benth.
H. membranacea Muell. Arg.
  H. spruceana Oliv.
H. guianensis Aubl.
  Jatropha elastica L.
  Caoutschoua elastica Gmel.
  Siphonia cahuchu Willd.
  Siphonia elastica Pers.
  Siphonia guianensis Juss.
  Siphonanthus elasticus Schreb.
H. nigra Ule.
H. collina Huber.

Pax pointed out the great difficulty encountered in delimiting species of Hevea with such material as is available, which in the case of only a few species consists of specimens of leaves, flowers, and fruits and even in some of these offers no certainty that the different structures are derived from the same source. Pax decried the practice (to which he feels Huber was especially addicted) of describing species from leaf specimens only.

Huber (*9, 11*) recognized 24 species in the genus, which are listed below:

Hevea guianensis Aubl.
H. nigra Ule.
H. apiculata Baill.
H. cuneata Hub.
  H. peruviana Lechler.
H. benthamiana Muell. Arg.
H. duckei Hub.
H. paludosa Ule.
H. rigidifolia Muell. Arg.
H. minor Hemsley.
H. microphylla Ule.
H. randiana Hub.
H. brasiliensis Muell. Arg.
  var. *stylosa* Hub.
H. spruceana Muell. Arg.
  var. *tridentata* Hub.
H. similis Hemsley.
H. discolor Muell. Arg.
H. confusa Hemsley.
H. pauciflora Muell. Arg.
H. nitida Muell. Arg.
H. viridis Huber.
H. kunthiana (Baill.) Huber.
H. foxii Huber.
H. glabrescens Huber.
H. lutea Muell. Arg.

From an examination of the type material in the Museu Goeldi of a number of Huber's species, the writer is inclined to believe that Huber, although in all probability better acquainted with the genus Hevea than any other botanist, was too much inclined to describe species from inadequate material and to base them on rather small and not certainly constant differences.

A satisfactory revision of the genus can not be made until more extensive collections than are now available have been assembled. Flowers, or fruit, or both are lacking in too many type specimens.

But such extensive collections are not likely to be made in the near future. The genus is widely spread over a sparsely settled country which contains few people with sufficient scientific interest to induce them to make botanical collections. Spruce (*40*) long ago pointed out the difficulty encountered in collecting specimens from Hevea trees 100 to 125 feet high, which no native can be induced to climb and which cost much time and much money to fell. The writer can testify that Spruce did not exaggerate the obstacles.

As things stand at present, it is by no means impossible that certain species differing little from other related species may represent merely fluctuating variations and may not be constant at all. Material from a single collection can tell nothing conclusive about such things. The writer's experience (*17*) with Hevea trees on plantations in the Orient, especially in Sumatra, shows that the trees there display a great range of variation in their characters. In this case we are dealing with *Hevea brasiliensis*, though we must admit the possibility that the oriental race may represent some admixture with other species, such as *H. collina*. Huber (*10*) is inclined to doubt the hybridization, as does the writer. Also it may be found that the cultivated species is more variable than it was in nature. The common notion that cultivation induces variation has been attacked in recent years, although its possibility is admitted here. But if other species in Brazil are anything like as variable as *H. brasiliensis* in the East, we need to be very sure of the stability of the characters used for species delimitation.

Where differences are known to be constant, their extent is not of such great importance. As in other groups of plants, the determination of a difference as specific or only varietal will largely depend upon the measuring stick used by any given student of the group. For example, it does not much matter whether we consider *H. randiana* Huber a separate species or with Pax reduce it to *H. brasiliensis* var. *randiana* (Huber) Pax, but it does matter greatly whether or not we know that its deviations from *H. brasiliensis* are constant and heritable.

GEOGRAPHICAL DISTRIBUTION

The results of this expedition add very little to our knowledge of the geographic distribution of the species of Hevea. Ule (*42*) discussed the distribution of the different species and published a map showing the entire range of the genus. He stated that the area of distribution is divided by the Equator into a northern region through which rivers of black waters flow and a southern region drained by rivers of white water. The northern region he reported as containing *H. guianensis*, *H. collina*, *H. benthamiana*, *H. duckei*, *H. rigidifolia*, *H. discolor*, *H. minor*, *H. pauciflora*, *H. membranacea*, *H. microphylla*, and *H. lutea*, 11 species in all.

The southern area, he said, was inhabited by *H. guianensis*, *H. nigra*, *H. brasiliensis*, *H. nitida*, *H. paludosa*, *H. spruceana*, and *H. similis*, seven species.

Huber (*11*) points out that the Equator does not represent the division between the black-water rivers and those with white water; even the Rio Negro lies south of the Equator. The area north of the Equator contains, according to Huber, *H. guianensis*, *H. benthamiana*, *H. rigidifolia*, *H. microphylla*, *H. minor*, *H. pauciflora*, *H.*

membranacea, and *H. lutea*, a total of eight species. The district south of the Equator bears *H. guianensis*, *H. collina*, *H. nigra*, *H. duckei*, *H. cuneata*, *H. nitida*, *H. paludosa*, *H. brasiliensis*, *H. viridis*, *H. discolor*, *H. spruceana*, and *H. similis*, a total of 12 species.

Huber divides the area inhabited by the genus as follows:

The Rio Negro region: *H. lutea*, *H. apiculata*, *H. benthamiana*, *H. rigidifolia*, *H. minor*, and *H. microphylla*. The region west of the Rio Negro: *H. duckei* and *H. paludosa*. The eastern region to the coast of Guiana: *H. guianensis*, *H. membranacea*, and *H. pauciflora*. The upper central Amazon basin: *H. brasiliensis*, *H. spruceana*, *H. similis*, *H. discolor*, *H. nitida*, and *H. viridis*. The region south of the Amazon: *H. cuneata*, *H. nigra*, and *H. collina*.

Work on the distribution of Hevea is difficult and time consuming. Travel on the rivers is very slow, and vast distances must be traversed before adequate knowledge of this subject can be obtained. The reason why the Rio Negro region is apparently so much richer in species may well be that that region has been better explored; perhaps, also as Huber quotes from Ule (*11, p. 227*), "bei dem niederen und schwaecheren Wuchs der Waelder am Rio Negro blühendes Material von Kautschukbaeumen leichter zu sammeln ist." With conditions as they are at present in the Amazon basin our knowledge of the distribution of Hevea is likely to remain imperfect for some time.

RUBBER-BEARING SPECIES

Of the species of Hevea which bear rubber, *H. brasiliensis* is unquestionably the most important. Not only is it the most extensively exploited tree of the Amazon basin, but it is also the species which, of all rubber-bearing plants, has succeeded best in cultivation. The rubber produced from this tree is superior both in quantity and quality to that from any other known plant.

For convenience the other species may be listed in the following three groups:

Species yielding fair to good rubber	benthamiana. discolor. rigidifolia. foxii. pauciflora. minor. cuneata.
Species yielding poor rubber, rarely collected	guianensis. nigra. lutea. apiculata. duckei. paludosa. microphylla. spruceana. viridis. membranacea.
Species not yielding rubber, or at least not known to yield rubber	randiana. similis. confusa. nitida. glabrescens.

Hevea benthamiana is one of the leading producers, if not indeed the most important producer, of rubber in the area north of the Amazon. *H. discolor* is another species of importance; according to Ule (*42*) it is the principal rubber producer of the Rio Negro. Still another species worthy of mention is *H. foxii*, which is the principal source of commercial rubber of the Putumayo district.

Some other species are known to yield fairly good rubber, but it is doubtful whether any of them are exploited to any extent at the present time.

None of the species of Hevea except *H. brasiliensis* have been considered promising for plantation culture, and none of the other species have been given extensive plantation trials.

STATUS OF THE RUBBER INDUSTRY IN THE AMAZON VALLEY

There is no denying the fact that the rubber industry of the Amazon Valley is in a serious, even a precarious, situation at the present time.[3] The price of rubber has declined to such a degree that it is almost impossible for the industry to continue at all. True, it is likely that a certain quantity of rubber will be produced for an indefinite number of years, because a few people who live in areas rich in rubber trees and have no other employment will continue to collect rubber, even though a very low return for their labor is realized. But no new supply of labor will go into the rubber country as in times past; on the contrary, every boat from such rubber areas as those drained by the Purus and the Acre Rivers descends with a load of laborers returning to the south, especially to Ceara, where the developing cotton plantations offer better remuneration for their labor.

The crisis here, of course, has been brought about by the overproduction of rubber by the oriental plantations. In former years, when rubber was "black gold" almost literally as well as figuratively, its high price justified any sort of production, however expensive.

When plantation rubber began to enter the market in an acceptable quality and in quantity sufficient to supply the demands the price began to decline. As this decline progressed the planters learned to reduce the costs of production more and more, until they are now lower than the exploiters of the Amazonian forests or even the pioneer planters could have believed they ever would be. The rubber collectors of South America were slow to adapt themselves to the new conditions and were much less successful in reducing their production costs, partly because they are very different folk from the progressive planters and partly because the conditions under which they work are more difficult to control.

When the seriousness of this state of affairs became apparent, the Brazilian Government appointed a group of officials under the direction of the Minister of Agriculture to aid in the "defesa do borracha," the defense of rubber. A commission (*12*) was sent into the rubber country to study the conditions of production and to make suggestions for their improvement, and a long series of acts relating to the encouragement of the industry was passed (*37*). In addition to the activities of the Brazilian Government, a group of commercial organizations interested in the welfare and development of the industry sent a commission to the Amazon Valley to study rubber production. The findings of this commission were published in the extensive report by Akers (*1*), which also contained

[3] Since this section was written the price of rubber has increased considerably, and it is probable that this has led to a general improvement in conditions.

recommendations for improving conditions. As it happened, most of the acts passed by the Government were not enforced, and the suggestions of Akers were not carried out, so that conditions were not improved. The low price of rubber did operate to reduce living costs in the region from the extremely high level they had formerly attained; otherwise little change occurred.

Akers suggested in his report that a decline in Brazilian exchange might be a means of relieving the situation, and that is exactly what has happened. The lower rate of exchange has undoubtedly been harmful for Brazil as a whole, but it has enabled the rubber industry to survive for a number of years. Most of the supplies for the rubber collectors are produced in Brazil, and the larger number of milreis received in exchange for each pound of rubber has enabled them to live. At present, however, with a very low price for rubber, the exchange is steadily improving and bids fair to toll the death knell of

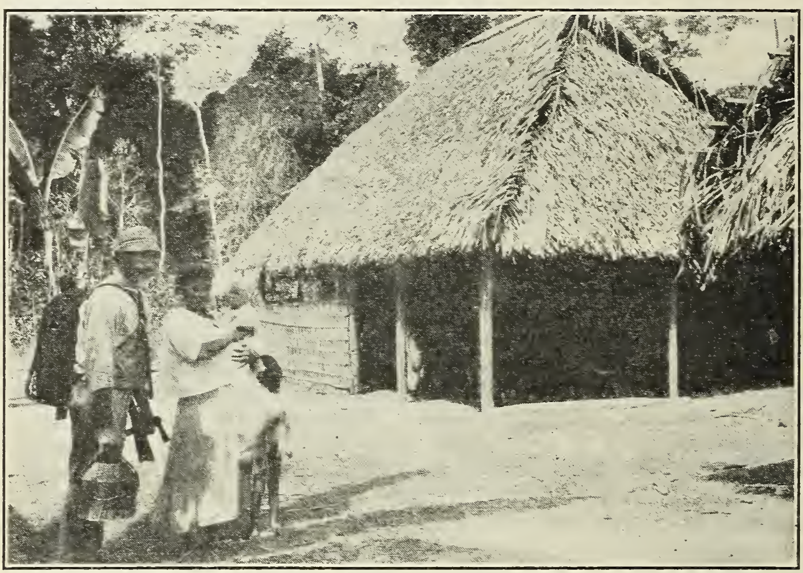

FIG. 2.—A seringueiro of Matto Grosso at home. In his left hand he carries his machadinho; in his right hand he holds a baldê. On his back is the wicker basket which holds a rubber bag full of latex

this industry, which has meant more to the great Amazon basin than all others combined.

METHODS OF COLLECTING RUBBER

The methods used by the rubber collectors in the Amazonian forests and the mode of life of the "seringueiros," as they are called in Portuguese, have been described many times, and good accounts may be found in the publications of Ule (*42*), Akers (*2*), Pearson (*32*), Lange (*15*, *16*), Woodroffe (*47*), Woodroffe and Smith (*48*), Walle (*44*), Lecointe (*25*), and others. Therefore, only a brief sketch will be given here.

The seringueiro who plans to tap virgin trees selects an area which has not yet been worked, near the bank of a stream navigable by his canoe. He builds himself a rough dwelling, roofed and sided with palm thatch (fig. 2), and then begins scouting for rubber trees. With a big machete (tercado in Portuguese) in his hand and the indispensable Winchester .44 over his shoulder he enters the jungle and searches out the rubber trees. As he locates them he connects them by a trail cut through the undergrowth, and this trail connecting the rubber trees is his estrada. Estradas vary in the number of trees which they contain, from 50 to 300, depending on the conditions and the men who lay them out.

Generally a seringueiro will lay out two or three estradas extending in different directions from his dwelling, and these are afterwards tapped in rotation. After the trees in the estradas are located, some further work is necessary to clean the trails more thoroughly, to bridge streams with poles, and the like. Then the seringueiro is ready to begin tapping. Of course, if old estradas are to be worked all this is unnecessary; he has only to move into the house built by his predecessor, cut the recent growth from the estrada, and repair a few bridges.

Although a seringueiro may thus establish a collecting ground of his own at some distance from any of his fellows, it is more usual for a group of seringueiros to enter a region together and lay out estradas near each other.

Such a group of estradas on a rubber property is called a seringal. Each seringal has a barracão, or large warehouse and dwelling combined, where the agent of the man or company owning or leasing the rubber property lives. In the barracão a store of food and supplies for the seringueiros is kept. These commodities are advanced to the seringueiros as they need them and are charged against the value of the rubber which they bring to the barracão from time to time. The plan of a seringal with its estradas may be seen in Pearson's book (*32, p. 63*). The map of an estrada in Matto Grosso studied in detail by the writer is shown as Figure 3.

Tapping is begun by the seringueiro in the early morning. Incisions are made in the bark of the rubber tree with a small ax, called a machadinho. The purpose of these incisions is to open the latex vessels which extend through the cortex of the tree, so that the latex, or "milk," may flow out. The cuts are made in a slanting direction, so that the latex flows from the upper end of the cut to the lower, where a cup is placed to receive it. This cup is made of light-weight tin plate and is affixed to the tree by thrusting the sharp edge of the brim into the bark.

Several incisions are made at equal intervals around the tree and cups placed beneath them, when the seringueiro hurries on to the next tree. So he continues until the whole estrada is tapped. Usually he has finished tapping by 9 o'clock. Early tapping has been found to give the highest yields, as the flow of latex decreases considerably as the temperature rises, partly, perhaps, because of the effect of the heat in coagulating the rubber on the cuts and stopping the flow and partly because of the increased transpiration of the tree, which may lower the pressure in the latex tubes and so diminish the flow.

When the seringueiro judges that the flow of latex has ceased, he begins to collect the contents of the cups. The latex from each cup he pours into a narrow-mouthed tin pail, called a "baldé," of about 2 gallons capacity. When the baldé is filled he pours the latex from it into a cloth bag which has been thoroughly coated with latex and smoked to coagulate the rubber on its surface, so that it is waterproof. This bag is tied with a strong rubber band, put into a wicker supporting frame, and carried on the seringueiro's back while the baldé is refilled. Each cup as it is emptied is roughly wiped out with the fingers and hung upside down on a convenient twig, to prevent its being filled with water by the rains. Figure 2 shows a seringueiro with his collecting outfit.

When he returns with his latex the seringueiro rests for a time and eats his midday meal. Then he builds a fire in the palm-thatched hut used for smoking rubber. Usually the fire is built in a little pit

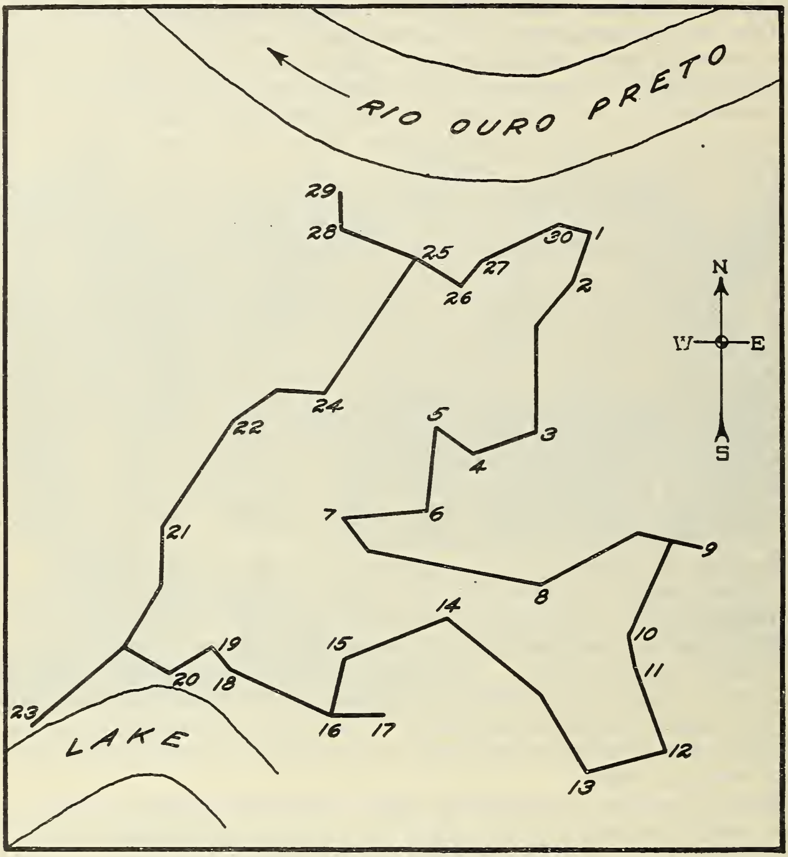

FIG. 3.—An estrada of virgin trees on the Rio Ouro Preto, Matto Grosso, Brazil. (Drawn by Avellino Olivera, of the Brazilian Commission)

under a dome or cone of baked clay which has an opening at its apex through which the smoke pours in a dense cloud. Sometimes the fire is built on the surface of the ground, and a cone of tin is inverted over it. The fruits of *Attalea excelsa* are much used for making the smoke to cure rubber, and for a long time the superior qualities of the fine hard Para rubber were supposed to be due to the use of this smoke. On this account the export of seeds of this tree from Brazil was forbidden by law. It is now known that other substances serve very well for smoking the rubber; fruits of the babuassu palm are used and also various types of wood.

If a ball of rubber has been started on preceding days and not yet finished the seringueiro adds to this. This ball is formed on a pole about 6 feet long, which is laid across two other poles supported at either end by posts set on either side of the smoking cone. This enables the pole bearing the rubber ball to be rolled back and forth, into the smoke, then out of it.

