Native tapping trees of *Hevea guianensis* during the years of the Second World War, when wild rubber stands of the Amazon helped to replace plantation production interrupted by the Japanese occupation. R. E. Schultes photo.

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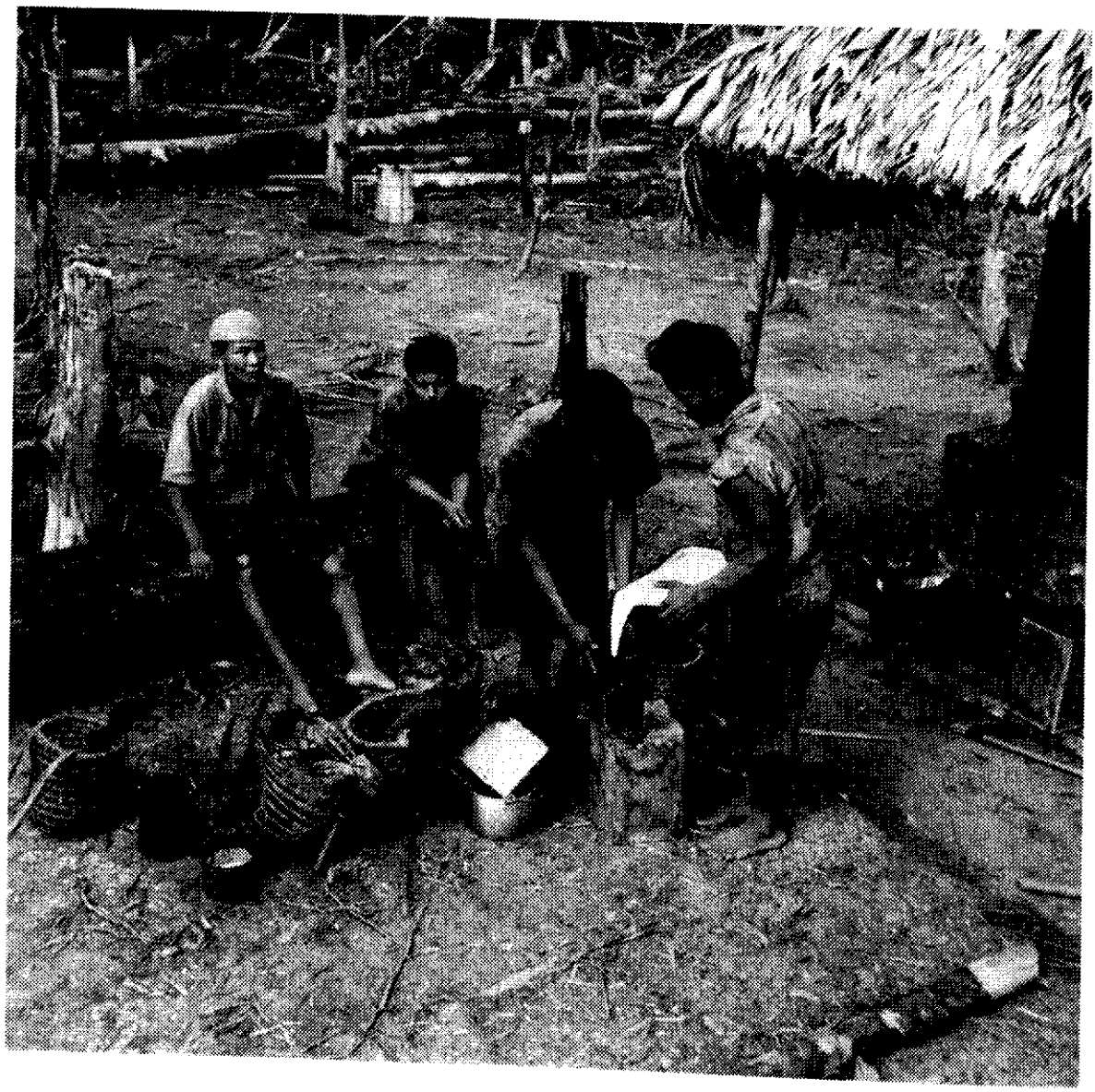
Front cover photo: Leaves of the American smoke tree (*Cotinus obovatus*). *Back cover:* trunks and branches of the same species.