The latex is poured into a pan set just back of the smoking cone. With one hand the ball of rubber is now rolled over the basin, and with the other the seringueiro dips up latex from the pan in a calabash and pours it over the ball. As soon as the latex ceases to drip the ball is rolled into the cloud of smoke and turned slowly, so that the smoke covers the whole surface of the fresh latex and coagulates the rubber in a thin film. Then the ball is again rolled over the pan, coated

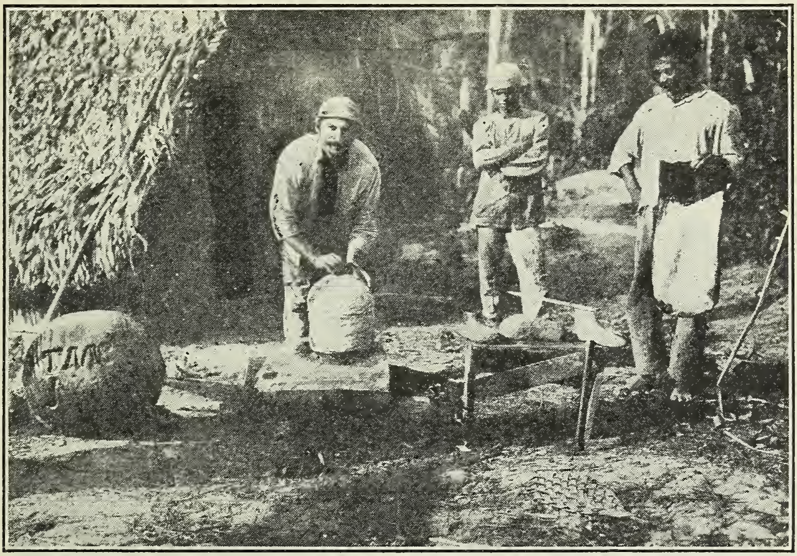

Fig. 4.—A seringueiro rolling a ball of freshly coagulated rubber to shape it and press out the bubbles of air and vesicles of serum. At his right is a finished ball of fine hard Para rubber. Behind the seringueiro is the smoking shed. The rubber shoes in the foreground were made by coagulating latex over the wooden mold. The man at the right holds a cloth bag which has just been given a coating of latex

with latex, and returned to the smoke. So the process goes on until the whole of the day's collection of latex has been turned into rubber. The ball is then removed from the pole and rolled on a slab of wood to shape it and to squeeze out any liquid which has formed in it. (Fig. 4.) If the ball is large enough, about 65 kilos, it is set aside to cure; if not, it is added to on successive days until it has reached the desired size. (Fig. 5.)

A new ball is usually begun by allowing a little latex to stand in the pan over night so that it undergoes natural coagulation. The coagulum thus formed is rolled around the pole, and over this latex is poured and smoked in the manner described. This method has the advantage of quickly bringing the ball to a size such as to hold considerable latex on its surface at each pouring, but it has the disadvantage that the center of each ball is made of naturally coagulated rubber, which is considered inferior in most markets. As the average seringueiro is not so cleanly as to care greatly what falls into the latex while it is coagulating, the coagulum usually contains various impurities.

The lumps of rubber which have formed in the latex in the cups, in transit, or in the basin are squeezed into an irregular mass, to which is added the film formed on the surfaces of the various utensils. Little attempt being made to keep this rubber clean, it is usually found to contain a considerable percentage of impurities. This low-grade rubber is called sernamby.

In some places the latex is smoked over a square paddle. The yield for one day only is smoked; then the layer of rubber is cut open at the upper end of the paddle and the paddle is pulled out. This

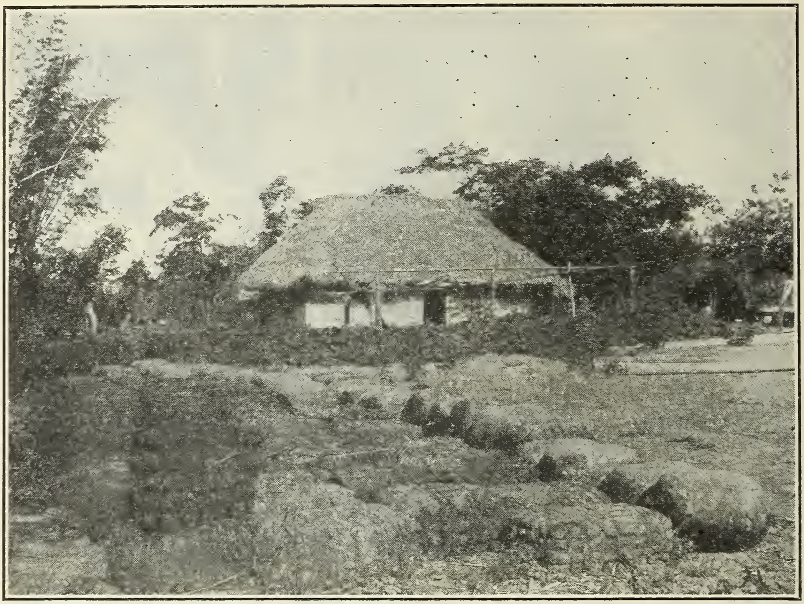

FIG. 5.—Rubber awaiting shipment on the banks of the Madre de Dios, at Conquista, El Beni, Bolivia The balls are of fine hard Para rubber; the bales are of caucho rubber

leaves the rubber in a flat cake rectangular in outline. It is called knapsack rubber, presumably from the cavity in the cake formed by the paddle. At Tres Casas, on the upper Madeira River, such rubber is prepared in large quantities and is said to command the best price in Manaos (fig. 6).

Around Para, in the delta region, the rubber is much less carefully prepared. The latex is allowed to coagulate in the cups, and the rubber is then collected and pressed into irregular masses. Sometimes the latex is poured into holes in the ground to coagulate. According to Lange (*15*), the resulting coagulum is often allowed to stand in water for months with the idea that it will absorb water and increase in weight.

As a result of such practices this rubber comes into Para in a wet, stinking, and indescribably filthy condition, and it would likely find no market at all were it not that a washing plant now exists in that city which washes, sheets, and dries this rubber. Considering the raw material it uses, this plant turns out a product of surprisingly good quality.

The machadinho employed in tapping usually has a cutting edge about 2.5 centimeters long, but the writer observed on the Rio Ouro Preto in Matto Grosso and elsewhere the use of machadinhos with an edge 7.5 centimeters long. In former times the machadinho was supposed to be made of iron, never of steel. Some thought this was because steel in some mysterious way injured the tree; others said that the iron ax could not be kept sharp and being dull would not penetrate to the cambium and therefore would not damage the tree. Woodroffe and Smith (*48*) as late as 1915 continue to perpetuate this supposition. Judging from the trees tapped in the iron age of the machadinho, one is compelled to believe that the ax rarely failed to reach the cambium.

Fig. 6.—Knapsack rubber at Tres Casas, on the Madeira River. This rubber is coagulated by smoking latex over a rectangular paddle. Each knapsack represents the collection of one man for one day

When plantation rubber first came into tapping in the East a great controversy, now merely of historical interest, arose as to the best method of tapping. Two rival schools sprang up. One insisted that the trees must be incised, as with a machadinho or other sharp instrument. The other group was for excision, that is, paring away the outer bark with a farrier's knife or a gouge, so as to open the latex vessels. The incisionists predicted the destruction of all the plantations by the arboricidal method of excision, which was not the traditional treatment to which the tree had been accustomed in its native jungles. They also expatiated on the harmlessness of the use of the machadinho and the great care with which this instrument was used.

If there ever were seringueiros who were careful in using the machadinho the tribe has vanished from the soil—and the waters—of the Amazon area! It is hard to imagine what the incisionists thought the ever-present knots and swellings around the base of the tree might be, for they were certainly grossly distinct even then. Perhaps they considered them a natural part of the tree, as did Fresneau, whose description and drawing of the Hevea tree were published by La Condamine (*14*). Fresneau's drawing shows the tree with a scaly trunk, as though leaf bases still clung to it, as is the case with many palms, *Elaeis guineensis*, the African oil palm, for example. He says that the base of the trunk is ridged, somewhat like a pineapple. It is hardly conceivable that he sketched the upper part of the tree and then mistook the trunk of a palm for that of Hevea; so one familiar with the appearance of the trunks of tapped Heveas in South America is led to the conclusion that the ridges which Fresneau saw were excrescences due to slashing the trunk (in a rather regular pattern) with knives to obtain the latex. Though an unconscious one, this is undoubtedly the earliest note on the pathology of Hevea.

TABLE 1.—*Data from 239 Hevea trees on an estrada on the Rio Ouro Preto, Matto Grosso, Brazil*

Tree	Circumference (cm.)	Number of cuts	Latex yield for one day (c. c.)	Bark thickness (mm.)	Rings of latex vessels	Tree	Circumference (cm.)	Number of cuts	Latex yield for one day (c. c.)	Bark thickness (mm.)	Rings of latex vessels
No. 1	80	1	9	------	------	No. 53	107	2	42	------	------
No. 2	132	3	60	7.0	19	No. 54	129	3	150	8.0	27
No. 3	96	2	26	6.5	19	No. 55	89	1	35	------	------
No. 4	102	2	112	10.0	21	No. 56	82	1	24	8.0	17
No. 5	75	1	12	4.0	12	No. 57	81	1	6	------	------
No. 6	48	1	8	6.0	17	No. 58	74	1	13	------	------
No. 7	83	2	57	5.5	20	No. 59	93	1	17	4.0	25
No. 8	118	2	121	------	------	No. 60	63	1	7	4.0	15
No. 9	96	2	32	6.0	17	No. 61	138	3	115	------	------
No. 10	93	2	30	5.0	20	No. 62	148	3	310	10.0	31
No. 11	133	2	83	6.0	19	No. 63	152	3	138	9.0	22
No. 12	151	2	33	10.0	25	No. 64	102	2	80	8.0	26
No. 13	145	3	230	15.0	33	No. 65	125	3	245	14.0	41
No. 14	75	1	23	6.5	19	No. 66	85	2	55	------	------
No. 15	154	3	158	------	------	No. 67	134	3	97	------	------
No. 16	168	3	24	6.0	21	No. 68	104	2	120	------	------
No. 17	117	2	151	------	------	No. 69	149	3	140	------	------
No. 18	111	2	60	6.0	24	No. 70	88	1	52	------	------
No. 19	140	3	55	11.0	26	No. 71	135	3	120	------	------
No. 20	169	3	57	------	------	No. 72	108	2	110	------	------
No. 21	58	1	1	6.0	20	No. 73	128	3	145	------	------
No. 22	121	3	52	------	------	No. 74	132	2	33	------	------
No. 23	117	2	12	7.0	24	No. 76	157	3	327	10.0	18
No. 24	141	3	65	------	------	No. 77	84	3	47	3.0	15
No. 25	96	1	16	------	------	No. 78	181	3	255	------	------
No. 26	111	2	8	------	------	No. 79	95	1	8	5.0	10
No. 27	94	2	27	------	------	No. 80	125	3	217	11.0	37
No. 28	151	3	98	------	------	No. 81	109	3	165	------	------
No. 29	153	3	110	------	29	No. 82	119	3	190	9.0	22
No. 30	89	1	20	5.0	33	No. 83	92	2	89	------	------
No. 31	146	3	18	7.0	16	No. 84	140	3	267	------	------
No. 32	100	2	12	4.0	16	No. 85	80	2	88	5.0	14
No. 33	117	2	50	------	------	No. 86	79	1	18	------	------
No. 34	146	3	97	8.0	11	No. 87	92	2	47	4.0	12
No. 35	107	2	45	5.0	13	No. 88	113	3	31	------	------
No. 36	64	1	56	------	------	No. 89	69	1	14	4.0	13
No. 37	68	1	110	------	------	No. 90	145	3	198	------	------
No. 38	93	1	8	------	------	No. 91	93	3	31	------	------
No. 39	117	2	78	------	------	No. 92	127	3	79	7.0	22
No. 40	131	2	50	------	------	No. 93	67	1	5	5.0	17
No. 41	147	3	175	------	------	No. 94	168	4	456	12.0	21
No. 42	118	2	30	5.0	12	No. 95	131	2	33	------	------
No. 43	73	1	20	------	------	No. 96	102	------	[1]	7.0	17
No. 44	81	1	25	8.0	20	No. 97	108	2	12	6.0	18
No. 45	70	1	10	3.5	12	No. 98	124	3	102	7.0	15
No. 46	132	3	57	9.0	21	No. 99	125	3	133	10.0	25
No. 47	116	2	10	5.0	17	No. 100	133	3	65	------	------
No. 48	112	2	65	7.0	19	No. 101	172	4	205	8.0	18
No. 49	101	2	80	5.0	19	No. 102	118	3	96	------	------
No. 50	79	1	20	4.0	8	No. 103	88	2	27	5.0	26
No. 51	163	3	130	8.0	17	No. 104	117	3	215	6.0	21
No. 52	135	3	134	------	------	No. 105	107	2	108	------	------

[1] Not tapped.

TABLE 1.—*Data from 239 Hevea trees on an estrada on the Rio Ouro Preto, Matto Grosso, Brazil*—Continued

Tree	Circumference (cm.)	Number of cuts	Latex yield for one day (c. c.)	Bark thickness (mm.)	Rings of latex vessels	Tree	Circumference (cm.)	Number of cuts	Latex yield for one day (c. c.)	Bark thickness (mm.)	Rings of latex vessels
No. 106	82	2	85	5.0	22	No. 175	99	2	16	------	------
No. 107	124	3	110	------	------	No. 176	66	1	12	6.0	7
No. 108	91	2	12	5.0	22	No. 177	99	3	295	------	------
No. 109	79	2	90	10.0	27	No. 178	107	3	67	6.0	16
No. 110	114	2	22	------	------	No. 179	112	3	163	8.0	26
No. 111	189	3	153	7.0	------	No. 180	176	4	98	5.0	14
No. 112	65	1	12	------	------	No. 181	62	1	8	------	------
No. 113	135	3	140	9.0	24	No. 182	152	3	62	5.0	20
No. 114	233	5	183	------	------	No. 183	127	3	92	------	------
No. 115	97	2	48	5.0	14	No. 184	127	3	111	13.0	31
No. 116	115	3	201	11.0	32	No. 185	151	3	113	5.0	11
No. 117	65	1	70	4.0	14	No. 186	85	3	96	------	------
No. 118	124	3	97	6.0	14	No. 187	95	2	100	6.0	23
No. 119	84	2	66	------	------	No. 188	81	2	43	6.0	23
No. 120	117	3	175	11.0	35	No. 189	124	3	127	5.0	10
No. 121	99	2	77	6.0	9	No. 190	127	2	56	------	------
No. 122	102	2	46	6.0	16	No. 191	122	3	44	7.0	30
No. 123	96	2	100	7.0	18	No. 192	104	2	26	------	------
No. 124	149	4	115	5.0	15	No. 193	102	3	150	------	------
No. 125	210	5	490	12.0	31	No. 194	97	2	27	5.0	21
No. 126	130	4	442	5.0	19	No. 195	207	4	70	12.0	28
No. 127	93	2	164	------	------	No. 196	82	2	24	4.0	16
No. 128	136	3	375	------	------	No. 197	142	3	16	8.0	32
No. 129	130	3	85	9.0	20	No. 198	101	2	57	6.0	23
No. 130	160	4	276	9.0	28	No. 199	100	2	39	8.0	21
No. 131	153	4	505	9.0	32	No. 201	112	2	132	4.0	12
No. 132	158	3	132	8.0	23	No. 202	129	2	62	8.0	19
No. 133	129	3	151	7.0	27	No. 203	132	3	35	6.0	28
No. 134	121	3	107	------	------	No. 204	122	3	91	------	------
No. 135	97	3	175	------	------	No. 205	167	4	55	5.0	11
No. 136	137	3	125	9.0	27	No. 206	82	2	120	------	------
No. 137	111	3	50	4.0	15	No. 207	153	3	260	------	------
No. 138	79	2	15	------	------	No. 208	119	3	101	------	------
No. 139	161	3	536	------	------	No. 209	63	1	12	------	------
No. 140	150	4	167	10.0	22	No. 210	88	2	39	------	------
No. 141	110	3	200	6.0	24	No. 211	83	2	21	7.0	21
No. 142	81	2	22	------	------	No. 212	67	1	9	------	------
No. 143	108	3	135	------	------	No. 213	88	2	38	9.0	25
No. 144	82	2	34	5.0	15	No. 214	88	2	18	------	------
No. 145	115	3	161	10.0	26	No. 215	110	2	8	9.0	17
No. 146	169	4	230	------	------	No. 216	108	2	14	------	------
No. 147	90	2	53	5.0	18	No. 217	95	2	12	6.0	22
No. 148	116	3	198	11.0	35	No. 218	127	3	87	------	------
No. 149	153	3	110	------	------	No. 219	137	3	20	10.0	29
No. 150	103	2	123	9.0	29	No. 220	130	3	61	------	------
No. 151	105	2	54	10.0	22	No. 221	102	2	143	------	------
No. 152	105	2	46	6.0	18	No. 222	126	3	176	------	------
No. 153	84	2	132	5.0	11	No. 223	190	3	24	------	------
No. 154	138	3	65	------	------	No. 224	99	2	13	------	------
No. 155	91	2	54	------	------	No. 225	95	2	21	------	------
No. 156	124	3	167	9.0	31	No. 226	123	2	17	------	------
No. 157	106	2	142	4.0	17	No. 227	142	3	212	------	------
No. 158	100	2	130	------	------	No. 228	92	2	106	------	------
No. 159	105	2	47	6.0	12	No. 229	84	2	23	------	------
No. 160	94	2	95	6.0	21	No. 230	98	2	104	------	------
No. 161	103	2	35	4.0	22	No. 231	107	2	20	5.0	19
No. 162	123	2	130	------	------	No. 232	78	1	10	------	------
No. 163	117	2	75	5.0	15	No. 233	86	1	54	------	------
No. 164	105	2	65	------	------	No. 234	136	3	77	6.0	28
No. 165	102	2	75	------	------	No. 235	86	1	25	------	------
No. 166	141	3	113	8.0	23	No. 236	97	2	55	6.0	17
No. 167	110	2	151	------	------	No. 237	123	2	28	10.0	34
No. 168	124	2	46	5.0	17	No. 238	156	3	54	7.0	21
No. 169	140	3	83	5.0	22	No. 239	136	3	71	------	------
No. 170	120	3	112	9.0	28	No. 240	85	1	22	7.0	26
No. 171	113	3	25	8.0	25	No. 241	117	2	143	------	------
No. 172	147	3	147	------	------						
No. 173	121	3	93	5.0	22	Total	27,324	564	22,136	946.0	2,822
No. 174	120	3	54	7.0	18	Average	114.3	2.4	93.0	7.0	20.9

TABLE 2.—*Data from 127 Hevea trees on an estrada at Porvenir, Northwest Territory, Bolivia*

Tree	Circumference (cm.)	Latex yield in a day (c. c.)	Number of cuts	Tree	Circumference (cm.)	Latex yield in a day (c. c.)	Number of cuts
No. 1	223	105	5	No. 66	228	84	5
No. 2	218	58	4	No. 67	160	116	4
No. 3	170	57	3	No. 68	170	33	3
No. 4	257	55	3	No. 69	158	47	3
No. 5	245	39	3	No. 70	175	39	3
No. 6	95	48	2	No. 71	206	60	4
No. 7	225	316	4	No. 72	168	31	3
No. 8	205	27	4	No. 73	131	24	2
No. 9	200	16	4	No. 74	103	16	2
No. 10	240	175	5	No. 75	186	66	4
No. 11	255	215	6	No. 76	189	70	4
No. 12	190	34	4	No. 77	258	42	5
No. 13	130	44	3	No. 78	203	75	4
No. 14	80	6	1	No. 79	76	35	2
No. 15	70	20	2	No. 80	60	19	1
No. 16	150	17	3	No. 81	188	145	4
No. 17	135	48	3	No. 82	210	130	4
No. 18	100	50	2	No. 83	184	76	4
No. 19	120	25	2	No. 84	147	9	1
No. 20	129	88	3	No. 85	88	28	2
No. 21	115	26	2	No. 86	87	20	2
No. 22	160	79	3	No. 87	180	45	4
No. 23	175	173	4	No. 88	130	23	3
No. 24	200	19	2	No. 89	70	5	1
No. 25	205	82	4	No. 90	185	161	4
No. 26	149	30	3	No. 91	140	23	3
No. 27	100	2	1	No. 92	141	21	3
No. 28	149	36	3	No. 93	91	15	2
No. 29	250	41	2	No. 94	108	45	2
No. 30	115	33	2	No. 95	130	48	3
No. 31	225	187	4	No. 96	147	85	3
No. 32	202	77	4	No. 97	189	74	4
No. 33	204	235	4	No. 98	160	45	3
No. 34	105	8	2	No. 99	251	97	5
No. 35	163	97	3	No. 100	176	144	4
No. 36	106	34	2	No. 101	170	51	4
No. 37	148	81	3	No. 102	180	110	4
No. 38	120	20	2	No. 103	108	29	2
No. 39	100	78	2	No. 104	278	377	6
No. 40	220	54	4	No. 105	160	51	4
No. 41	108	72	2	No. 106	153	79	3
No. 42	220	9	1	No. 107	208	63	4
No. 43	165	60	3	No. 108	172	155	4
No. 44	210	20	4	No. 109	127	43	3
No. 45	208	80	4	No. 110	106	23	2
No. 46	168	10	3	No. 111	230	46	3
No. 47	156	45	3	No. 112	85	21	2
No. 48	168	53	3	No. 113	210	3	2
No. 49	200	65	3	No. 114	150	57	3
No. 50	225	31	2	No. 115	215	22	4
No. 51	246	144	5	No. 116	180	21	2
No. 52	120	7	2	No. 117	175	48	4
No. 53	190	205	4	No. 118	105	12	2
No. 54	180	146	4	No. 119	96	35	2
No. 55	178	53	3	No. 120	112	9	2
No. 56	168	62	4	No. 121	156	46	3
No. 57	176	66	4	No. 122	165	8	2
No. 58	148	84	3	No. 123	240	30	5
No. 59	222	47	4	No. 124	266	67	5
No. 60	158	96	3	No. 125	90	16	2
No. 61	245	122	5	No. 126	236	120	4
No. 62	190	63	4	No. 127	120	13	1
No. 63	130	73	3				
No. 64	174	105	4	Total	21,172	8,205	400
No. 65	205	101	4	Average	166.7	64.6	3.1

At the present day the seringueiro makes no special effort to avoid cutting into the cambium. At every stroke of the ax he not only cuts into the cambium but into the wood from 3 to 12 millimeters. Frequently a piece of wood and bark half the size of a man's hand is broken out, and at least a small chip nearly always results from the cut. Probably the South American methods were once better; certainly the methods in the East were formerly worse; but by comparison with the tapping done in the oriental plantations to-day that in Brazil is incredibly stupid and barbarous.

In the Acre Territory of Brazil and in the adjoining Northwest Territory of Bolivia the treatment accorded the trees seems a little less vicious than in the region of the Madeira and its tributaries. The machadinhos used here have a cutting edge 5 centimeters long, which, however, is capable of chopping out a chip 7 to 7.5 centimeters long, 5 to 6 centimeters wide, and 0.5 centimeter thick as an average.

Apparently the number of cuts to the tree is less where the larger machadinho is used. On the estrada from which the data in Table 1 were taken the average number of cuts per tree is 2.3 where the trees average 114 centimeters in circumference. On an estrada in Bolivia, between Cobija and Porvenir, the number of cuts was also 2.3 per tree, but the trees here averaged 162 centimeters in circumference.

A second estrada in Bolivia, data from which are given in Table 2, has the much higher average of 3.1 cuts per tree on trees 166.7 centimeters in circumference. But on closer examination it proves that the trees in Matto Grosso have one cut for every 49 centimeters of circumference; the estradas from the Bolivian Acre district have one cut for each 70.5 centimeters of circumference and one for each 53.6 centimeters of circumference, respectively, so the latter are much less severely tapped than the former.

The number of cuts is proportional to the size of the tree, though deviations from the proportion frequently occur. A high yield from a given tree is likely to cause the seringueiro to increase the number of cuts, while a low yield will lead to a smaller number of cuts than a large tree would normally receive. Such tendencies may be noted in Table 2 in trees Nos. 24, 27, 29, and 42.

One can only guess what the number of cuts per tree used to be in the days of high-priced rubber, but they were at least what one would call numerous. Walle (*44*) shows a photograph of a rubber tree which bears 19 cups on the area exposed to the camera. The machadinhos in those days were smaller than those generally used now, but even so the tapping was excessive.

The consumption of bark is always great with machadinho tapping. The vertical distance between cuts is generally about 10 centimeters, of which 5 or 6 centimeters represents the bark broken out by the stroke of the ax and the remaining 4 or 5 centimeters the bark left intact. Each estrada is tapped approximately twice a week over a period of six months or more. Tapping for 30 weeks would exhaust 6 meters of tapping space. Three meters is as high as a tapper can reach, and this usually represents the maximum height of tapping. Most seringals now prohibit the use of ladders or scaffolds in tapping, and they are forbidden by law in Bolivia, though they are still occasionally seen there as well as in Brazil. At this rate, even allowing a height of 3 meters (and most trees are not now tapped so high), the tapping surface would of necessity be changed once in the season. The space between rows is 3 or 4 centimeters in width, and these spaces with the rows of cuts would use up practically all the bark on the Matto Grosso trees in one season. The Bolivian trees would last somewhat longer, but not more than two seasons, after which the trees should be allowed to rest for at least two years. In most cases such rest periods have been given, and now with thousands of idle estradas even longer periods are given for recuperation. Longer intervals are surely needed, for there is ample evidence that many trees have been killed by the severity of the tapping, and most old trees show evidence of poor bark renewal. Anything like the incessant tapping to which most of the trees in the East were formerly subjected would be impossible with machadinho tapping. The remarkable way in which these oriental trees have endured the strain upon them indicates that it is not loss of latex but loss of tissue which has exhausted the South American trees.

NUMBER OF TREES IN AN ESTRADA

The number of trees in an estrada depends somewhat on their distribution in a given area, somewhat on the lay of the land, but more particularly on the number of trees which the seringueiro feels like tapping. The estrada on which Table 1 is based is an unusually large one, containing 265 trees, of which 239 were actually being tapped regularly when the data were taken. Usually the number of trees tapped is somewhere between 100 and 200. At Sena, Bolivia, the average is 150 trees; in the Acre Territory, perhaps a little less. Akers (*2*) estimates the number at 135 to 150 per estrada in the Madeira region. Lecointe (*25*) quotes a report on the Rio Tapajos, by Raymundo P. Brasil, in which it is estimated that in the municipality of Itaituba 287,045 trees were tapped in 5,407 estradas, or 53 trees per estrada. This is probably a smaller number of trees per estrada than is common in most regions.

YIELDS OF THE TREES

Tables 1 and 2 give the yields of latex of a number of Hevea trees, each from one day's tapping. The yields of individual trees are given for comparison with individual-tree yields in the East and elsewhere. Yields from a single tapping are unsatisfactory for such purposes but are the best available data, since very few records of yields of individual trees in the Amazon region have ever been published.

The maximum yield in Table 1, 536 grams, was the highest observed by the writer in the course of his trip in South America. Reports of much higher yields are current; trees are even reported which yield as much as 4 liters per tapping, but if such yields exist they are very rare.

Another estrada at Kilometer 10, between Cobija and Porvenir, Bolivia, showed about the same variations in yield of individual trees as the two estradas included in Tables 1 and 2. The highest yield was 350 cubic centimeters of latex, the lowest 5 cubic centimeters. Yields of 60 trees gave an average of 86.4 cubic centimeters. All three of these estradas gave yields which would be considered good in plantation trees.

The seringueiro who tapped the estrada on which Table 1 is based says he collects 1,000 kilos in six months. At Tres Casas, on the Madeira River, collectors were said to obtain about 600 kilos in a season.

At Calama, on the Madeira River, it was reported that the men on the Rio Machado collected 16 to 18 kilos a day. Allowing only 20 days a month for six months, this would give a production of about 2,000 kilos, which is almost certainly too high an estimate for Hevea rubber, though not for one man's production of caucho.

The Guapore Rubber Co., at Guajara Mirim, Matto Grosso, gave 1,000 kilos as the average production of a seringueiro for five months. At Sena, Bolivia, on the Rio Madre de Dios, the average for a large number of estradas is 633 kilos, and in the Acre Territory of Brazil 800 kilos is an average, though 2,000 kilos have frequently been obtained from virgin estradas. At Porvenir, Bolivia, the average is 800 kilos.

Lecointe (*25*) estimates the average production of a seringueiro at 450 to 500 kilos of fine hard Para rubber and 90 to 100 kilos of sernamby. Akers (*1*, *2*) gives an average of 5 pounds a tree for the whole Amazon region, which, assuming that a seringueiro works three estradas of 150 trees each, would give 1,000 kilos for each man or 680 kilos if only two estradas are tapped by each man.

From the data in Tables 1 and 2 and also that from the estrada at Kilometer 10 near Cobija, Bolivia, it appears that the yields secured on estradas visited by the writer are considerably less than Akers estimates, which was an average of 3 pounds a tree for the lower Amazon and as much as 8 pounds a tree for some other regions.

AGE OF THE TREES

There is no doubt that the large rubber trees in South America are of great age. In some places there are trees which have been tapped for more than 50 years and must have been of considerable age before tapping was begun. (Figs. 7 and 8.) In addition to such data we have the evidence from annual rings of growth. These are formed by the unequal rate of growth at the beginning and at the end of the growing season. In the early spring rapid growth takes place and wood elements of large diameter are formed; toward fall growth slackens greatly and small elements are formed. The alternate zones of large elements and small elements are apparent to the eye in the cross section of a tree trunk as rings, commonly called annual rings.

In tropical climates having uniform growing conditions annual rings are usually lacking. In Sumatra, for example, it was practically impossible to distinguish annual rings in the rubber trees. In regions having alternating wet and dry seasons annual rings are formed. However, if a second dry season occurs a second ring may be formed the same year. A drought also may cause the development of a second ring in temperate climates. But, in spite of these vagaries, the number of annual rings normally corresponds closely with the number of years of growth.

In Brazil there is normally only one dry season, and the rings of growth may be accepted as a rough measure of age. Counts of rings made for a number of trees in Brazil and Bolivia are shown in Table 3. Some of the trees were felled, but in most cases borings

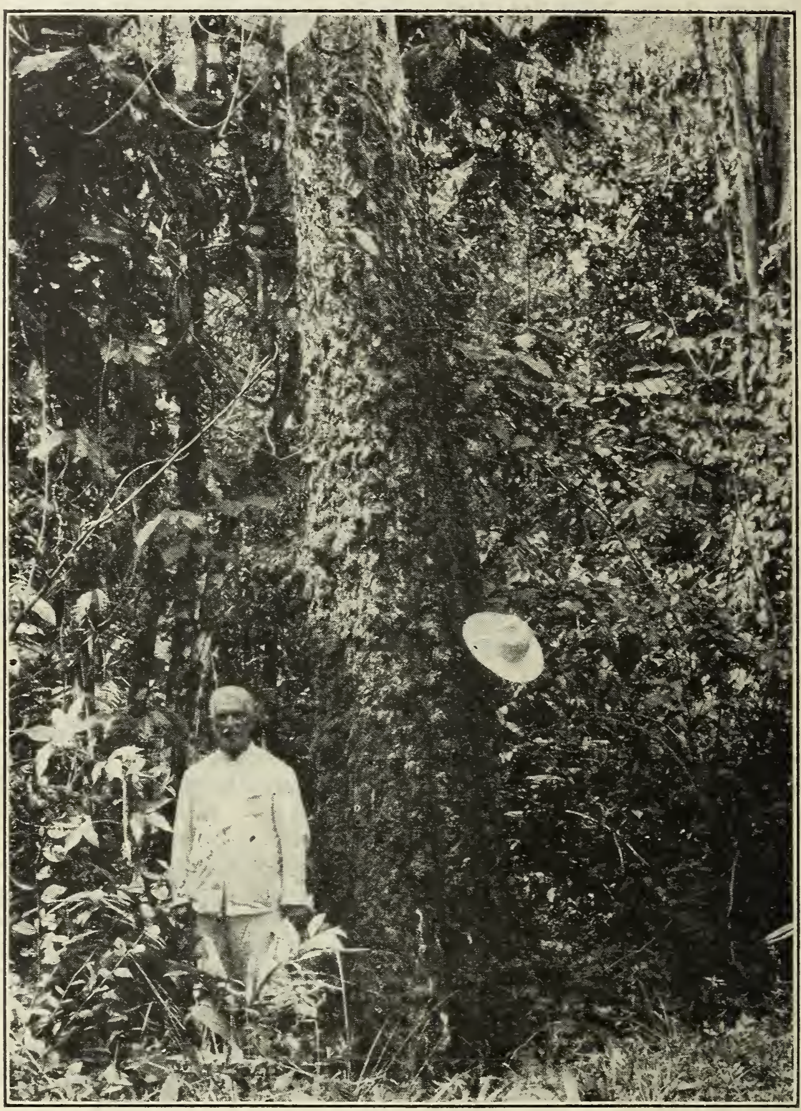

FIG. 7.—An old Hevea tree at Diamantino, on the Madeira River, which has been tapped for more than 30 years. Dr. Raymundo Monteira da Costa, rubber specialist with the Brazilian Commission, is standing by the tree

were made with an increment borer which cuts out a cylinder of wood extending from the bark to the heart of the tree. The rings show clearly in such a cylinder, and the age of a tree may be determined without damaging it.

The counts made at Porvenir, Bolivia, and at Kilometer 10 (near Porvenir) are shown in Table 3. These trees have an average age of 91.8 years and an average circumference of 130.8 centimeters.

Fig. 8.—A very old tree at Diamantino, on the Madeira River. The excresences caused by tapping have formed ridges. The ridges have been retapped until the whole lower trunk has become fluted

This gives an average diameter increase of 4.53 millimeters per annum. Two old trees at Kilometer 10 were too large for the increment borer to reach their hearts, but cores 25 centimeters long were taken out with the borer and showed 117 and 96 rings, respectively, which is equal to a diameter increase of 4.26 and 5.43 millimeters, much like that shown in the other trees.

TABLE 3.—*Age of Hevea trees as indicated by their annual rings*

Locality	Circumference of tree at 1 meter (cm.)	Number of annual rings	Locality	Circumference of tree at 1 meter (cm.)	Number of annual rings
Kilometer 10, near Porvenir, Bolivia	128	69	Fazenda Palmaris, Acre Territory, Brazil:		
	164	95	Very little crowded	60	21
	140	74	In jungle	24	26
	151	89	Arroyo Limonao, on Rio Madre de Dios (in jungle)	9.5	10
	169	74		7.6	8
Porvenir, Bolivia	106	79		8.5	8
	120	77		7.0	7
	108	101		9.4	10
	106	122			
	116	138			
Average	130.8	91.8			

If we accept such diameter increases as typical, the trees in the estradas on the Rio Ouro Preto in Matto Grosso and at Sena have an average age of 128.3 years; those at Porvenir and Fazenda Palmaris average 86.5 years; and the big trees at Sena are 185.3 years old. The largest tree seen by the writer, with its girth of 395 centimeters, should be 278 years old. Trees 5 and even 6 meters in circumference are reported by creditable observers, so it is entirely possible that rubber trees which were growing when Columbus landed on the continent are still living in the remote jungles.

The idea that Hevea is a jungle tree and therefore can not thrive outside the jungle was ardently advanced in the early days of rubber planting. It is still held by many South Americans, who think planting must be done under the jungle cover if success is to be obtained. Whether this is true or not may be learned from Table 3, where the growth of young trees in the jungle is shown at Fazenda Palmaris and Arroyo Limonao. All observations at other places show the same thing—that the growth of the trees is extremely slow until they reach the level of the jungle crown and receive a proper share of light.

The number of seedlings which reach a considerable age is very small. In many places small seedlings are rare, possibly because the old trees are not bearing seeds or possibly because the seeds are eaten by animals. It is not unusual to find trees which have many open fruits beneath them, though not a seed is to be found. Deer are said to be especially fond of the seeds, as are wild pigs.

In other places seedlings from 1 to 2 feet in height are plentiful, sometimes even hundreds under a single mother tree. But of these very few reach a greater size, and the percentage of Hevea trees is not increasing. Where the old trees are being tapped the percentage, of course, is decreasing rapidly.

There is no question that the growth of trees under the jungle canopy is very slow indeed compared with that of trees in the open. In some places attempts have been made to plant trees in estradas, but usually no clearing whatever was done around the young trees and consequently they did not thrive. It seems possible that where estradas are being tapped new trees could be interplanted between the mature ones and a certain amount of clearing around each could be done at little expense. The larger jungle trees should be girdled, the smaller ones felled, and the undergrowth cut and burned. Beyond that the undergrowth would need cutting from time to time. The growth of these trees would be slow compared with plantation trees, but ultimately the estradas would be filled in with trees so close to each other that tapping could be done at low cost, and the cost of such plantings would be very low. Had this method been applied years ago the Amazon Valley might still be a strong competitor of the Orient in rubber production.

HEIGHT OF THE TREES

The trees on the lower Amazon are, for the most part, of medium height; most of them are under 15 meters. But on the more elevated alluvial soil, the so-called varzea alta, and on the high land of the upper rivers they grow to a much greater height. At Fazenda Palmaris a fallen tree in an estrada was measured and found to be 36.7 meters from the ground level to the tips of the highest branches and 18.3 meters to the base of the lowest branch. The circumference of this tree was 2 meters. A tree in another estrada near here measured 36 meters from the ground to its highest twigs and 27 meters to the first branch. This tree was 206 centimeters in circumference. Although both these trees were of large girth, they were not taller than other Hevea trees around them, even though the latter were frequently more slender. Apparently in this region the top of the forest canopy was more or less uniformly 36 meters above the ground. Some trees, of course, notably the castanhas, or Brazil-nut trees, reach far above this canopy.

The trees on the upper Madeira, the Guapore, the Mamore, the Beni, and the Madre de Dios Rivers are of approximately the same height as the foregoing, as are also the trees on the Acre, on the Tahuamanu in Bolivia, and on the upper Purus. Such heights of trees mean naturally that the trees in the Amazonian jungle are much more slender than those of the plantations in the East. These latter trees have had full light during their entire period of growth and on this account have headed much lower than shade-grown trees would or could. Those plantations where thumb-nail pruning has been practiced have developed trees of still lower stature.

SHIPMENT OF RUBBER

After the rubber is prepared the seringueiro has to deliver it at the barracão, where he is credited with its value minus deductions for loss of weight on drying, etc. Although estradas are located near a stream whenever possible, in many cases the rubber has to be transported for miles before a stream is reached. Such transportation is naturally very expensive.

From the barracão the rubber must be carried by launch, raft, or batelão to streams navigable by boats from Para or Manaos and then shipped to those markets.

In the days of the expedition of Spix and Martius (*38*), from 1817 to 1820, most of the Para rubber was said to come from the jungles near Para and the island of Marajo. Spruce (*40*) tells of the spread of the industry up the Amazon, the Rio Negro, and elsewhere. At the present day the principal rubber-producing districts are all far from the ports of Para or Manaos, and the transportation is one of the great factors in the high cost of production in South America.

The price of labor and its scarcity are factors which are of the greatest import in the paralysis of the rubber industry of the Amazon Valley. Labor is cheaper there now than in the boom days of rubber—in money but not in relation to the price of rubber. The high cost of transportation also affects labor by increasing the cost of living. Everything which is shipped up the rivers doubles or trebles its price as it goes, and most of the supplies of the seringueiro have always gone up river. The rubber regions have never been food producers, so food must be shipped in at any cost.

Some of this food, such as farinha and pirarucu, is produced on the lower Amazon, but much of it, such as xarque, comes from the southern part of Brazil, making a very long voyage before it reaches the rubber-producing areas far up the rivers from the sea.

The cost of transportation has not decreased in later years, because the source of the rubber has steadily retreated up the rivers, until one is amazed at the vast distances which must be traversed from the port of Para before a producing field of any note whatever is reached. Naturally the trees near the coast, first exploited, have been first to succumb, and collectors have been forced to go farther and farther afield.

POSSIBLE IMPROVEMENT OF CONDITIONS

It is easy to suggest means of remedying or at least alleviating the evils of the present situation; but it is much less easy, in fact, it may even be quite impossible, to put these methods into effect. Akers (*1*) made a series of excellent suggestions for improving conditions and that at a time much more promising than the present, but his suggestions have not borne fruit. The Brazilian Government passed a series of acts (*37*) for the purpose, but these laws have not been enforced. Lecointe (*25*) more recently has also prescribed a valuable regimen, which will likely avail little. Therefore the writer admits a feeling of trepidation in attempting to deal with so critical a state of affairs.

The Brazilians frequently express the wish that the price of rubber could be brought a little higher and that it could be stabilized. At the present time (July, 1924) there is a general tendency to be unwilling to advance money for supplies for rubber gatherers whose collections may be well-nigh worthless when brought in some months later. If rubber could be stabilized at 5 milreis per kilo in Manaos the industry could be saved, at least in some degree. But in view of present conditions there is little hope now that the price will become more stable.

LABOR CONDITIONS

A better supply of labor and cheaper labor would do much to continue the rubber industry, but the supply constantly becomes less. For many years the rubber fields drew a stream of workers from other regions of Brazil, especially Ceara. Many of these workers were destined never to return from the land of the black gold, for the quest for this, like that of the yellow sort, was carried on at a high cost of life.