The Tree that Changed the World in One Century

Richard Evans Schultes

I can assure you that on that 14th of June (1875) when Mr. Wickham arrived at Kew in a hansom cab with his precious bags of seeds, not even the wildest imagination could have contemplated its result. . . .

— Sir W. T. Thiselton-Dyer
Kew Bulletin (1912), p. 65

History is usually written in the context of political, social, or religious changes. Yet it might well be written from the point of view of the effects that plants have had on the development of mankind and civilization.

It is safe to say that no single species of plant has, in the short space of 100 years, so utterly altered lifestyles around the globe as *Hevea brasiliensis*, a member of the spurge family, which today is the source of 98 percent of the world's natural rubber. Stop for a moment and try to imagine life without rubber!

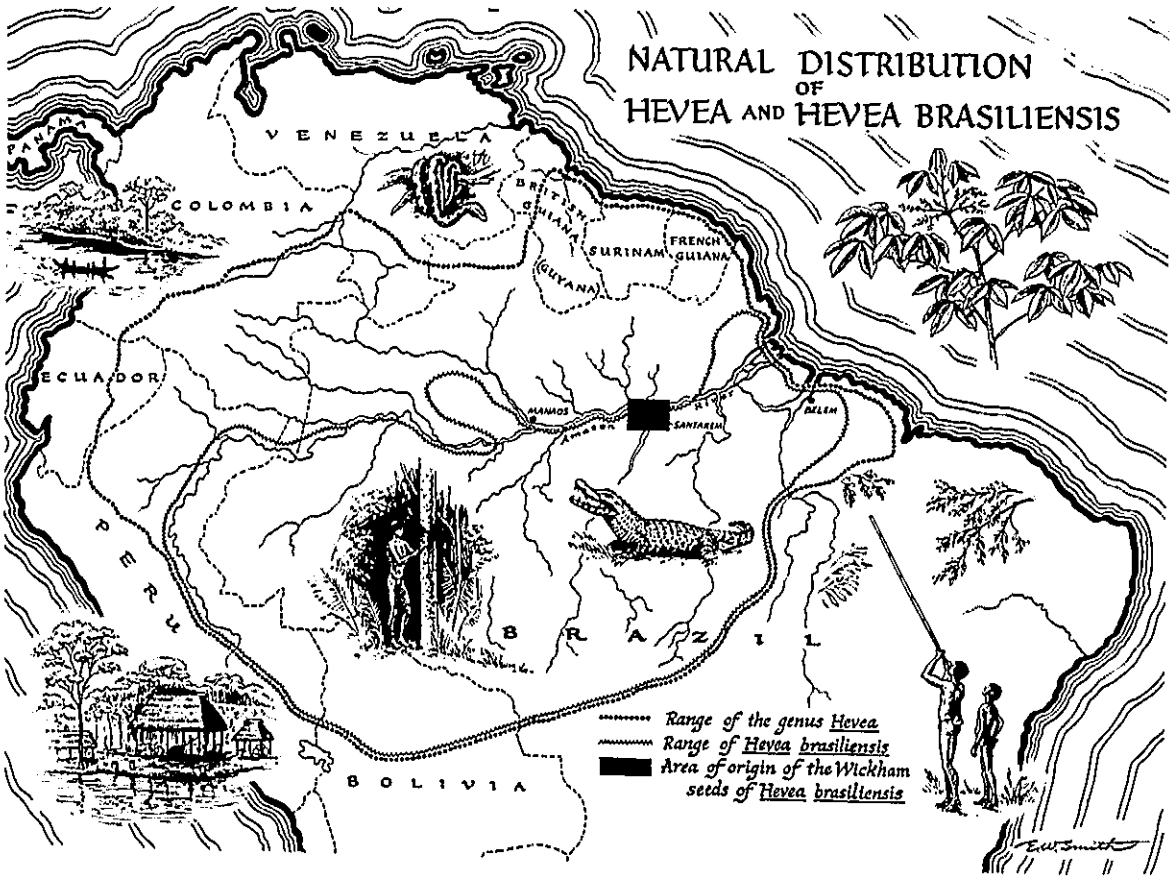
The introduction of this Amazonian tree from the wild and its domestication in the 19th century was the work of the British botanical gardens, especially the Royal Botanic Gardens at Kew, and is unquestionably the most outstanding example of the value of such institutions in bettering life on earth.