For the last few years the tide has turned and now the seringals are sadly depleted of seringueiros; one great seringal on the Rio Machado of 3,000 estradas has only 600 in tapping. On the Madeira, the Mamore, and the Guapore one hears the same story, and in the Acre Territory the scarcity of workers is so great that numbers of estradas have not been tapped for years. "Lack of labor," or literally "lack of arms," as the Portuguese has it, is heard everywhere.

Of course a considerable increase in the price of rubber may again draw workers from other regions, but they will be held only by the higher income. They will not come when prices are low nor remain when higher prices have declined, and so they will not help the industry in its crises.

Colonization of the rubber country and the development of agricultural industries would ultimately reduce the cost of living and increase the supply of labor in the region. But large areas of the Amazon Valley are not well fitted for colonization by people of the white race; certainly they will not be so colonized while areas in more healthful and agreeable lands are available. On the other hand, there are vast areas high up on many of the rivers where the climate is more salubrious and the land is exceedingly well suited to general agriculture. Such a region is the Acre Territory, where the white race could thrive and where a great population could be supported. But such colonization, though it may some day come, can not develop in time to save the rubber industry of South America.

Reducing the cost of living in the rubber country would be equivalent to an increase in income of the seringueiro and might be a considerable aid. This has come about to such an extent at least that the seringueiro now usually does grow a portion of his foodstuffs. This has been of greater importance in improving health conditions than in reducing costs, for it has reduced beriberi almost to a rarity. When rubber was high everybody lived on preserved and tinned foods, and beriberi was the worst scourge of the region. Now most seringueiros grow some of their food, and in a few places the houses of the collectors are surrounded by all sorts of fruits and vegetables, and the amount of money which is paid out for supplies must be small indeed.

As a general thing, however, the seringueiro does not like cultivation and will not do it if he can subsist otherwise. Furthermore, his tenure on an estrada is uncertain, and he does not like to plant trees and crops which another may harvest. In all too many cases his estrada is flooded during a part of the year and permanent cultivation is impossible. The total quantity of food grown by the seringueiros is now very great compared with that in past years, and it may be predicted confidently that such rubber as is collected in the future in Brazil will be the product of seringueiros who are so well established on the land as to secure the greater part of their food from it, so that very little money need be spent.

The seringueiro is ignorant and careless in cultivating crops; varieties of plants are poor and no improvement is being made. In the past he was not encouraged to do any planting, for the more food he bought the greater the profit to his patron. At present many seringals are a source of profit only because the sale of supplies is profitable, the rubber being handled practically at cost.

MORE ECONOMICAL PRODUCTION NEEDED

A second means of improvement lies in more economical production. To this end tapping methods may be improved, the latex handled more carefully, and less rubber allowed to go to waste. These economies are not at all easy to carry out in an exploitation so little controlled as the one in question. They are especially hard to insure when an industry is so sadly demoralized as this one. Some saving might be effected by expending more time in selecting trees for tapping in an estrada. As may be seen by an inspection of Table 1, some trees give an excellent yield. There are 22 trees which have yields of latex of 200 cubic centimeters or more, and these give a total yield of 6,749 cubic centimeters; that is, 9 per cent of the trees give 30 per cent of the latex. Of trees yielding less than 50 cubic centimeters of latex, there are 88 which give a total yield of 2,033 cubic centimeters of latex. This is 9 per cent of the yield of the estrada and is given by 37 per cent of the trees. There are 42 trees bearing 20 cubic centimeters or less of latex, and these yield 528 cubic centimeters. Of these trees the lowest yielding contingent makes up 17 per cent of the estrada, but yields only 2.4 per cent of the latex. It is easy to see that these 42 trees are not worth tapping even though they are directly on the estrada. They should be dropped out and other trees added which give a higher return for the labor. Obviously, it is not always possible to rearrange estradas so that more trees may be available. Sometimes the limitations are those of site; impassable streams intervene, etc. If every estrada were in tapping it would be more difficult than it is now with idle estradas everywhere, so that some rearrangement should not be difficult. The seringueiro can well afford a somewhat longer round, if he secures a considerably augmented return. There are dozens of trees in nearly every estrada which are not worth tapping. With these eliminated, there is a chance that the higher yielders may prove worth tapping even under present conditions.

The loss of latex in the average estrada is very great. Much of it never reaches the cup, but drips over the edge of the slanting cut and runs down the bark or drops to the ground. The lip of the cup, which is thrust into the bark at the lower end of the cut, is bent into so narrow an angle that it does not form an adequate spout for collecting the latex.

The rubber which coagulates on the cut is never removed, though in many trees it exceeds the quantity secured from the collected latex. Akers (*2*) considers that this fact has saved the trees of the region from ruin, keeping insects and fungi out of the cuts. This is probably not the case, because the rubber rarely seals the cuts, at least such cuts as are made nowadays. How far the rubber prevents insect attack the writer will not venture to say; but he knows from experiment that the rubber is of no avail in preventing attacks by fungi, because many fungi will grow on latex as a substratum, and coagulated rubber is in no way injurious to them.

Latex is frequently lost also from cups which have broken along the seams. Most of the cups used are of flimsy tin and are rather poorly soldered. As a consequence of the bending which the edge undergoes in the formation of a sharp lip which can be thrust into the bark, the seams break open, a fact frequently overlooked by the seringueiro who in his haste has little time to look at each cup.

Another source of loss is in the scrap which clings to the cups, which are never clean when the latex flows into them. In the beginning they are made with flat bottoms, and the angle formed by side and bottom can not be kept clean. Rubber adheres here, and on its surface more rubber coagulates. The cups are thinly plated and soon rust, which causes rubber to cling to the whole surface. The seringueiro pours the latex from the cup, then cleans the inside of the cup with a stroke of his finger. The dirtiness of the cups not only causes the loss of the rubber which sticks to them but initiates coagulation in the whole mass of latex in the cup. Where the quantity of latex is small the coagulation may be completed before collection; in other cases it is only a fruitful source of lumps, which must be classed as sernamby and sold for almost nothing.

There is no question that the cups should be kept clean. Porcelain cups so widely used in the East, though easy to keep clean, are not applicable to the Amazonian wilderness. They are too expensive and too difficult to transport for use there. Furthermore, their use would necessitate the use of cup hangers, which would be an impossibility where a number of cups are used on each tree. Then, when it is considered that each seringueiro keeps two or three estradas in tapping at the same time, it is apparent that the outlay required for better cups and for cup hangers is entirely out of the question.

A new type of cup could be made, however, which need not be more expensive than those now in use. Such a cup should be seamless and should have a round bottom and a smooth surface to make it easy to keep clean. The metal should be heavy enough to prevent battering, and, since this would make it impossible to bend the edge to form a lip to be thrust into the bark, the rim of the cup should bear a lip with an edge for thrusting into the tree. This lip will also serve as a spout for the latex. Figure 9 gives the writer's idea of the appearance of such a cup.

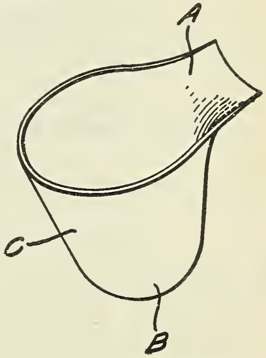

Fig. 9.—An improved latex cup. The lip, A, is thrust into the bark and serves as a support for the cup and as a spout for the latex. The bottom, B, is rounded for ease in cleaning, and the side of the cup, C, is slanted so that the cups may be nested. The whole cup is seamless and is stamped from one piece of metal

Akers (*1*) estimated that 10 per cent of all the rubber taken from the trees is lost. The writer would go farther, estimating that 15 per cent of the rubber is completely lost and another 10 per cent saved only as sernamby. Such waste is inconceivable to the rubber planter. There are thousands of tons of rubber in the Amazon basin in the form of bark scrap and earth rubber. Most of this could have been saved by slight and inexpensive changes in methods and by the exercise of more thought and care.

WASTEFUL AND INJURIOUS TAPPING

That the method of tapping in use at present is injurious in the extreme has been pointed out somewhat insistently. It is necessary to consider a better method to substitute for it. The cut which a machadinho makes is nearly as well adapted to running the latex down the trunk as into a cup. There are methods which do not allow that and that at the same time do a great deal less injury to the tree.

The Jebong knife and the gouge which are used for tapping in the Orient are absolutely useless on trees which have been tapped with the machadinho, on account of the huge excrescences which develop on the trunk and over which tapping can not be done without constantly penetrating to the wood. Possibly after a few years' rest the trunks of such trees would become sufficiently regular to allow tapping, though still with much more wounding than would ever be necessary in a normal plantation.

Knife tapping over one-third or even one-fourth the circumference of the trees opens the vessels of a much larger part of the trunk than does the number of ax cuts now usually made by the seringueiro. This is shown in Table 4.

TABLE 4.—*Lengths of cuts made in tapping rubber trees by different methods, the data being obtained from various estradas*

Machadinho tapping		Knife tapping		
Number of cuts per tree	Total length of cut (cm.)	Number of cuts per tree	Total length of cut (cm.)	
			One-third circumference	One-fourth circumference
1	8	1	26	20
3	24	1	44	33
2	16	1	32	28
2	16	1	34	26
1	8	1	25	19
5	40	1	78	58
3	24	1	41	31
5	40	1	108	81
4	32	1	106	79
6	48	1	118	89
3	24	1	76	57
4	32	1	101	75
4	32	1	106	80
4	32	1	103	77
5	40	1	115	87

The length of cuts made by the knife is at least twice that of the total length of cuts made by the machadinho in the trees shown, which are typical ones from various estradas. The greater length of the cuts should give greater yields, but this is to some extent counterbalanced by the fact that the ax cuts extend to the wood, while the usual tapping with the knife goes only to within 1.5 millimeters of the cambium, as has been determined by the writer (*18*).

Akers (*1*, *2*) attempted to introduce the oriental systems of tapping into Brazil and caused a number of experiments to be made in various places. Unfortunately, the result of these experiments has been to confirm everybody in the belief that such methods are not adaptable to South American conditions. The report of his experiments has traveled throughout the rubber country, and everybody thinks, whether rightly or not, that all the trees tapped by the Akers commission died at once.

Akers himself concluded that oriental methods could not be used in Brazil on account of bark-rot and also on account of the high labor cost. In experiments performed on an estrada near Abuna, Matto Grosso, Brazil, he secured the results shown in Table 5.

TABLE 5.—*Comparison of results obtained by Akers (2, p. 84) by tapping Brazilian rubber trees with a gouge and with a machadinho*

Tool used	Number of—		Quantity of latex (c. c.)			Yield of dry rubber, including lump and scrap (pounds)
	Trees	Tappings	Total yield	Per tree per day	Per pound of dry rubber	
Machadinho	235	3, 190	68, 750	21. 8	886	77. 52
Gouge	57	798	32, 000	40. 1	836	38. 27

Based on these data machadinho tapping for 180 days a year would give an average of 4.4 pounds per tree and gouge tapping 8.6 pounds for the same period. To offset the decided improvement in yields Akers (*2*) found that experienced tappers could tap only 60 to 70 trees a day and that after tapping for six months the cambium disease set in.

Exact details of the methods used by Akers are lacking, but it is known that he brought experienced native tappers from the East. Whether these men were adequately controlled or not does not appear, but 60 to 70 trees seem a small task to the writer in comparison with the number of trees in a tapping field in the East, due allowance being made for the difference in conditions. However, at that time tapping systems were much more complicated and much more severe than at present, which may account for the small number of trees tapped as well as for the early and serious onset of disease.

The writer laid out an estrada of 30 virgin trees on the Rio Ouro Preto, in Matto Grosso, Brazil (see fig. 3), and tapped them for a few days, using one cut on one-third the circumference. All tapping was done to the wood in order to give results comparable to those of the ax, which penetrates to the wood.

The cuts were opened to the wood on one day; the next day tapping was begun. The scrap from the cut of the day before was put into the cup with the latex yield of each day. This introduced a small error in the quantity of latex, since the scrap rubber is somewhat less in volume than the latex from which it comes. Where the yield is very small most of the rubber is coagulated on the cut as scrap, and this makes the measurement of the latex merely an approximation. Tree No. 17 in Table 6 is an example of such a condition. With the average tree the errors are small and over long periods are practically negligible, so that this proceeding offers as satisfactory a means as has been found of obtaining the total daily yield of a tree.

Time was available for only four consecutive tappings, the results of which are given in full in Table 6. It is unfortunate that the trees could not have been tapped long enough for the wound response to become fully established, so that the trees might have shown their full yielding power. A considerably larger yield might have been expected later, for five days is not long enough for the full response to tapping to be shown; in fact, some trees do not yield to their full capacity for at least a month after tapping is begun.

The results were enough to show that tapping with a knife according to the plantation method will very likely be successful under proper conditions. The yields compare favorably with those of good areas of rubber on oriental plantations, though the latter are, of course, for trees younger than the Matto Grosso trees (*18*, *20*).

TABLE 6.—*Yields of rubber trees on an estrada on the Rio Ouro Preto, Matio Grosso, Brazil, tapped by the writer*

Tree No.	First tapping (cubic centimeter)		Second tapping (cubic centimeter)		Third tapping (cubic centimeter)		Fourth tapping (cubic centimeter)		Average of tappings (cubic centimeter)		Rubber yield (per cent)	Circumference of tree (cm.)
	Latex	Dry rubber	Latex	Dry rubber	Latex	Dry rubber	Latex	Dry rubber	Latex	Dry rubber		
1	-------	11.9	53	27.9	55	27.4	55	23.7	54.3	22.7	41	106
2	157	25.6	68	32.1	83	37.9	100	46.4	102.0	35.5	34	173
3	52	22.2	46	23.4	36	17.1	54	27.5	47.0	22.5	48	134
4	10	1.9	10	1.6	4	3.8	10	2.7	8.5	25.0	29	116
5	20	11.9	28	20.6	52	20.6	46	18.2	36.5	17.8	49	95
6	57	23.3	49	22.2	63	28.1	76	29.8	61.2	25.8	42	129
7	39	16.8	45	19.6	47	20.4	48	21.0	44.7	19.4	44	188
8	66	24.8	65	27.4	74	32.3	80	34.0	71.2	29.6	42	180
9	62	22.1	83	39.3	63	29.9	82	40.8	72.5	33.0	45	129
10	31	9.6	40	17.9	37	14.9	30	12.8	34.5	13.8	44	100
11	18	4.0	13	7.3	41	17.2	49	18.2	30.2	11.7	38	81
12	56	22.3	41	20.7	47	23.8	45	20.5	47.2	21.8	46	115
13	10	8.9	10	14.5	38	16.4	40	13.9	24.5	13.4	70	105
14	126	23.0	125	68.6	166	90.8	239	108.5	164.0	72.7	69	164
15	10	3.2	54	26.4	45	19.2	50	21.7	39.7	17.6	45	133
16	193	89.9	212	119.3	153	74.1	140	72.2	174.5	88.9	50	134
17	-------	1.5	5	4.1	7	4.0	8	-------	6.6	3.2	48	48
18	12	3.1	50	25.3	33	15.3	52	23.7	36.7	16.9	46	122
19	27	7.7	35	16.6	31	14.6	35	16.6	32.0	13.9	43	124
20	-------	-------	15	8.7	31	17.0	21	11.1	22.3	12.3	55	73
21	25	7.5	40	12.5	43	13.0	37	18.7	36.2	12.9	31	168
22	240	136.3	225	124.4	245	135.8	262	138.1	243.0	133.6	55	209
23	28	16.0	84	42.9	60	29.1	70	32.2	60.5	30.1	50	180
24	21	7.9	26	10.9	28	11.9	25	-------	25.0	10.2	41	120
25	23	21.2	43	10.5	50	18.7	53	10.9	42.2	15.3	36	116
26	65	-------	200	95.0	169	65.9	115	-------	137.2	80.5	56	172
27	84	38.8	172	72.2	108	37.5	96	42.9	115.0	47.9	44	169
28	21	7.1	53	26.6	64	23.5	43	17.4	45.2	18.7	41	90
29	18	5.9	17	19.6	13	11.6	12	4.2	15.0	10.3	68	120
30	13	5.1	18	8.5	18	8.6	22	9.6	17.7	8.0	45	84

These yields can not be compared directly with those in Table 1, because definite knowledge of the rubber content of the latex from that estrada is lacking. Samples of rubber coagulated from measured quantities were taken but lost in later travels. However, samples taken from the estrada at Porvenir, already mentioned, show that the rubber content of the latex there was 33 per cent. To assume that the latex from the three estradas from which data have already been given contains 33 per cent of dry rubber gives approximately the results shown in Table 7.

TABLE 7.—*Yields of rubber trees tapped by different methods*

Territory	Tapping method	Average daily yield of latex per tree (c. c.)	Average daily yield of dry rubber per tree (grams)
Rio Ouro Preto, Matto Grosso	Jebong knife on one-third circle	59	[1] 25.1
Do	Machadinho	93	[2] 30.1
Porvenir, Bolivian Acre	do	86.4	[2] 28.5
Do	do	64.6	[2] 21.3

[1] Samples weighed. [2] Rubber content estimated at 33 per cent of latex.

According to these data the Jebong knife gives, even in the first few days, yields that are comparable to those obtained by the machadinho. The average daily yield of latex is considerably in excess of that obtained by Akers, who doubtless used more severe methods; but the yield shown in Table 1 is greatly in excess of that obtained by Akers with the machadinho in his experiments, so that the differences may be set down as due to differences in the condition of the estradas. Akers believed the yields in South America could be doubled by using the gouge or knife. This may be possible, though it is doubtful whether modern conservative tapping systems would give so great an increase, but there can be no doubt that a substantial increase would be obtained, though part of this advantage might be lost in a slightly increased cost of tapping. A trained tapper should be able to tap nearly as many trees with the knife as the ordinary seringueiro does with the ax.

The writer inclines to the belief that oriental methods can be adapted to tapping on virgin trees with good results, but not on old tapped trees unless they have rested for a long time. The greatest difficulties lie in the training and control of the tappers. It is doubtful whether an old seringueiro can ever be trained to be careful of the bark of a tree, and unless care is exercised the knife may be even more terrible in its effects than the ax. At present an adequate system of control is practically impossible, so that for most estradas the gouge and the Jebong knife may be dismissed from consideration.

The tool known as the Amazonas knife is very promising as a substitute for the ax. As usually made, it has a long handle and is provided with a cutting blade shaped like that of the Jebong knife, but with a smaller curve, so as to be adapted to use in thinner bark. It is complicated by an attachment designed to clean the blade or to regulate the thickness of the cut; the writer never knew for which use it was intended, and it is certainly equally worthless for either. The shank of the knife is provided with a long extension, like the blade of a table knife. This was intended to serve as an instrument of incision after the knife had been used to excise a grooved cut to conduct the latex. The custom of using the knife in this way is indeed more honored in the breach than in the observance, for wherever the knife penetrates the cambium it produces an excrescence, as might be expected. These excrescences are small and not very serious if a rather long time be allowed for bark renewal, but there is no need of producing them, and the knife is usually used only for excision and not for incision. Only at Seringal Miry, near Manaos, an experimental plantation in as good condition as any seen in South America, did the writer find the knife used for incision.

In using this knife the bark is not pared away completely, as with the gouge or the Jebong knife, but a small portion of bark is left intact between each two cuts. The cuts do not run so deep as those made by the other tools; therefore the knife is better adapted to tapping the bark of old injured trees. It is also successful with thinner bark than can be tapped with the gouge or Jebong knife. Figure 10 shows a tree which has been tapped with this knife.

On old trees badly affected with excrescences this knife causes considerable injury to the cambium, but much less than the ax. In general, the bark seems to be readily renewed after its use, and fungous infection seems less likely to follow its use than that of the ax.

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Actual yield data from trees tapped with this knife are lacking, but the common report is that increased yields result from its use, that injury to the trees is reduced, and that the time consumed in

FIG. 10.—A Hevea tree at Seringal Miry, Manaos, which is being tapped with the Amazonas knife. On the right side of the tree the knife was used for incision also, and the excrescences may be easily seen

tapping is not increased. The knife is constantly coming into wider use, and on some seringals it has completely supplanted the machadinho.

Examination of trees tapped with the Amazonas knife shows that on an average 16 cuts are made for every 13 centimeters of bark used. Tapping a given segment of bark is begun at a height of 150 or 160 centimeters from the ground; therefore this segment would last at least three years and generally longer. With trees tapped on one-third of the circumference, a 9-year rotation system could be applied, so that the renewed bark should be in excellent condition. It is probable that after such treatment most of the trees could be tapped with the Jebong knife and still larger yields secured.

Some rubber is lost as scrap in the cuts from this knife, because the cuts are too narrow to permit scraping the cut without undue loss of time; but the quantity of scrap left in the cuts is small. In leaning trees, latex sometimes flows over the edge of the cut and is lost; but in general the loss of rubber is much less than with the machadinho, and the use of the knife would be justified on this basis alone. The adoption of this knife is one of the steps in the direction of more economical production.

PREPARATION OF THE RUBBER

Few changes in the preparation of the rubber are to be recommended. The smoking process used generally in the Amazon district is probably the best native method of preparing rubber ever devised. It is hard to see how any better method can be applied on the estradas, which are always too scattered to support a central factory of any size. Various fancy drums, etc., for smoking the rubber have been patented and recommended by different people, but none of them are so simple as the native method, none are so cheap, and none are so good for the purpose they have to serve. Though we now know that as good rubber can be produced by other methods as by smoke coagulation, there is certainly no other method by which as good rubber can be made under the conditions which exist on the estradas.

The task of smoking the rubber is not a pleasant one; it may even be a somewhat unhealthful one, but for the present it must be continued until it is shown that another one is as good and costs no more.

One small change in preparing ball rubber is to be recommended. As has been said, the ball is begun by wrapping a mass of naturally coagulated rubber around a pole, so that sufficient surface is provided to begin the formation of a ball. This naturally coagulated rubber is sometimes very dirty and is always classed as sernamby. In some places the seringueiros start pouring latex over a large block of imbauba wood (*Cecropia* sp.) which has been cut into the form of a ball, with a projecting rod at either end. Imbauba wood is very easily cut, so this shaping is not difficult. Over this ball latex is poured and smoked until a considerable mass is secured. This layer is then cut, pulled off the block, and wrapped on the pole used for smoking the rubber, to form a foundation for a ball. When a ball so started is completed it consists of nothing but smoked rubber throughout and is uniform in quality. Increased care in handling the latex at all stages is desirable, so that more of it may be made into fine hard Para and less into sernamby. Greater cleanliness of cups has already been suggested as a means of reducing the formation of lump. More care in keeping the sernamby free from unnecessary dirt and contamination would be a decided advantage, while the bark and earth rubber could be collected without great expenditure of labor and would add to the income of the collector even though the price were low. At present practically none of this is collected in most estradas.

RUBBER RESERVES OF THE AMAZON VALLEY

It is doubtful whether anyone knows even the approximate number of trees in the Amazon Valley which have been exploited. As to the virgin trees even less is known, but it is known that there are great areas in which rubber trees occur in considerable numbers. In some of these areas the rubber trees are said to be a large percentage of the stand. General Rondon, the leader of the Roosevelt-Rondon expedition, is reported by Oakenfull (*29*) to have found a great area of jungle in Matto Grosso, between Porto Velho and Cuyaba, where the rubber trees occur in an almost pure stand. In a letter to the writer General Rondon said the report of Oakenfull was probably not quite correct, but the proportion of rubber trees in many places was surprisingly high, perhaps as great as 50 per cent.

Lecointe (*25*) estimates that on the lower Amazon the jungles have 8 to 10 rubber trees per hectare; in the Acre district there are about 15 per hectare; while in some parts of Matto Grosso there are as many as 25 per hectare. Akers (*1*, *2*,) states that in general the rubber trees are from 200 to 250 feet apart, which appears to be nearly correct. Lecointe's percentages are certainly higher than will commonly be found. Doubtless there is great variation in the stand of rubber trees in different places, but the writer doubts whether the tappable rubber trees average more than 2 per cent of the stand of the Amazonian jungles. But even at this rate the number of rubber trees is very great, perhaps not hundreds of millions, as Akers states, but certainly many millions.

These trees offer a real reserve of rubber which would be available to the Western Hemisphere in case a crisis of any sort cut off the Eastern supply. In such a case the price of rubber would quickly rise to a point which would make exploitation of these trees possible, and a large quantity of rubber could be secured in a short time.

Modern methods of tapping could be used on these virgin trees, and such methods could the more readily be applied because the greater part of the tappers would be new men who had never tapped by the older methods and who could easily learn the new ones.

The greatest difficulty in this exploitation would probably be the rapid recruiting of labor for the industry, and transportation facilities would need great improvement and extension.

Whatever the difficulties may be, there is no doubt that a serious shortage of rubber would lead to the exploitation of these trees. For the present there is little likelihood that these reserves will be drawn upon, but they will remain a great resource until such time as a need for them arises.

PLANTATION POSSIBILITIES IN THE AMAZON VALLEY

It was a great disappointment to the members of the expedition not to be able to find any plantation of rubber trees which had been planted and maintained in the same way as a good oriental plantation. If such a planting exists there it was not located, though many planted trees were seen. Therefore, it is impossible to make direct comparisons with oriental plantations, and conclusions must be drawn from various small groups of planted trees as well as from the self-sown jungle trees.

There is no reasonable doubt that rubber will thrive in many different parts of the Amazon basin. In some of these regions there are indications that it will develop equally as well as on the best rubber lands in the Orient; in others its growth will probably be better than on many areas now planted to rubber in the East. There is no indication that the tree will develop more rapidly or produce more abundantly in any part of South America than in other regions to which it is not indigenous but which are fitted by soil and site for its growth. There is no indication, however, that the tree will not grow fully as well in selected areas in the Amazon basin as in selected areas on the Malay Peninsula or in the East Indies. That rubber plantations have not been established in the Amazon basin has not been because the trees would not thrive there but because of other considerations.

One of the conditions of greatest weight in the determination of future development is that of labor. A greater supply of labor would be necessary than is now available in this region. Probably enough laborers could be procured from Para to make a beginning, and the prospect of regular employment might bring a new supply of workers from Ceara and elsewhere. However, the people of Para would have to be cured of their dislike of going up river to work, and the number of laborers available in Ceara is variable. The immigration and colonization of Europeans would be another solution, but immigrants thus far seem to prefer southern Brazil to the Amazon Valley. Colonization would take time, and while it would ultimately reduce the cost of living it would probably not bring very cheap labor. It would provide labor sufficiently skillful to use tractors and other machinery which could be employed more profitably than where labor is very cheap or where competent mechanics and operators are hard to find.

A third possibility is that of procuring cheap labor from Asia. This would probably mean Chinese labor, for the British plantations in the Federated Malay States and elsewhere make use of most of the labor which can be recruited from India, and it is doubtful whether Javanese could be induced to migrate so far, even if the Dutch Government would permit it.

Chinese laborers can undoubtedly be procured in sufficient numbers, but the proposition of importing them is not without difficulty. The Chinese Government makes stipulations as to housing and medical and hospital care, etc., which preclude the use of Chinese except in rather large numbers. Therefore, companies with large capital will be the only ones capable of importing this labor, unless groups of smaller companies form associations for this purpose.

Bolivia has given consent to the importation of Chinese for the rubber industry, and Brazil will likely follow its lead. However, many Brazilians are strongly opposed to allowing the entrance of Chinese labor. They do not care to save the rubber industry at the cost of reduced wages in their country and the menace of competition with the Chinese in the future. From an agricultural standpoint there is no question that the Chinese would be a benefit to the Amazon Valley; the economic and social consequences of their introduction are outside the scope of this discussion.

Plantations started in the Amazon Valley now would have the benefit of the planting knowledge which has been developed by the Eastern planters. Many mistakes which were made in the beginning of rubber planting could be avoided. For example, no one now would think of planting rubber in swampy water-logged soil, but such soil was originally considered a requisite for the successful development of the trees. Friable well-drained soil with an ample water supply, the sort best suited to rubber trees, is abundant and should be carefully chosen.

Eastern experience has shown the importance of planting only stock of the highest quality. Formerly seed of any sort was planted, emphasis being laid only on the percentage of germination. Some planters insisted on procuring seeds from old trees, a practice which seems to have no scientific basis, but until recently none of them insisted that seeds for planting should be taken from trees of high yield.

Plantations grown from miscellaneous seeds show great variations in the yielding power of the trees, and it is not always possible to save all the good trees and eliminate the poor ones in thinning operations, because the distribution of good and bad trees is not uniform.

Selection of seeds of high-yielding trees in plantations offers some advantage, but on account of the large proportion of cross-pollination it can not be depended upon to give progeny of much greater uniformity than common seeds (*19*). Seeds from special seed gardens containing only high-yielding trees should be used.

Budding young stock with buds from selected trees offers a means of obtaining a much higher yield than propagation by ordinary seeds. Donkersloot (*7*) describes the practical methods of budding on a plantation scale which were developed in Sumatra under the direction of the writer or in collaboration with him. The preservation of wood for budding, so that it may always be available for use and may be transported to considerable distances from its source, is absolutely essential to success in budding on a practical plantation scale. Methods for doing this were developed by the writer, and they make possible the transportation of bud wood even from one continent to another. These methods also are given by Donkersloot in the paper cited.

If budding were practiced in these hypothetical plantations some difficulty would be met in selecting trees from which to take buds. The actual yielding power of the jungle trees is difficult to determine, because the trees are of varying ages and some have been subject to much more severe competition in the jungle than others more fortunate. The experience of Eastern workers will need to be supplemented by careful studies before suitable methods can be developed for the selection of trees, either for seeds or for bud wood.

Recent trials of budded trees indicate that the character of the stock exercises a considerable influence on the scion. This is more pronounced in some cases than in others. That this might have been expected was shown by some preliminary experiments on the flow of latex which were performed several years ago by the writer on the Sumatran plantations of the United States Rubber Co.

Records of individual yields of a group of trees were kept for some time, to determine the normal range of variation from day to day. Some of these trees were kept in tapping as a check plat. The others were girdled by a cut made through the bark to the wood. With some of the trees this had no effect on the yield whatever; in other cases there was an immediate decrease in yield, which in some trees was very noticeable.

Later, in successive periods, girdles were cut, at higher and higher levels, so that they were nearer and nearer the tapping cut. Again the trees behaved differently. Some showed no decrease in yield until girdled very near the tapping cut. It may therefore be expected that the influence of the root will be great on some budded stock and of little significance in other cases. To secure the highest possible yields the stocks for budding should be grown from selected seed.

The use of cuttings might insure uniformly high-yielding trees, but cuttings of Hevea are extremely hard to root. Out of hundreds of cuttings the writer was able to grow only one tree. Furthermore, there is some uncertainty as to the type of root system which will develop from a cutting. It is also impossible to take a great number of cuttings from a superior tree, while a single tree will supply a large number of buds. For the present at least, propagation by cuttings is not practicable for plantations.

In addition to using the latest methods of propagation and planting, a rubber plantation in South America would need at every step the advice of the best authorities obtainable. Anything like a boom development is almost certainly destined to fail.

On account of the expense involved in securing experienced advisers, in importing labor, etc., organizations with small capital are not likely to succeed unless a considerable number of them form an association, so that the costs may be distributed.

In some cases it may be possible to combine the collection of wild rubber with the development of plantations. If cheap labor could be procured for the plantation, it could also be used for collecting rubber, and with improved methods of tapping and collection and with better freight rates the wild rubber reserves might become a substantial asset to the plantation.

The slight development of agriculture in general in the Amazon country increases the difficulty of establishing rubber plantations. The agricultural possibilities of this region are truly great, and when they are even partially developed a large population will be able to live on the products. Such magnificent areas as the Acre district should not long remain unused. The possibility of combining rubber growing with the planting of other crops should not be overlooked.

THE LOWER AMAZON REGION [4]

From the trees examined in the lower Amazon region one is not favorably impressed with plantation possibilities there. Most of the old trees, it is true, have been exploited for a long time and have been subjected to great abuse, so that one would not expect them to be in very good condition. Such trees as have been planted have in nearly every case received so little care as practically to guarantee their failure.

At the Campo de Cultura Experimental Paraense, near Para, a considerable number of Hevea trees have been planted, some of them as early as 1910. None of these trees have made a satisfactory

[4] This section refers only to the land which lies immediately along the river and not to the extensive areas south of the river which are reported to be suitable for rubber cultivation.

growth and many of them show severe die-back. None of the area has been clean weeded, and practically all the trees have been planted too close except those interplanted with other trees, where interference is just as great. The soil here appears not to be good, so there is a combination of unfavorable circumstances.

At Utinga, outside Para, there is a small plantation which is now clean weeded, whatever its past treatment has been. The soil is rather sandy, and the appearance of the trees suggests that of trees in sandy areas (permatangs) in Sumatra. The age of the trees could not be ascertained. Bark measurements were made at three different heights from the ground. The average for 36 trees was 6.4 millimeters at 1 foot from the ground, 6.1 millimeters at 2 feet, and 5.9 millimeters at 3 feet.

Planted trees, most of which were in poor condition, were observed at various points along the Braganca Railway. Nearly all of them are undersized for their age, and most of them have the bottle-shaped trunks characteristic of trees grown in poor soil. On all of them the bark is very hard and contains little latex. The best trees seen at the experiment station were from Igarape Assu. These were 10 years old and of nearly normal size. The bark was soft and very full of latex. These trees were grown from seeds brought from the Acre Territory, and their superiority may be varietal rather than due to site and treatment.

In Table 8 girth measurements are given for trees from a number of different plantings at Cocal Grande, near Obidos. This plantation is the property of Paul Lecointe, who has done experimental work on rubber for many years. Most of the trees were planted between rows of cacao. The older trees are growing in an alluvial loam which is well drained. Most of these are now fine trees, though not so large as they should be for their age. The six trees grown from seed from the Purus are very superior in their development.

Table 8.—*Girth measurements of rubber trees in the lower Amazon region*

Location	Age (years)	Number of trees	Treatment	Girth at 1 meter (centimeters)	Remarks
Cocal Grande, near Obidos	19 to 20	1	Planted between rows of cacao	102	
	21 to 22	8	do	132	
	23 to 24	9	do	139	
	25 to 26	4	do	139	
	(?)	3	do	129	
	24	6	do	170.5	Seeds from Purus.
	11	14	Jungle cleared and planted 4 by 4 meters.	58	Very poorly developed.
Cacoal Imperial, near Obidos	15	3	do	125	
	13 to 14	30	Planted in cacao, 4 by 4 meters.	70.2	Do.
	13 to 14	18	Planted in cacao, 5 by 8 meters.	93	Do.
Cainama (old trees, age doubtful).		3		166.3	Do.

The other trees are growing in heavy clay, which is submerged from one to two months each year. All of the trees have been planted rather close, and in the main they have not had proper care. The ones not interplanted with cacao have grown up in grass. Many of them are badly affected with leaf disease. They are generally stunted and much below the size they should be for their age. The writer (*20*) found that a group of nearly a thousand trees in a representative area in Sumatra had an average girth of 80 centimeters at 8 years of age, which is much superior to the growth of any of these.

At Cacoal Imperial, also near Obidos, a number of trees were seen, all of them between 13 and 15 years old. Their growth is a little better than that of the trees at Cocal Grande, but they are not in a vigorous condition at present.

The best area of planted rubber seen on the whole journey was that at Seringal Miry, an experimental planting near Manaos (fig. 11). Most of the trees were planted 30 by 16 feet apart on ground which had been plowed and prepared. Stumps were used for the planting, which was done in 1915. Sixty of these trees were measured and

FIG. 11.—Trees of *Hevea brasiliensis* at Seringal Miry, Manaos. This is the best area of planted rubber trees seen in the Amazon Valley

were found to have an average girth of 72.3 centimeters at a height of 1 meter from the ground.

A group of five old trees grown from seeds from the Jurua is also to be seen there. The age of these trees is uncertain—at least, efforts made to ascertain it were fruitless—but their size (178 centimeters average circumference) suggests that they are over 20 years old at the very least.

At Cachoeira Grande, near Manaos, the Campo Experimental of the Sociedade Amazonense de Agricultura is located. The largest trees here are 12 years old and have an average girth of 88.7 centimeters. All the trees are much neglected now, and practically nothing is being done to develop this once ambitious experiment station.

A plantation here of trees about 6 years old is in very bad condition. All are stunted and unhealthy in appearance, and most of them are seriously attacked by die-back.

In general, the condition of the bark on the trees in the lower river region is very bad. Both virgin bark and renewed bark are very thin and hard. Table 9 gives bark thicknesses and numbers of latex-vessel rows for a number of trees from various points in this area. Most of the data are from untapped bark, but on very old trees it is often impossible to be sure that any of the bark from the ground level up to a height of 10 feet is really virgin bark. However, the greater part of the data in Table 9 are from untapped trees and certainly represent virgin bark.

TABLE 9.—*Bark development of rubber trees on the lower Amazon*

Locality	Number of trees	Age of trees (years)	Character of bark	Circumference of trees at 1 meter (cm.)	Bark thickness (mm.)	Rows of latex vessels	Remarks
Colonia de Outeira	15	12	Very hard, little latex.		6.6	11.1	Grown among fruit trees, no cultivation.
Do	28	20	Very thin and hard.			13.4	Old stumps of trees cut years ago.
Pinheiro (old trees)	4		Much tapped	141.3		11.7	
Japacany Island	15	11	Thin and hard		4.8	10.1	
Japacany Island (old jungle trees).	22		Much tapped			17.5	
San Francisco de Jararaca (old jungle trees).	22		do			13.5	
Itamaraty	1	2?			3.0	11	
Do	4	3?		47.1	4.4	12.5	
Do	1	4?			5.5	12	
Itamaraty (old tapped trees).	2				6.3	13.3	
Cocal Grande, near Obidos.	1	19	Bark very hard	102.0	3	9	
Do	7	21 to 22	do	124.5	5.6	14.1	
Do	9	23 to 24	do	138.8	5.1	14.3	
Do	4	25 to 26	do	148.7	5.3	16.3	
Do	3	(?)	do	129.3	6.5	14.3	
Do	6	24	do	170.5	7.1	15.8	Seed from Purus.
Do	14	11	do	58.0	4.3	8.7	
Cacoal Imperial, near Obidos.	18	13 to 14		93.2	5.0	10.6	
Do	28			69.1	4.1	9.3	
Parintins	4	15+			6.8	15.5	
Itacoatiara (old trees).	6				6.3	17.1	
Cainama (very old trees).	3		Bark fairly hard	166.3	12.0	25	
Cainama (planted trees).	29?				5.8	16.3	

The thinness of the bark and the small number of latex vessels are shown by these data, which were taken from 246 trees. With the exception of a few at Itamaraty all the trees are 11 years old or over, but the bark thickness and the number of latex-vessel rows are far below the means of 9.05 and 20.78, respectively, for the average area in Sumatra already mentioned at eight years. Only three very old trees at Cainama were above this average bark thickness; these also had an average number of latex-vessel rows higher than that of the Sumatran area. But these trees were undoubtedly well over 20 years of age.

The few trees at Itamaraty are very exceptional in girth as well as in bark thickness and number of latex vessels, if the ages given for these trees are correct. But there is very great doubt whether the ages are even approximately correct, both because the development is so very different from other trees in the region and because a general tendency was observed in the rubber country to give far too low an estimate on the age of planted trees. Even if correct, the data from these few trees can not counteract the general impression that bark development in the whole area is as backward as growth in general.

The younger trees at Seringal Miry have an average bark thickness of 6 millimeters and an average of 9.6 rows of latex vessels. The old trees from Purus seeds have means of 5.5 millimeters and 17.5 for bark thickness and rows of laticiferous vessels, respectively.

The 12-year-old trees at Cachoeira Grande, near Manaos, have a mean bark thickness of 5.3 millimeters and an average of 12 rows of latex vessels.