Rubber-yielding trees and vines grew in the Old World, yet, curiously, no significant use of their product had been made anywhere in the Eastern Hemisphere. When Columbus arrived in the West Indies, he noted that the natives were playing a game in which rubber balls were employed, but the rubber for these balls came not from *Hevea* but from *Castilla elastica*, of the fig family.

As early as 1755, King John of Portugal tried to foster a rubber industry in Belém do Pará at the mouth of the Amazon River: rubber shoes were manufactured for export to Portugal, but the quality was so poor that the industry did not prosper. The process of vulcanization, which has made rubber the useful product that it is now, had not yet been discovered.

After Goodyear discovered vulcanization in the 1830s, rubber became a product with ever-increasing uses in the industrializing nations, and demand for it increased at a vertiginous rate. The only source was the wild stands of *Hevea* — especially *H. brasiliensis* — hidden away in the dark corners of the vast Amazon forests. The demand for rubber in Europe and the United States rapidly became so great that production from forest trees rose from 31 tons in 1827 to 2607 tons in 1856. This dramatic increase was accomplished by the virtual enslavement of whole tribes of Indians. Tapping the trees in the jungles for four or five months a year, away from their agricultural lands and sources of

A group of rubber tappers bringing in their daily harvest of latex from forest trees in the Amazonian region of Colombia. R. E. Schultes photo.



Natural distribution of *Hevea* and *H. brasiliensis*.

nourishment, falling prey to tropical diseases and malnutrition, and often suffering from exposure, mistreatment, torture, or even assassination if they did not bring in enough rubber, they were being exterminated by this forest industry, directed primarily by unscrupulous "rubber-barons" who resided in the cities of Manáos and Iquitos, usually in sumptuous luxury.

The modern age of rubber had its beginnings in 1876, a "rubber revolution" that was the consequence of an incredible series of sometimes fortuitous events.

Hevea became known to the scientific community when in 1775 the French botanist J. B. C. F. Aublet described the genus from material collected in French Guiana. He not only described the genus and its first species, *H. guianensis,* but detailed the native method of exploiting it for rubber and appended numerous ethnobotanical data on the use of the seeds by the natives as food. Twenty-six years later, K. L. Willdenow, a German botanist, described a second species, *H. brasiliensis,* from material collected at the mouth of the Amazon River. Subsequent botanical exploration of the Amazon Valley — notably that carried out

by the British botanist Richard Spruce — continued to add new species to the genus, which now comprises 10 species and three varieties.

Not all of the species yield a latex capable of producing rubber: only *H. guianensis*, *H. benthamiana*, and *H. brasiliensis* have sufficient caoutchouc to give a usable rubber; and of these, *H. brasiliensis* supplies the best product.