The lower Amazon has a great advantage as a plantation site for the rubber industry on account of its proximity to the sea and transportation facilities to both New York and Europe; but the evidences available do not point to it as a favorable location for plantations, because the trees do not appear to thrive there. Neither has the region ever been noted as a producer of high-grade rubber. At best one can only hazard a guess as to the reason for this, but it is possibly one of soil. A great deal of this land is permanently water-logged; other areas are better drained but are not fertile. The uplands, such as one sees in the direction of Braganca, do not appear to be especially well suited to rubber. The temperature throughout the rubber country of Brazil and Bolivia is well suited to rubber production in that the thermometer never reaches a dangerously low point. Rainfall, too, is probably adequate in most regions, though the dry season is rather long for the best growth of the trees.

THE VALLEY OF THE MADEIRA RIVER AND ITS TRIBUTARIES

As on the Amazon, not many trees of known age are to be found in the Madeira River region. In the aggregate doubtless a fairly large number have been planted, but these are mostly in lots of 10 or fewer around dwellings, and it is not certain that the ages of even these are correctly recorded. Larger plantings are extremely rare. Data from a number of plantings and several groups of old jungle trees are shown in Table 10.

In general one feels that the planted trees here are rather smaller than they should be for their age but not so backward as the trees on the Amazon. The girth of the trees is somewhat greater, and the condition of the bark is better. The bark is thicker, much softer, and has a larger number of latex vessels. Conditions of planting and culture are about the same as on the Amazon, but in general the soil on which these trees were planted is better than that of the lower Amazon. Most of these trees are growing either on terra firma, permanently above the flood level of the rivers, or on varzea alta, which is alluvial soil well drained and subject to only occasional floods. These conditions allow better root development than is possible in water-logged soils. According to a preliminary report by C. F. Marbut, who accompanied the expedition as a member of the party from the Department of Commerce, the soils of the Madeira, especially the upper Madeira, are superior to those of the down-river areas.

TABLE 10.—*Data on rubber trees from the region of the Madeira River and its tributaries*

Locality	Number of trees	Age of trees (years)	Circumference at 1 millimeter (cm.)	Bark thickness (mm.)	Number of rows of latex vessels	Remarks
Urucurituba, Brazil	5	±20	108.6	7.3	22.4	Close planted with cacao, oranges, and coffee; on terra firma.
Diamantino, Brazil	26	12	95.4	7.1	17.9	On terra firma; tapped for three years.
Do	3	±100	310	7.7	23.0	Tapped for over 30 years.
Eden do Rosarinho, Brazil.	12	(?)	135	7.2	19.1	Rubber trees planted among coffee, cacao, and jungle trees.
Itapenima	1	12	101 105	5.0	13	Tree with two trunks; on terra firma.
Democracia	2		286.5	10.0	24.5	Very old trees; data from untapped bark.
Do	26	12	104.6	5.8	15.0	Planted on well-drained alluvial soil.
Conceicao, Brazil	100	±25	100.5	6.0	19.9	Planted very close, 180 by 180 cm.; larger ones severely tapped.
Santa Laura	8	25	162.4	8.3	19.9	On fine soil; considerable undergrowth and some coffee in plantation; on terra firma.
Do	31	15	103.7	5.7	13.5	Trees planted on terra firma about 180 by 210 cm.
Rio Ouro Preto:						
Untapped trees	6		172.2	9.5	26.3	Very old untapped trees on varzea alta.
Estrada tapped by the writer.	30		129.2	6.6	19.6	Do.
Jungle estrada	239		114.4	7.1	20.0	Very old jungle trees on varzea alta.
Igarape do Soldanho, Matto Grosso.	18		182.5	8.3	21.4	Very old tapped trees on terra firma.
Sena, Bolivia	5		262.6	12.2	30.8	On terra firma; very old trees, tapped for years.
Do	20		158.0			Very old trees.

The land along the Madeira River is apparently superior to that bordering the lower Amazon, and there are many areas where it appears entirely likely that rubber would thrive if properly cultivated. This is true likewise of the regions above the falls of the Madeira, but these areas are handicapped by the necessity of shipping all supplies as well as the harvested rubber over the expensive Madeira-Mamore Railway. Special considerations might offset this handicap, and increase in traffic might result in decreased rates, but the operation of such a railway is likely to be permanently expensive, and the regions above the falls show no significant advantages over those below.

THE ACRE TERRITORY

The region considered here is that of the valley of the Acre River, which drains land belonging to both Brazil and Bolivia. Planted trees are rather rare here, and the only planting of any size seen was at Curupaety. This, however, was most discouraging. Some 2,000 trees had been planted without any adequate preparation. The jungle had been cleared away and the trees planted, after which little care was given the plantation. Many of the trees are in rather low ground, and as a whole the trees have failed miserably and are now in a badly diseased condition. Two trees were found which had made excellent growth, data from which are shown in Table 11, but none of the others even approached normal development.

TABLE 11.—*Data on rubber trees from the Acre Territory*

Locality	Number of trees	Age of trees (years)	Circumference at 1 meter (cm.)	Bark thickness (mm.)	Number of rows of latex vessels	Remarks
Cobija, Bolivia:						
Garden trees	4	±5	56.1	5.8	10.3	On fine rich terra firma; not planted too close.
Plaza tree	1	16	136	8.0	19.0	Not in good soil nor under good conditions.
Porvenir, Bolivia	127		167.5	8.2	31.0	Old jungle trees, on varzea alta; tapped for many years.
Fazenda Palmaris, below Xapury, Acre, Brazil:						
Much-tapped trees	54		136.1	7.9		Old trees, estrada on terra firma.
Seringueiro house yard.	1	8	95	9.0		Tree growing under fair conditions.
Old estrada	50		187.7	8.9		Very old trees, on terra firma.
Curupaety	2	6	67.5	8.3		Many other trees here of same age, but all uncared for, very small, and diseased.

Four trees near Cobija, Bolivia, were found which had been grown in a garden and had been given reasonable care. These showed a very good development and appeared to be extremely vigorous.

One other tree showing excellent growth was seen in the house yard of a seringueiro, whose wife had planted the tree immediately on her arrival at the seringal and knew its age.

The old trees in the estradas are of great size, and for the treatment they have received their condition is good. The trees are very large and tall and have very thick soft bark which is extremely rich in latex vessels, as is shown in the average of 31 rows for a large number of trees which have been tapped for years. (Table 11.)

The Acre Territory has long been famous for the quantity and the quality of its rubber. On this account, if for no other reason, it is deserving of consideration. Of all areas examined by the writer, this appears the best as regards the growth and development of rubber. Here the largest trees were encountered, and the general appearance of the trees was best, though the data given in Table 11 do not show great differences. Much is to be learned from general observation. Crops of various kinds—corn, coffee, rice, beans, cotton, cane, Manihot, etc.—thrive here and indicate the great possibilities of the region for general cultivation.

There are great areas of terra firma, very well drained and sufficiently level to obviate terracing, except possibly in rare cases. This soil in general resembles the best rubber soils of Sumatra more than any other soils seen in the course of this expedition. Its loose friable condition admits of the extensive root development so necessary for success in Hevea planting. Mohr (*28*) thinks that proper physical condition is the paramount consideration in rubber soils, and this soil of the Acre Territory appears to possess the most desirable physical characteristics.

This region is a magnificent one for colonization, and it appears likely that the territory is one in which the white race can thrive. The climate is not oppressive, nor does it appear deleterious, although the whole region has a very bad reputation as a pesthole. It may have been such in the past but it certainly is not now. Malaria, naturally, is prevalent along the rivers, but the high areas back from the rivers are free from mosquitoes and are surprisingly healthful.

The great distance from a seaport militates against economical production, because all laborers and all supplies for the laborers and for the plantation must be carried over this long stretch of water at rather high cost. An extensive development of plantations in this region would undoubtedly result in an improvement in transportation and cause a decided decrease in freight rates. This territory is after all so much nearer the rubber-manufacturing centers of the world that there appears to be no good reason why rubber should not be marketed from the South American plantations with a lower transportation cost than that of the eastern product. Lower freight rates on supplies for the plantations should also result in lower production costs than would be possible at present.

OTHER REGIONS

Reports have it that there are superior lands on the upper stretches of such rivers as the Tocantins, the Tapajos, and the Xingu. If these are the equal of the lands already mentioned, they should be excellent for rubber planting on account of their accessibility. Their proximity to Para would greatly reduce transportation rates and to that extent help to reduce production costs.

TYPES OF HEVEA BRASILIENSIS IN THE AMAZON VALLEY

There has been considerable confusion about the types of rubber trees exploited in the Amazon Valley, particularly in regard to the native names applied to them. Mention has been made of the rubber-bearing species other than *Hevea brasiliensis*. Since these are all recognized as inferior and of lesser importance in exploitation and of no immediate value for planting, there is no need to discuss them further.

It seems to be almost an article of faith with the seringueiro that three types of trees exist—seringa branca (white), seringa vermelha (red), and seringa preta (black). Various other names are applied to other species; in fact, seringa vermelha is most often applied to a species other than *Hevea brasiliensis*, usually *H. collina*. In the island region and on the lower Amazon the preta tree is rarely seen, but the branca and vermelha types are common. Sometimes the vermelha is spoken of as rosa; at least no distinction could be made between vermelha and rosa except that one man would use one term and another the other.

Both these types of trees are obviously *Hevea brasiliensis*. The only distinction which is used in determining to which type a tree belongs appears to be the color of the inner bark. In the branca type the inner bark is whitish in color with tan flecks in it. In such trees wounding causes the formation of bark which is red in color. This is the type of bark which is predominant on the trees in the Orient.

The vermelha trees have red or reddish inner bark, which is otherwise quite the same as in the branca type. The distinction between the two as usually applied means nothing. A branca tree badly chopped with a machadinho will present red bark over all its lower trunk and on superficial examination might be classed by the seringueiro as vermelha. There are also intergradations between the two types, so that frequently it is hard to say whether a tree belongs to the one or to the other. These two sorts may be separate varieties, and the fact that true vermelha trees are rare on eastern plantations, if indeed they occur there at all, seems to lend weight to this idea. Breeding tests alone will tell the truth about these relationships.

The names "seringera boa (good rubber tree)" and "seringera verdadeira (true rubber tree)" are common in this region also. They do not refer to the type of the tree, but rather to the type of rubber produced. A tree which produces strong rubber will always be called by one or the other of these names, but they are not applied to a tree which produces borracha fraca (weak rubber).

On the Madeira River and its tributaries and in the Acre Territory the names used for different types of trees are the same as on the lower Amazon, but the basis of classification appears to be somewhat different. The type known as seringa branca on the lower river, that is, the one with white inner bark, is not common here, though it is occasionally seen along the river banks, but the name is used here to designate trees which have a trunk with a whitish exterior. This appearance is due to a development of soft light-colored cork, and it often happens that it is developed on one side of the tree and not around the whole trunk. So a tree viewed from one direction might be called a branca tree, but from another direction it might be classed as something else. This type of cork development is found on plantation trees in Sumatra, though it is not common and does not give so light a color to the trunk. It is very certain that the so-called branca type of the upper rivers is not a true type at all.

The vermelha or rosa trees are so named from the color of the inner bark, as on the lower rivers. The preta trees are distinguished by an inner bark which varies in color from dark red to a very deep purple. This type of bark is very different from anything which exists on the eastern plantations. The true preta tree has also a very thick bark, which is soft and contains a much smaller number of stone cells than the vermelha, the branca, or the plantation type of tree. This bark contains a large number of latex vessels and is very full of latex.

There is no sharp line of demarcation between the vermelha tree and the preta, though it is easy to distinguish typical representatives of the two sorts.

Ule (*42*) considered that the branca and preta (narrow-leaved) types are varieties of *Hevea brasiliensis*. These he called, respectively, "variety *latifolia*" and "variety *angustifolia*." The types can not with certainty be thus separated, for when the leaves of numerous trees of each kind are examined they are found to be not distinguishable.

LEAF CHARACTERS

So far as the writer was able to determine, it is not possible to separate any of these types from the others on the basis of leaf characters. Huber (*9, 11*) has probably gone as far as anyone can in distinguishing types by the use of leaf characters. In some cases his species based on such characters seem very imperfectly defined, and the leaf typical of *Hevea brasiliensis* is very like that of some of these other species. Perhaps one ought not to speak of a form of leaf as typical of *H. brasiliensis*, because of the great range in variability of leaves within this species. This is shown particularly well on the plantations of the East where within a short time one can see thousands of trees of the same age which have a similar habitat and nurture. In the forests of Brazil and Bolivia it is very hard to collect leaf specimens from the mature trees on account of their great height. It is rarely possible to find a man who can or will climb these trees. In many cases leaves could be secured only by cutting them off with a shotgun or rifle. Leaves or twigs cut off in this manner often lodge in branches out of reach, and specimens are finally obtained only at a great cost of time, patience, and ammunition.

Leaves of a considerable number of trees of various types and from widely separated regions were studied, but they were of little use in tracing the relationships of the various strains. In general, the leaves of these trees showed less variability than those of the trees in the Orient. This may be due to the hybrid character of the Eastern trees; it may equally well be due to the smaller number of South American trees on which it was possible to make observations.

FLOWER CHARACTERISTICS

What has been said about the difficulty of collecting leaves applies even more forcibly to floral characteristics, since the collector can not visit the various regions during the flowering season of a single year. Some trees are found in flower at almost all times of the year, and one has to depend on these if he visits a region at other than the regular time of flowering. When such a tree is found, floral specimens are harder to obtain than leaf specimens because it is much easier to shoot down leaflets than flower clusters.

The inflorescence of *Hevea brasiliensis* in Sumatra and Java has been well described by Arens (*3*), Sprecher (*39*), Maas (*26*), and Heusser (*8*). Those of the Amazonian representatives of the species are in all respects like those described. Variations in South America, as in the East, occur principally in the size of the flowers. Certain trees are found which bear flowers considerably larger than the average, but the writer has never found that these were indications of a special type of tree.

SEED CHARACTERS

It is a difficult matter to collect representative seeds on a journey such as this. When the Madeira region was visited the seeds were not yet ripe, and the seeds of the past season had either germinated or decayed. It was found that the shells of many of the germinated seeds could be found at the bases of the young seedlings, and sometimes a considerable number could be picked up under a given tree. These still retained their original shape and size, but were usually so discolored as to show nothing of the color patterns. The loss of the color patterns is probably not serious, as they seem to vary with every tree. In Sumatra, the writer (*17*) studied collections from hundreds of trees, but never found two collections which showed the same color pattern. Yet the pattern for a given tree is so definite that it may be used in determining which of the seeds picked up under a certain tree belong to that tree. The range of variation in the seeds of a given tree will include some seeds which resemble certain rather wide variations from the type of another tree, but they can still be distinguished by plantation laborers with sufficient certainty for routine selection of seeds for planting.

In the Acre district many trees were found in fruit, but not many of the fruits were fully ripe. Where the seeds were falling, as was shown by the open carpels on the ground, it was often very hard to find more than a few seeds. This is partly because of the distance to which the seeds are thrown when the fruits burst, so that they scatter over a considerable area and are hidden by the carpet of leaves and undergrowth, and partly because of the liking which deer, pigs, and other animals have for the seeds. The seeds are generally considered poisonous, but do not seem to affect these animals.

Table 12 presents the measurements of seeds from various regions. The most striking thing about the seeds first collected in the Madeira region was their small size. They are on the average very near the size of the smallest seeds found in Sumatra by the writer (*17*) and by Sprecher (*39*). It is possible that their small size indicates that they were borne on very old trees. It is frequently said that seeds borne by old trees are smaller than those from young trees. It seems that no one has ever determined the facts, so far at least as Hevea seeds are concerned. The writer has not had an opportunity to make any study of the matter, but scattered observations lead him to believe that there may be a difference in this respect between young trees and really old ones.

TABLE 12.—*Measurements of Hevea seeds from the Amazon Valley*

Locality, number of tree, etc.	Dimensions (mm.)		
	Length	Breadth	Thickness
Igarape do Soldanho, Matto Grosso:			
No. 7	21	19	15.5
	19.5	18	15
	20	18	15.5
	20.5	18	15
	19	17	14.5
	19.5	17.5	14.5
Average	19.9	17.9	15.0
No. 9	21	16	12.5
	20	17	12
	19.5	16.5	12.5
Average	20.1	16.5	12.3
No. 11	22	19	17
No. 18	21	18.5	16
	20.5	18.5	15
	21.5	18	16
Average	21.0	18.3	15.7
Sena, Bolivia:			
No. 2	22.5	21.5	15
	22	19.5	14.5
Average	22.3	20.5	14.8
No. 3	31	24	18.5
No. 10	26.5	21	19
No. 11	29.5	23	18
No. 13	25.5	19.5	16.5
No. 20	21.5	19.5	17.5
	23.5	20	17
	22.5	20.5	18
	21.5	18.5	17
	21	18	15.5
	23.5	21	18
	22.5	20.5	18
	23.5	21	18
	22.5	22	17
Average	22.4	20.5	17.3

Locality, number of tree, etc.	Dimensions (mm.)		
	Length	Breadth	Thickness
Museu Goeldi, Para:			
No. 1	27	24	20
	26.5	21.5	18
	27.5	23	19.5
	25.5	24	20
	25.5	22	19
	25	23	18.5
	26	24	20
	25	21.5	19
	25	23	19
	20.5	20	16
	23.5	20	16
	23.5	20	16.5
	26	22.5	19
	24.5	22	18
	22.5	20	15.5
	22.5	19.5	15.5
Average	24.8	21.9	18.1
No. 2	25	20.5	17.5
	25.5	20	16
	27.5	20	17
	26.5	20.5	17.5
	29	21.5	19
	26	21	17.5
	27	20.5	17
	26.5	20.5	16.5
	27	20.5	17
	27.5	21	16.5
	26	20.5	17
	26	22	16.5
	27.5	20.5	17
	26	20.5	16
	25.5	19.5	17.5
	25.5	21	17
	26	20	16.5
	27	21	17.5
	26.5	19.5	18.5
	24.5	19	18
	24.5	19	17.5
	23.5	19	16.5
Average	26.2	20.3	17.1

TABLE 12.—*Measurements of Hevea seeds from the Amazon Valley*—Continued

Locality, number of tree, etc.	Dimensions (mm.)		
	Length	Breadth	Thickness
Museu Goeldi, Para—Continued.	23.5	19	16
	27	21.5	18
	26	24	19
	26.5	22	18
	25	23.5	18.5
	24.5	22.5	17.5
	26	22	17.5
	26.5	24	18.5
	25.5	23.5	18.5
	25	23 5	18.5
	26.5	21.5	17
	24.5	22	18
	27	21.5	18.5
	26	21.5	17.5
	25	23	18.5
	23	18.5	16.5
	22	19.5	15
	27	20.5	16
	22.5	20	15.5
No. 3	24	20.5	16.5
	26	19.5	17.5
	25	21	17.5
	26	24	18.5
	24	19.5	17
	23.5	19	16
	24.5	20.5	17
	24.5	19	18.5
	26.5	21.5	19.5
	26	20.5	18.5
	25	23	18
	24	23.5	18
	26.5	23.5	18
	25	22.5	17.5
	25	22.5	17.5
	25	20	17.5
	24	22	17
	24.5	20.5	17
	23.5	20	17
	25.5	21	17
	23.5	20	16.5
Average	25.0	21.4	17.5
	27	20.5	17
	27	20	16.5
	27	20.5	17
	25.5	20	16.5
	25.5	20	16.5
	24	19.5	19.5
	26.5	19.5	16
	26	20	17
	24.5	20	16.5
	25	19.5	17
	26	17.5	16
	24.5	19.5	16.5
	24.5	19	16
	25.5	19.5	16
	25.5	21.5	16.5
	24.5	19.5	15.5
	26	19	18
	25	19.5	17
	24.5	19.5	15.5
No. 4	25	20.5	16
	25.5	19.5	15.5
	24.5	19.5	16.5
	24.5	19	15.5
	26.5	20	15.5
	24.5	20	15
	24	20	16.5
	25.5	20	16
	25	20	16
	25	20	16
	25.5	19.5	17.5
	25	20	16
	26	21.5	16
	24.5	19.5	16
	25	19.5	16
	26	20.5	16
	25.5	20.5	16.5
	24.5	19	15
	23.5	19.5	15
	24.5	19.5	16
Average	25.2	19.5	16.3