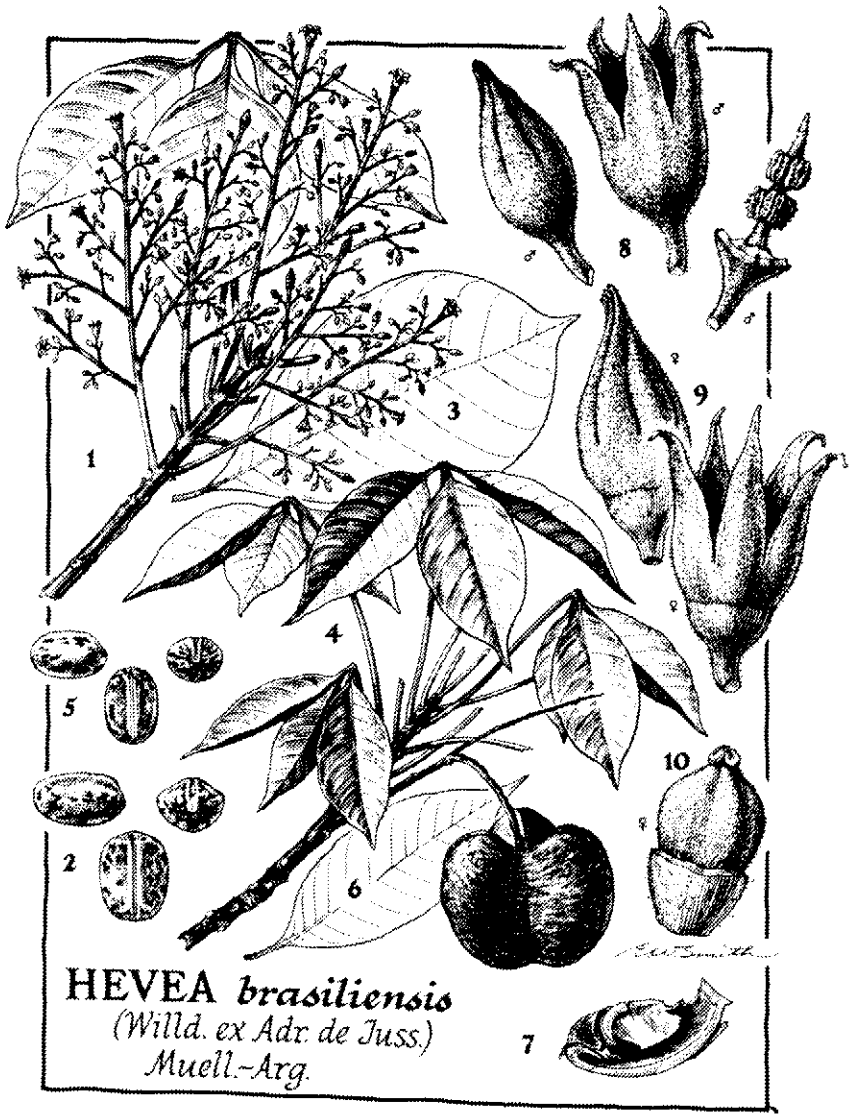
When in 1823 a Scot, Charles Macintosh, discovered that rubber would dissolve in naphtha, it acquired many new uses, leading to the establishment of factories in England, France, and the United States. These factories failed, however, because the product still became sticky in the heat and brittle in the cold.

This problem was overcome in 1839 when a Bostonian, Charles Goodyear, discovered vulcanization, a process that greatly altered the physical properties of rubber and changed the history of the significance of this vegetal product and its effect on human life. It led immediately to new and hitherto unexpected applications and a host of new industries. It also sparked the "rubber boom" of the Amazon, then the only source of natural rubber: production from the South American forests rapidly increased.

Exploitation of wild rubber is a difficult and frustrating operation. The natives, living during the tapping season under such abominable conditions, produced a poor-quality product. The latex was frequently laden with bark, dirt, and stones and adulterated with other rubbers, since often the tappers were punished if they did not procure stipulated quotas. Furthermore, each individual had to labor from dawn or predawn until nearly noon to tap 100 or fewer trees in his forest circuit, then return to his shack and begin the long process of coagulating the latex. Large balls of rubber were formed by pouring the latex little by little over a pole that was rotated in smoke rising from an inverted funnel.