Locality, number of tree, etc.	Dimensions (mm.)		
	Length	Breadth	Thickness
Museu Goeldi, Para—Continued.	22	16.5	16
	23.5	18	16.5
	24	19	17
	24	18.5	16.5
	25.5	19.5	17.5
	25	18.5	18
	23.5	18.5	16.5
	24.5	19	17
	24	18.5	17
No. 5	23	19	17
	23.5	18.5	15.5
	24	19	17
	23	18	15.5
	23	17	16.5
	24	19	17
	23.5	18	16.5
	24	19	17
	22	18	16.5
	23	18.5	16.5
Average	23.6	18.4	16.7
	26.5	20.5	18
	26.5	21	17.5
	27	21	17.5
	27	21.5	18
	26.5	20.5	17
	28.5	22	17
	25	20	18
	26.5	21.5	18
	25	20.5	17.5
	27	20.5	17.5
	25.5	19.5	17
	25.5	21	16.5
	26	20.5	17.5
	25.5	21	17
	27.5	21	18
	27	20.5	17
	26	20.5	17.5
	26	21	16.5
	26.5	20.5	18
	26	20	17.5
No. 6	27.5	20.5	16.5
	26	20.5	18
	27	21	18
	26.5	21	18
	26.5	21	17.5
	26	20.5	17.5
	26.5	21	17.5
	25.5	20.5	18
	25	20	17.5
	25.5	19.5	17.5
	27.5	21	18
	26.5	20	18
	26	21	16.5
	27.5	20.5	18
	26	20.5	17
	27	21	18
	25	20	17
	26	20.5	17
	26.5	20	17
	26.5	20	17.5
	25.5	20.5	17.5
	25.5	20.5	17
Average	26.3	20.6	17.5
	18.5	16	15
	19	16	15
Hevea guianensis	17.5	14	12
	17	14	12
	17	14	12
	17.5	14	11.5
Average	17.8	14.7	12.9
	27	18.5	16
	25	17.5	16
	26	19	16
	24	17.5	16
	27	20.5	15
Hevea randiana	25	17.5	15
	26	20.5	15
	25.5	18.5	16
	25	18	15.5
	25	18	15.5
	24	18	15.5
Average	25.4	18.5	15.6

TABLE 12.—*Measurements of Hevea seeds from the Amazon Valley*—Continued

Locality, number of tree, etc.	Dimensions (mm.) Length	Breadth	Thickness
Manaos, Brazil:			
Hevea spruceana	45	26	19.5
	46	27	21
Average	45.5	26.5	20.3
Porvenir, Bolivia	27	19.5	16.5
	26.5	19	17
	24.5	18	16.5
	26	19	17
	28	18.5	16.5
	27.5	19	16.5
	27	19	16.5
	26.5	18.5	16.5
Average	26.6	18.8	16.6
Cobija, Bolivia:			
Old tree	25.5	19	16
	25.5	18.5	16
	24.5	18.5	15.5
Average	25.2	18.6	15.8
Tree in square	25.5	20.5	18
	26	23.5	17
	25.5	21.5	18
	24.5	19	17
	26	22	18
Average	25.5	21.3	17.6
House-yard tree No. 2	26.5	21	19
	27.5	22	20
	31	23	21
	29	21.5	19
	27	20.5	17
	27	21	19.5
	28.5	21.5	19
	26	20	18
	27	21.5	19.5
	29.5	22	20
Average	27.9	21.4	19.2
Six trees 4 to 7 years old, said to be seedings of best local variety	29.5	28	18.5
	31.5	23.5	18.5
	28	23	17.5
	28.5	23.5	18
	30	24	18.5
	30.5	24	18.5
	30	23.5	19.5
	30	23	19
	29	23	18
	30.5	24	19.5
	29.5	28.5	19
	30.5	23.5	19
	30	22.5	19.5
	29	24	18
	30.5	23	18
	31	24.5	18
	30	24	18
	26	22.5	17.5
	27	20.5	19.5
	26	23	17
	29	23	19.5
	29.5	19.5	20.5
Average	29.3	23.5	18.6
Itauba (?) trees, estrada at Kilometer 10	24	18	18
	20.5	17.5	16.5
	19	19	15
	19	16.5	15
Average	20.6	17.8	16.1
Collected from estrada at random:			
At Fazenda Palmaris, Acre Territory	25	20.5	16.5
	25	21	17.5
	24.5	21	16.5
	23.5	20.5	17.5
	22.5	19.5	18
	31	24.5	21
Average	25.3	21.2	17.8
Collected from estrada at random—Contd.			
At Porvenir, Bolivia	23.5	20	16
	26	21	17
	23.5	20	16.5
	25.5	21	16
	27.5	21.5	18.5
	26	22	17.5
	24	21	16.5
	23	20.5	14.5
	25	21.5	16.5
	23	19	16
	25.5	21	16.5
Average	24.8	20.8	16.5
At Kilometer 10, Cobija, Bolivia	27.5	19	16.5
	23	19.5	14.5
	24	19	16.5
	24	18.5	16
	27	18	17
	25	22.5	17.5
	24.5	21	16.5
	29.5	23	19
	28	20.5	16.5
	24.5	21.5	16.5
	28	22.5	18
	25	20	17
	23	21	14.5
	27	21	17
	22.5	21	17
	29	23	19.5
	27.5	22.5	18.5
	27.5	21.5	20
	27.5	20.5	16
	25	16.5	14.5
	27	21	17.5
	27.5	23	18
	25	20	16.5
	25.5	20	18
	22.5	20	17
	26	22	16.5
	25.5	19.5	16.5
	25.5	21	17
	25.5	21	16
	25	20	16.5
	28	21	18.5
	26.5	20.5	16.5
	28	20	17.5
	26	20	16
	24	20.5	15
	26.5	21.5	18
	26	22	16.5
	25.5	20.5	16.5
	27	20	17.5
	25.5	22.5	16
	22.5	19.5	14
	27	21.5	17
	29.5	22.5	19
	27	22	18
	28	21	18
	29	19.5	17.5
	28.5	21	17.5
	28	23.5	19
	26.5	22	17
	26	20.5	17.5
	26.5	18.5	14
	26	22.5	16
	21.5	20.5	16.5
	21	19.5	15.5
	22	18	14.5
	18.5	16.5	12.5
	20.5	18	15
	23.5	22.5	16
	22.5	20	17.5
	23.5	20	18.5
	26.5	22	17
	25.5	21.5	16.5
Average	25.6	21.1	16.7

In the neighborhood of Sena, Bolivia, some seeds were collected which were only slightly larger than those from the Igarape do Soldanho, Matto Grosso, whereas others were near the average size of seeds from Sumatra and Java. All these seeds came from large trees, as may be seen by referring to Table 10, where measurements of these trees are given.

From the Acre Territory a larger number of seeds was obtained. These are all normal in size. It may be noted that tree No. 2, Cobija, and the six young trees at Cobija bore the largest seeds. These are all young trees.

The seeds from the Museu Goeldi are very like similar seeds from a plantation in Sumatra. They are all from planted trees, most of them probably grown from seeds from the lower Amazon. For the sake of comparison, measurements of some seeds of *H. spruceana*, *H. guianensis*, *H. randiana*, and *H.* sp. (*itauba?*) are included in Table 12. These show how distinct some of the species are in respect to size of seeds. Such distinction is not to be found between any of the varieties of *H. brasiliensis* so far as could be determined.

None of the seeds of *Hevea brasiliensis* collected in South America have shapes which can not be duplicated in a random collection from a plantation in the Orient, and no shape could be found characteristic of a special type of tree.

The seeds from the Acre region and those from the Museu Goeldi at Para were collected soon after they fell, and the color patterns could be studied. These were entirely typical of the species as grown on the plantations and were of no aid in making varietal distinctions.

To summarize, it may be said that none of the characters of the seeds collected were of any value in classifying the trees which they represented.

FRUIT CHARACTERS

All of the fruits examined resemble very closely those of plantation trees generally, and none were found characteristic of special tree types. Fruits with a number of locules other than three appeared to be fewer than in plantation trees as studied by the writer in Sumatra (*17*); but this difference may be only apparent and not real, since the number of fruits seen in South America was very small compared with those studied in Sumatra.

Table 13, compared with Table 12, shows that the relation of seed length to carpel length is about the same as that shown in the publication cited (*17*).

Table 13.—*Measurements of carpel lengths of Hevea fruits in Bolivia and Brazil*

Tree	Carpel length (mm.)	Tree	Carpel length (mm.)
Tree in square at Cobija, Bolivia	38.5	Hevea guianensis, Museu Goeldi, Para	31
	38.5		28.5
			30
Hevea randiana, Museu Goeldi, Para	37		28.5
	38		29
	39		31.5
	39		31.5
	37	Young trees at Cobija, Bolivia	48.5
	37		49
	38.5		50
	39.5		48
	39		46
	37.5		45
	38.5		49.5
	38.5		45.5
	38.5		47.5
	37.5		47
	38		47

BARK CHARACTERS

Of all the characters which may be easily observed, those of the bark alone offer any aid in distinguishing varieties, and these unfortunately do not admit of measurement. To be sure, the number of rings of latex vessels may be counted, but these vary so greatly among trees of the same type as to give only very general indications. The principal differences are in the relative numbers of stone cells and in the color of the bark.

The vermelha type seems not to differ greatly from the branca in the number of stone cells, but the preta type is remarkable for the small number of these cells, which causes the bark to be very soft in comparison with that of the other types. It is well known that cutting the bark induces the formation of stone cells on and near the cuts, and this greatly complicates observations. Most of the trees in the estradas have been heavily tapped as high as one can reach, and samples of virgin bark are hard to secure. To examine large numbers of virgin trees, which must be hunted out in the jungle, means weeks of search.

It is very difficult to classify the trees in a given area according to bark types. Table 14 shows an attempt at classification in an estrada at Kilometer 10, Cobija, Bolivia. The trees classed as vermelha have a rose-red bark; those called preta have the characteristic bark, which is a very dark red, sometimes almost black, also very soft. There are other bark colors which do not belong to either of these types, and an attempt has been made to classify these as tan or light tan as the nearest colors. A Ridgway color guide would have been very useful in determining the exact color of each.

TABLE 14.—*Classification of the bark of Hevea trees in an estrada at Kilometer 10, Cobija, Bolivia*

Type	Number of trees	Type	Number of trees
Preta	60	Tan to vermelha	5
Vermelha	14	Tan to preta	15
Tan	12	Vermelha to preta	4
Light tan	8	Total	118

Eight trees were found in this lot which had a noticeable development of the white soft cork on the outer surface which causes a tree to be called a branca in this region. Some of these when examined proved to be preta and some vermelha, and a few had a tan-colored inner bark. This shows very well that the branca of the Madeira and Acre regions is not a true type.

The classification in Table 14 was made in the field, and it is possible that a comparison of collected bark samples might have given slightly different results. The preta trees constitute the greater number in this lot, whereas the vermelhas are relatively few. These two types are distinct. The other classes represent slight but noticeable variations. It may be that these merely represent variates in the preta and vermelha populations. From the evidence of this estrada it might be considered that all the trees belong to one population, but the fact that the preta type is not found at all on the lower Amazon and that the vermelha type does occur there argues against this.

The writer agrees with Cramer (*6*) that the testimony of the seringueiro is untrustworthy, at least in the case of individual trees; but it appears likely that he is right in considering that the preta and the vermelha trees represent distinct types. The branca trees of the lower Amazon are almost certainly distinct from the other two types. The branca trees of the up-river country apparently are not distinct from the preta and the vermelha types.

It is possible that the differences between the up-river types and the lower Amazon branca are due to differences in climate and site. Most trees of the branca group are growing under unfavorable conditions as compared with the others. It does not seem likely that such factors play a part in producing the differences between the preta and the vermelha types, since these are found growing in identical situations. The differences between the preta and the vermelha types are much less than those between either of these and the branca type of the lower Amazon. The possibility must be admitted that the former types do not represent varieties at all, but merely variations in one population. The thing that most militates against the probability of this view is the fact that vermelha trees are found on the lower Amazon, whereas true preta trees are not.

RELATIVE VALUE OF DIFFERENT TYPES

The relative value of the various types of trees is difficult, almost impossible, to determine, because of the lack of data from trees of the different sorts grown under comparable conditions. The trees of the lower Amazon mostly are growing under unfavorable conditions and so can not be compared directly with the others. Up-river rubber has long been considered superior to that of the lower Amazon and the islands area; but it is not possible to say to what extent the acknowledged superiority of the up-river grades is due to superior methods of preparation. To-day the difference in the methods of preparation between the up-river and the lower Amazon areas is very great, quite enough to account for great differences in quality. If such conditions have obtained in the past, they may be responsible for the reputations of the different grades of rubber.

The yielding power of the different forms is also unknown, and truly comparative data can not be obtained at present. The trees near Para have been tapped for the longest time and are much mutilated. The condition of the bark is very bad, and this fact explains in part the poor yield of the trees in this area. The writer (*20*) found, as might have been expected, that there is a definite correlation between the rate of growth and the yield of rubber, and this fact further explains the low yield of the poorly grown trees of the lower Amazon.

The relationship of the plantation trees to those of the Amazon has been a matter of interest to the plantation-rubber industry since its beginning. Practically all the plantation Hevea trees both in the Orient and in the Western Hemisphere are descended from seeds taken from Brazil to the Kew Gardens by Wickham in 1876. It was commonly supposed that Wickham's introduction represented the lower Amazon type and that this accounted for the inferiority of plantation rubber. As better methods of preparation of plantation rubber were developed, less and less was heard of the inferiority of plantation rubber, until the prejudices of manufacturers against this product have now almost entirely disappeared. The quality of plantation rubber has also improved as the age of the trees has increased. De Vries (*43*) and others have shown that rubber from young trees is inferior to that from more mature trees. However, the fine hard Para rubber of the up-river regions until very recently has been considered the only grade suited to certain special products, such as cut sheet, for example. The recently developed spraying method of coagulation produces a product which is considered by many authorities the full equal of fine hard Para rubber.

Although fine hard Para rubber held the supremacy, conjectures were constantly made as to whether or not the up-river country did not contain a type superior to that introduced by Wickham. Wickham (*46*) insists that his seeds came from a high plateau between the Tapajos and the Madeira Rivers and that they were not like the poorly grown trees along the lower Amazon, though he does not say they differ in type. Huber (*11*) thinks Wickham's seeds came from the upper basin of the Rio Arapium, three days from Boim on the lower Tapajos, and states that the Tapajos rubber is now an inferior sort.

It has been considered by some that Wickham's seeds represented a hybrid between *Hevea collina* and *H. brasiliensis*. Huber (*10*) says that *H. collina* grows in the region from which Wickham got his seeds and considers it possible that he collected a few seeds of *H. collina* along with the others. But in his studies of eastern plantation trees Huber was unable to find anything like pronounced characteristics of *H. collina*, and he does not think the plantation type is a hybrid of *H. collina* × *H. brasiliensis*.

Whether or not the species of Hevea hybridize readily is not known. Trees supposed to be hybrids of *H. brasiliensis* with *H. confusa* (*5*) were grown in the experimental garden at St. Clair, Trinidad. It seems to be accepted now that these trees were grown from a mixture of seeds of the two species and were not hybrids at all. No authentic cases of hybridity in the genus have yet been reported.

So far as could be determined by this survey, the evidence indicates that the plantation trees belong to the white (branca) type of the lower Amazon. Whether this represents a type inferior to the up-river varieties is rendered doubtful by the excellence of plantation rubber as produced at present. It must not be forgotten that if rubber from the up-river types were prepared by the most modern methods it might still be found superior to plantation rubber. The possibility is great enough to warrant a trial of these types in plantations.

The true relationships of the various types and their relative worth to the plantation industry can only be determined by growing them all together under favorable conditions. A step in this direction has been made by the writer in the introduction of trees from the Acre region into the Canal Zone. A strict embargo on the exportation of Hevea trees producing commercial rubber exists in the Brazilian States of Amazonas and Para and in the Acre Territory, and planting material could not be taken from these regions. Bolivia has no such embargo, and several hundred seedlings and the few seeds which could be obtained were taken from the Acre region of Bolivia to the Canal Zone and planted in the Zone Experimental Garden at Summit.

Because of slow transportation, the material was a long time in transit and arrived in rather poor condition. It was planted during the dry season at Summit, where the conditions in general are not favorable for the growth of the tree. In spite of all care the seeds failed to grow, and most of the seedlings perished. A few still survive, and it is hoped that they will become established and aid in answering some of the questions which have been so often asked. At Summit they can be compared directly with trees of the plantation type which have been introduced from Trinidad and elsewhere.

THE DISEASE SITUATION

A detailed study of the diseases of the Hevea tree in the Amazon Valley is presented in the report of James R. Weir (*45*), pathologist of the expedition, which should be consulted by those interested in this subject. In this report only the general phases of the disease situation as it bears on the rubber industry will be considered, with a few observations in regard to the regions not visited by Doctor Weir.

In general it appears that the rubber planter in the Amazon region would meet about the same difficulties, so far as disease is concerned, as the oriental planter. Most of the ever-present parasites of the eastern plantations, such as Fomes (*33*), Diplodia (*24*), Gloeosporium (*23*), and Pestalozzia (*22*), are found on seedlings or mature trees in the South American jungles and of course would invade the plantations. Many of them are present on these plantations now.

Other parasites will likely pass from the jungle to the plantations and become established there, but it is doubtful whether these are more to be feared than similar organisms which may from time to time transfer themselves from their jungle hosts in Sumatra and the Federated Malay States to the plantations there.

Mistletoes of various types are extremely common on rubber trees in South America. These have been discussed by Doctor Weir, but it may be added here that they are as prevalent in the Purus and Acre Valleys as in the region of the Madeira and its tributaries and along the lower Amazon. Mistletoes are very common on jungle trees in the Orient; but, so far as the writer's observations go, they very rarely attack plantation rubber trees. It may be anticipated that they would be somewhat more troublesome on South American plantations, but it is doubtful whether they would become a serious menace.

The brown-bast disease, which is so serious a problem on eastern plantations, occurs also in the Amazon Valley. The writer in company with Doctor Weir found a tree in the jungle at Utinga, near Para, which showed definite symptoms of this disease. Later Doctor Weir located others, as he relates in his report. In the Acre Territory the writer located a number of trees affected with this ailment. Numerous dead trees in this locality gave evidence of having been attacked by the disease, though it was impossible to be certain of this or of the immediate cause of their death. All the cases noted were of trees which were being tapped very severely. The presence of the brown-bast disease in South America lends weight to the theory that it has a physiological origin.

As a matter of interest, rather than one of economic importance, the writer looked for injuries by lightning, such as have been noted by Rutgers (*35*) and himself (*21*), but no unquestionable cases were found.

The South American leaf disease has been made the subject of a recent bulletin by R. D. Rands (*34*). It was very carefully studied also by Doctor Weir, who found it prevalent in the areas which he visited. It is equally prevalent along the Purus River and in the Acre Territories of both Brazil and Bolivia. Whether the special conditions which have made it so serious a detriment to rubber production in the Guianas will also be found in the Amazon Valley is not known. In any event its presence must be reckoned with, and any serious plan of plantation development must contemplate the thorough study of methods of control of this disease.

OTHER TREES WHICH BEAR RUBBER OR SIMILAR SUBSTANCES

Beside the various species of Hevea, there are a number of other rubber-bearing plants which have been exploited at one time or another. The most important of these, and the only ones from which rubber is now obtained, are species of Castilla and of Sapium. Gutta-percha and balata are also obtained from various South American trees.