The death knell for this primitive industry was sounded when the era of scientifically managed plantation practices began in 1876, the year that rubber seeds were first germinated successfully in the Royal Botanic Gardens at Kew. The domestication of the rubber tree served civilization in two ways. First, it provided an abundance of high quality rubber at low cost, without which many of our great advances in industry, medicine, domestic appliances, and transportation would have been impossible. Second, when plantations finally came into full production in the second decade of the 1900s, the forest industry was all but obliterated, with the result that thousands of native tappers were liberated from the intolerable and inhuman exploitation to which they had been subjected for nearly 100 years. And, undoubtedly, whole tribes — e.g., the Witotos of the northwestern Amazon, a truly noble race of Indians — were saved from virtual extinction.

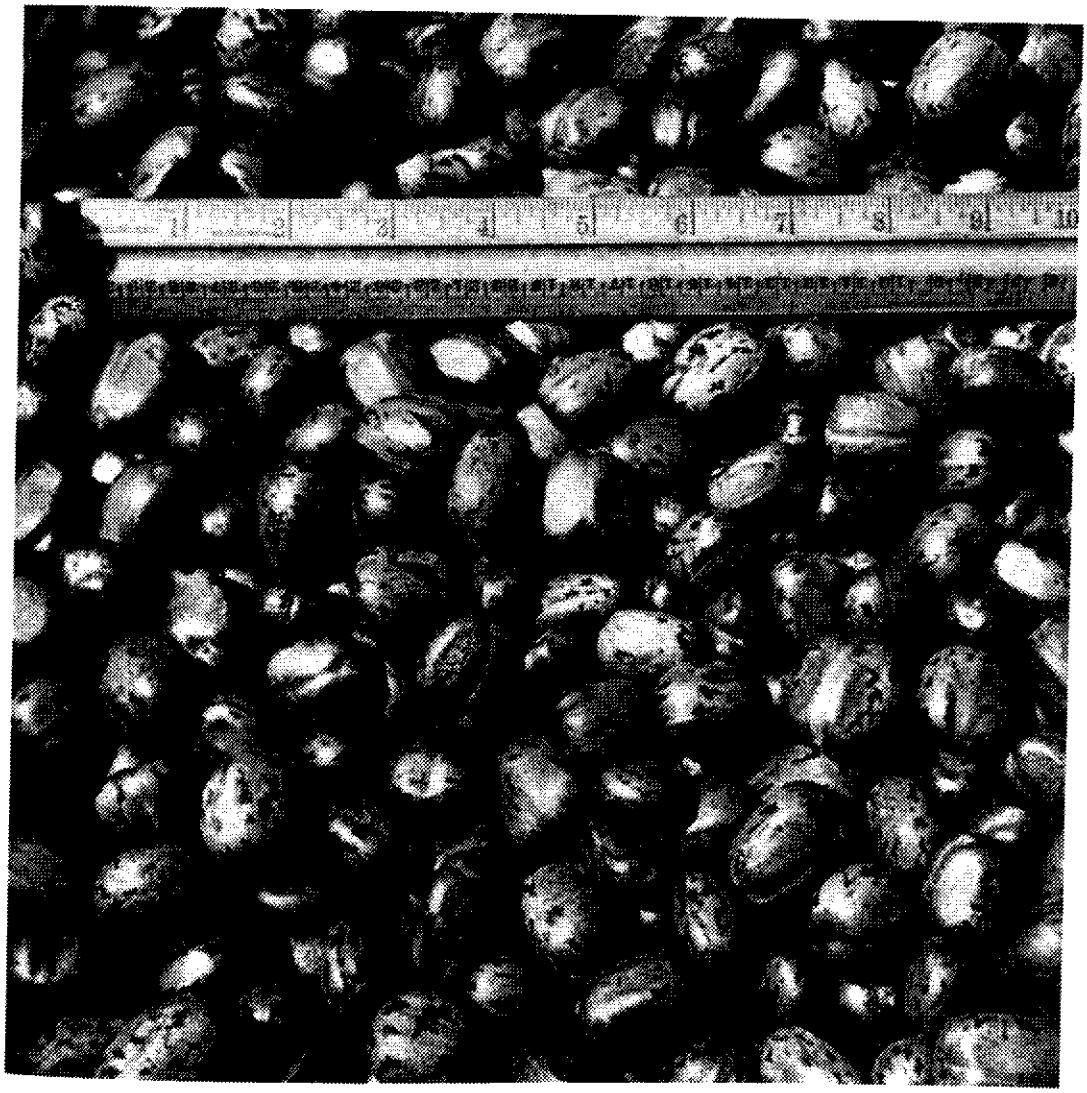
Domestication of the rubber tree occurred at the time the British were seeking new crops for their tropical colonies. The introduction of the quinine-bark tree into India from the Andes had just been highly successful. Sir Clements Markham, who had directed the introduction of that tree, was convinced that the rubber tree could be developed as a plantation crop that would be a good substitute for the coffee crop, which a fungal disease had almost exterminated in Asia. He had Mr. James Collins prepare a summary of what was then known about