CASTILLA

Second to the superior species of Hevea, but certainly superior in quality to the rubber from several species of Hevea, comes that from trees of the genus Castilla. This is known everywhere in the

Amazon Valley as caucho. The writer had always heard that caucho was inferior to Para rubber and had supposed that the generally low prices of rubber had nearly forced it out of the market. On the

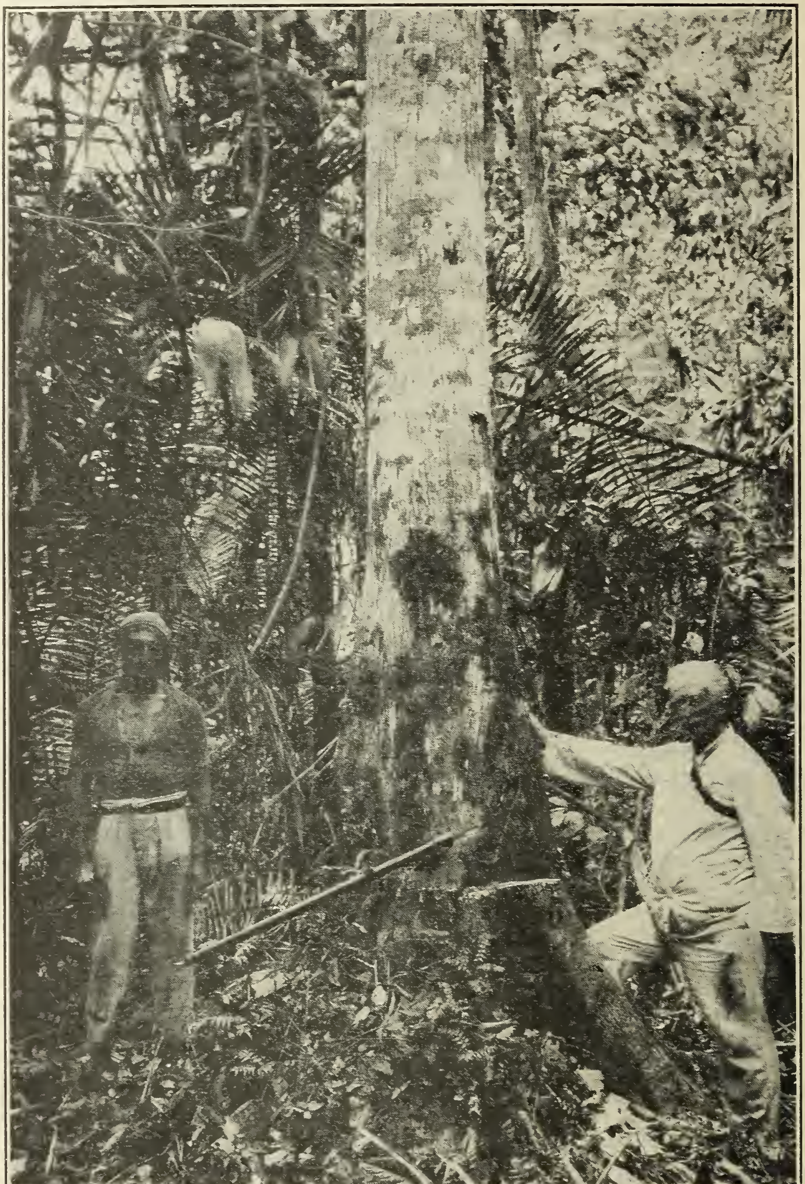

FIG. 12.—A tree of caucho (*Castilla ulei*) being felled for tapping

contrary, he found that it was bought at Manaos and Para for a price only slightly lower than that paid for fine hard Para rubber. Why this is true is not readily seen. Its inferiority in general is conceded by all investigators of the qualities of rubber. It is possible, however, that it is especially suitable for certain uses and that such uses coupled with its comparative scarcity account for its market price.

SOURCES OF CAUCHO

The caucho of the Amazon Valley is obtained from species of Castilla, probably principally from *Castilla ulei* (fig. 12). These trees grow on high ground above the high-water level of the rivers. They are large and grow to approximately the same height as those of *Hevea brasiliensis*. In girth, too, they approach the Hevea trees, though the writer found none so large as the largest Hevea seen.

FIG. 13.—The trunk of the caucho tree shown in Figure 12 tapped by a cut through the bark and extending entirely around the tree. Cuts like this are made about 4 feet apart along the whole trunk of the tree. The latex is usually collected in a hole in the ground, but sometimes vessels are used, as shown here

Since the trees grow on the uplands, most of them are found far up the rivers, and caucho cutters usually have to ascend the rivers much farther than the seringueiros to find profitable areas. As the tree is killed in the process of obtaining caucho, all of the trees of any size have disappeared from the uplands along all of the lower river courses. The process of extermination is going on rapidly, with the result that every year the collectors must go farther afield. Judging by the number of trees which have been cut yearly for a considerable time, the day is not far distant when all the caucho trees in the areas which can be reached by the present means of transportation will be destroyed.

METHOD OF COLLECTING

The latex is collected from caucho trees by felling them and then cutting rings around the trunks which extend through the bark to the wood. These cuts are made between 1 and 2 meters apart (fig. 13).

Holes are dug in the ground under each ring to collect the latex which runs out of the cut ends of the latex tubes in the bark. Sometimes basins are used as containers of the latex, but this is not the common practice.

As it flows out, the latex tends to separate into a dark thin liquid and a frothy light-colored portion which floats on the top. The flow of the latex is very rapid, and the quantity obtained from a given cut is much greater than in the case of Hevea.

The pools of latex under the trunks are allowed to stand until coagulation is complete. In some cases the juices of certain plants are added to bring about coagulation. This seems not to be a common practice in these days, and coagulation appears to be due to the putrefaction of various constituents of the latex. When the coagulation is complete the coagulum is removed to a stream and soaked for one to two weeks to remove the adhering earth as well as the ill-smelling, partially decomposed latex constituents. The coagulum is then beaten into flat sheets, packed tightly, and pressed into bales, which are tied around in both directions with strips of the raw rubber. Figure 5 shows typical bales of caucho rubber.

The yield from a caucho tree is reported to be as much as 20 or 30 kilos of rubber, and a cauchoeiro may collect from 2,000 to 3,600 kilos in six months. When rubber is bringing a good price caucho cutting is profitable, and most of the laborers of the region prefer this work to collecting Hevea rubber. Whether the preference is altogether due to the difference in monetary return is not clear. It seemed to the writer that caucho cutting had the preference even when the prices of the products made the differences in financial return hardly more than nominal. The work of collecting caucho is likely to involve less wading through swamps, because Castilla grows only on high ground, whereas Hevea is found in the swamps also. Then, too, the preparation of caucho does not involve the decidedly unpleasant task of smoking the rubber, and possibly there are other reasons for preference for caucho cutting.

AVAILABLE SUPPLY OF CAUCHO RUBBER

It is not possible to give a really significant estimate of the available quantity of caucho. It is commonly reported that Castilla extends in all directions far beyond the limits of *Hevea brasiliensis*. The number of trees in the more distant reaches of its distribution must be very great, but perhaps the greater part of these will be found inaccessible.

At the present time caucho cutting is going on at almost the extreme limits of navigation on many streams. This means the limit of travel even by a canoe at high water. Regions not reached by such streams can be tapped only when the demand is sufficient to warrant the development of trails and the introduction of mules. In all these regions mules are expensive and short lived.

The Castilla trees are apparently not reproducing themselves in the jungle to any extent, although young trees are occasionally found. Such reproduction, even if much more extensive than it appears to be, is of little significance, because the trees which are destroyed range in age from 40 to 100 years, and it would take many years for the new trees to reach a profitable size for cutting.

METHODS OF CONSERVATION OF SUPPLY

Naturally, nothing is being done at present to conserve the available supply of caucho, and it is indeed doubtful whether there is any way to do this. At first glance the destruction of trees to secure a single crop of rubber seems wasteful in the extreme, and one is inclined to think that some method of repeated tapping might be employed. But the history of Castilla in cultivation shows some of the difficulties of this practice.

In the first place Castilla can not be tapped frequently, but must be allowed to rest for some months after each tapping. This works against the tapping of wild trees, on account of the time which must be spent in hunting the trees in the forest. If trails are cut from one tree to another these will become overgrown between tappings, and it will be almost as difficult to relocate the trees as it was to find them in the beginning. This labor can be profitable only where the Castilla trees are much more numerous than is usual.

The nature of the bark offers another difficulty. In this genus the bark is tough and fibrous and is so much injured by tapping that it dies back for some distance on either side of the tapping cut, leaving a gaping wound in which the wood is exposed. Regeneration of the bark over these wounds is very slow, and the exposed wood is almost always attacked by borers, which seriously damage the tapped tree and very frequently cause its death.

A further objection is found in the nature of the latex, which does not readily flow along the tapping cuts, as does the latex of Hevea. Mention has been made of the tendency of this latex to separate into two portions. The light frothy portion blocks the channel of the tapping cut, and much latex flows down the bark of the tree and is lost. This can be obviated, partially though not entirely, by making the tapping cuts nearly vertical, but considerable loss is inevitable.

When each tree is tapped only once or twice yearly the number tapped by one man would be very large and spread over an extensive area. This would necessitate frequent changes of base by the tapper, with duplication of dwellings, etc., an objection which weighs heavily against this system.

In spite of all the objections, it is possible that caucho may be tapped successfully in some areas. The attacks of the borers may be prevented by the application in the tapping wounds of some substance poisonous to the insects. Steeper tapping cuts might reduce the loss of latex, but the other objections appear insuperable except in regions where the stand of caucho trees is much denser than it is in general.

SAPIUM

Numerous species of Sapium occur in the basin of the Amazon, and several of these are known as producers of rubber. Rubber-bearing species of Sapium are known also in other regions, and at one time *Sapium jenmanii* was recommended for planting in British Guiana.

One species of Sapium is common along the lower Amazon and at least some of its tributaries. This is generally known as itapuru or tapuru. By some it has been called *S. biglandulosum*, but, according to Ule (*42*), the typical *S. biglandulosum* is shrubby, whereas the plant in question is a tree of good size. The form found on the Jurua River has been named *S. tapuru* Ule. Whether this is the same as that of the lower Amazon is not certain, but it seems likely that such is the case. The Amazonian form was called *S. prunifolium* by Klotz, but Mueller Argoviensis considers *S. prunifolium* a form of *S. biglandulosum.*

Itapuru rubber was formerly listed, according to Akers, as third in quality of the Amazon rubbers; the black rubber was considered best, with the white next. Other writers consider this rubber about midway between Para and caucho in quality.

At present there seems to be no itapuru rubber in the market, although there is no doubt that latex from Sapium trees is frequently mixed with Hevea latex. Figure 14 shows a Sapium tree being tapped on an estrada with Hevea trees. In some places the collectors do not consider that the Sapium latex lowers the quality of their rubber, but even regard Sapium rubber as superior to that of Hevea.

The writer found the raw rubber from such trees to be very tough and resilient, but was unable to procure samples for further tests. Nor could any data be obtained concerning the response of the tree to repeated tapping. The seringueiros apparently tap any Sapium trees which they encounter in their estradas, but pay little attention to them.

The trees themselves showed that they have been tapped frequently. The scars showed that they had much greater ability to regenerate their bark than Castilla trees, though large slow-healing wounds are much more common than in Hevea.

The trees of Sapium seen by the writer were all tall, with straight columnar trunks and rather small branches. The bark is reddish brown in color, but is usually gray from the growth of lichens. A thin shell on the outer bark is dark red and very hard and brittle. Inside of this the bark is very soft and rather fibrous. It is very full of a latex which closely resembles that of *Hevea brasiliensis.*

A microscopical examination of the bark shows that the latex vessels are very numerous; they appear to be arranged in rows, like the latex vessels of Hevea, but close examination shows that the rows, if they are rows, have relatively few vessels in them and are very closely crowded together. An attempt was made to count the rows of vessels in the bark of several trees at Itamaraty, Para, Brazil, but on account of the crowding together of the rows, the counts can not be considered more than approximations (Table 15).

TABLE 15.—*Observations of latex vessels in the bark of Sapium trees at Itamaraty, Para, Brazil*

Bark thickness (mm.)	Rows of latex vessels	Bark thickness (mm.)	Rows of latex vessels
3	8	6	29
6.5	25	5	18
6	15	6	53
6.5	26	9	130

If the trees at Itamaraty on the lower Amazon were no older than they were said to be, they have made a remarkably rapid growth. Several trees said to be 4 or 5 years old averaged 25 centimeters in diameter and one alleged to be 6 years old was about 80 centimeters in diameter. Probably the trees, especially the last one, were older than they were said to be, but there is no doubt that the tree grows rapidly. The wood is soft and light.

FIG. 14.—A tree of Sapium (on the right) beside a Para rubber tree in an estrada at Paraiso, on the Madeira River

Little is known of the quantity of itapuru rubber which exists in the Amazon, but it is probably not great. The tree seems to be most common on flooded land, where it thrives much better than the Para rubber tree.

On account of the rapid growth of this tree and of the good quality of rubber which it produces, it is deserving of experimental trials.

The nature of its bark will not allow the same sort of tapping that is practicable with Hevea, but it is quite within the bounds of possibility that a place might be found for this tree in cultivation.

GUTTA-PERCHA

Gutta-percha is a substance which is in great demand for a variety of uses and for which as yet no satisfactory substitute has been found. The supply at present comes mainly from the Malay Peninsula and from the Dutch East Indies. In Java the Dutch Government has a successful gutta-percha plantation at Tjipetir, but elsewhere the supply is derived from trees in the jungle. Formerly the trees were felled and the bark tapped, but recently this method has been largely abandoned, and the leaves are collected and ground in mills to separate the gutta. Only leaves and young twigs are used at Tjipetir, where tapping of the trees was found unprofitable.

It seems possible that a supply of this valuable substance could be produced within the territory of the United States. Several gutta-percha producing trees are native to the Philippine Islands, and doubtless the tree now grown in Java could be successfully grown in the southern islands. It might become a valuable native crop there. It is better fitted for such culture than rubber, which requires more constant attention. The preparation of good rubber requires considerable skill, more than most natives are willing to develop. On the other hand, the gutta-percha leaves could be picked from time to time and sent to a central mill adequately supervised by experts, which could take care of the product of a considerable area.

Furthermore, as the price of gutta-percha is much higher than that of rubber, this should be an incentive to the development of the industry. Certainly, there is sufficient promise of success in the planting of this product to warrant a consideration of the problems connected with it.

In South America there are several gutta-percha producing trees worthy of study. One of these is a species of Chrysophyllum, which yields a product appearing to be of good quality. Another species, *Aburana colorado*, produces a gutta reported by authorities as the equal of the Java product. This tree is widely distributed in western Brazil, northern Bolivia, and eastern Peru. The writer found it in Bolivia in the neighborhood of Sena and also at Porvenir. In these regions many trees have been tapped by slashing them with a machete. Nothing could be learned as to the yield of these trees.

Around Maldonado, in eastern Peru, there are said to be great numbers of Aburana trees, and they are reported to be numerous for a long distance to the west of that place. Apparently, there exists here a large supply of gutta-percha which has been exploited to only a very small extent. The problem of extracting this substance is worthy of further study.

So far no experiments have been made to determine the quantity and quality of the gutta in the leaves or to develop methods of extracting it. Naturally, no planting trials have been made of the tree, but experimental plantings should be made, and the tree should be introduced into other regions for trial. The tree was not in fruit at the time of the writer's visit to the region, and material could not be procured for introduction at that time. Further attempts should be made to bring this tree into cultivation.

BALATA

A considerable quantity of balata, a substance extensively used for special purposes, such as the manufacture of belting, is extracted from jungle trees in the Amazon Valley. Most of this comes from the valley of the Rio Negro, which the writer was unable to visit. Therefore, no first-hand information can be given here. Balata is obtained entirely from wild trees (species of Mimusops) growing in the jungle. Promising species of balata trees should be tested in cultivation.

NEED OF INTRODUCTION OF OTHER SPECIES OF HEVEA

It may seem to many that so long as we have a rubber tree as good as the one now in cultivation, there is no need to seek further for other types of trees. The tree now grown on the plantations gives a product satisfactory both as to quantity and quality. However, planters believe in the possibility of increasing both the yield and the quality of the rubber, and selection experiments are being carried on with the hope of considerable improvement in plantation strains.

It is well known to plant breeders that selection creates nothing new but merely picks out and isolates desirable qualities which appear in the material under study. Therefore, there is a decided limit to the improvement which can be brought about by selection. The introduction of new strains frequently gives material for selection superior to anything formerly cultivated. An example of this is found in Cinchona, the tree from which quinine is derived. All the cultivated species of Cinchona were introduced to India and Java from South America, where they grew on the eastern slopes of the Andes Mountains. The climate of Java proved most satisfactory for the growth of the tree, and that country became the chief center of Cinchona cultivation.

As the industry developed, attention was paid to the improvement of the strains in cultivation. Selection resulted in increased yields, but plant exploration and introduction were begun also. In *Cinchona ledgeriana* a species was found which greatly excelled any plant produced by selection and revolutionized the production of quinine, resulting in making this indispensable drug generally available at a low price.

The possibility of the introduction of the South American leaf disease into the Orient may be remote, but it does exist. From the nature of the disease, the use of resistant varieties seems to offer the best means of control. According to Rands (*34*), varying degrees of resistance are shown by the trees in infected districts in the Guianas. It may be impossible to find resistant individuals which also have a very high yielding capacity, but there is a possibility of combining the two qualities by the crossing of strains.

There is a constant tendency for new diseases to appear, either through introduction from other places or through the adaptation of some local organism to the plant as a host. Some of these diseases can be combated effectually only by the use of resistant strains. Comparatively few of the many known species of Hevea are now in cultivation. It may be that some of the little-known species may supply the basis for breeding a strain resistant to some very dangerous

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disease, just as all wilt-resistant cowpeas have been developed by the use of one variety.

Aside from the question of disease resistance, these species may be useful in breeding work of other kinds.

The extent to which crosses between species of Hevea may be made is not yet known and can be determined only by procuring the various species and experimenting with them.

SUMMARY AND CONCLUSIONS

A study of the Para rubber tree in the Amazon Valley was made for the purpose of obtaining information on the following points:

1. The general status of the rubber industry in the Amazon region at the present time.
2. The rubber resources of this region available in case of a crisis in the production or importation of plantation rubber.
3. The suitability of the Amazon Valley for rubber cultivation.
4. The types of Hevea growing in the Amazon region and the possibility of procuring more desirable strains for plantation use.
5. The prevalence of diseases of Hevea and the general conditions regarding plant diseases in the region.

The members of the expedition made studies along the Amazon, Madeira, Beni, Mamore, Pacanova, Ouro Preto, Madre de Dios, Purus, Acre, and Tahuamanu Rivers. The regions covered lie in the States of Para and Amazonas, in the Acre Territory in Brazil, and in the Beni and Noroeste districts of Bolivia.

The genus Hevea is incompletely known both as to species and geographical distribution. The extension of knowledge depends on collections in distant regions, which are not likely to be made in the near future.

The rubber industry in the Amazon Valley is in a precarious condition, primarily because of the low price of rubber. Certain alleviating measures are suggested.

The methods of collecting and preparing the rubber described are extremely wasteful of bark and of rubber.

Tapping with the ax should be abandoned and should be superseded by the Amazonas knife where tapped trees are being worked. The Jebong knife should be used on virgin trees.

Seringueiros collect from 600 to 1,000 kilograms of rubber in a tapping season of six months.

Many of the rubber trees of the Amazon country are of great age. Some are hundreds of years old. Most of those in tapping are at least well over 50 years old.

The wild trees of the Amazon Valley contain a great reserve of rubber which could be secured in case of necessity.

All the rubber from this region comes from jungle trees. There are no plantations in production in the Amazon Valley.

Great areas of land suitable for the cultivation of the Para rubber tree are available in the Amazon basin.

The growth of rubber trees along the lower Amazon is generally unsatisfactory, and this region is not recommended for rubber planting.

The well-drained uplands along the Madeira River and its tributaries, and especially along the Acre and the Tahuamanu, are promising for plantation projects, at least so far as the growth and development of the trees is concerned.

The plantation trees of the Orient appear to be identical with the white rubber trees of the lower Amazon. The black rubber trees from which the up-river fine hard Para grade is obtained appear to be a different type.

Seedlings of the black type of rubber tree were taken from Bolivia to the Panama Canal Zone Experimental Garden, where they are being grown for comparison with trees of the plantation type.

The South American leaf disease of Para rubber is prevalent in the Amazon Valley. Its effect on plantation trees which may be planted there can not be predicted, but control measures should be devised.

The brown-bast disease of rubber trees, so common on oriental plantations, occurs also in South America.

Several parasites found on the trees in oriental plantations infest the South American jungle trees. So far as disease is concerned, the conditions in the Orient and in South America are much the same.

A brief account of Castilla and Sapium, two genera of rubber-bearing plants other than Hevea, is given.

The need of cultivating other species of Hevea for study and for possible use in hybridization is emphasized.

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