Parts of *Hevea brasiliensis*, the rubber tree.

rubber. Collins wrote: "In 1870, I came to the conclusion that it was necessary to do for the caoutchouc-producing tree what had already been done with such happy results for the cinchona [quinine] tree." Sir Joseph Hooker, director of Kew Gardens, knew of Spruce's discoveries and studies of *Hevea* in the Amazon, and he fully supported Markham's view concerning the future of *Hevea* cultivation.

Several earlier attempts had been made to introduce *Hevea* seed from Brazil, in 1873 and 1875. None were successful. *Hevea* seed, its latex rich in sugars, quickly ferments in the heat of the tropics, and the embryo is killed. But success eventually came.



Seeds of *Hevea brasiliensis*. R. E. Schultes photo.

An Englishman, Henry Wickham, who had spent many years living near the Amazon and Orinoco and who in 1872 had published a book on his travels in tropical South America, had previously sent seeds of *Hevea* to Kew with no success. Fully realizing that earlier shipments had failed because of slow transport, Wickham resolved somehow to surmount this difficulty. Then a fortuitous event happened! In 1876 a steamboat from England had sailed up the Amazon laden with cargo; it found no return load. "I determined," Wickham wrote, "to plunge for it. I had no cash on hand. The seed was even then beginning to ripen. I knew that Capt. Murry must be in a fix, so I wrote chartering

the ship." Wickham sent out his Indians to collect the seed and pack it properly in wicker baskets. The ship raced downstream from Santarém, 400 miles up the Amazon, and called in at customs in Belém at the river's mouth. Customs officials, told of the delicacy of the plants "for delivery to Her Britannic Majesty's own Royal Botanic Gardens of Kew," immediately, and with intelligence unusual among bureaucratic officials, dispatched the ship, which steamed off to England.

All of the earlier shipments had been sent on sailing vessels. The few days saved by using a steamboat ensured successful germination in Kew's hothouses. Of the 70,000 seeds, 2800 germinated — a rate of 4 percent, astonishingly high for *Hevea*, even in the field.

Young trees from this introduction were sent to Ceylon, where several of the original trees still are living in botanical gardens. From Ceylon some went to Singapore and other parts of the empire in the tropics. The domestication of this tree, which has in one century so drastically changed life around the world, would not have been possible without a chain of botanical gardens and a far-sighted director at Kew like Hooker.

In Brazil stories are rife concerning the British "seed steal." At that time Brazilian law permitted the exportation of seeds, and collection and exportation were carried out openly. Many Brazilians are persuaded to believe that rubber seeds were "stolen" or "smuggled" out of the country, however,

Henry Nicholas Ridley examining one of his early experiments in tapping systems of *Hevea brasiliensis*, Malaysia. Photograph courtesy of Rubber Research Institute of Malaysia, Kuala Lumpur.

and fail to realize that Brazil's major agricultural industries are based on plants introduced from foreign countries: coffee (originally from Abyssinia), rice (from India), sugar (from Southeast Asia), soybeans (from China), jute (from India), cacao (from Colombia and Ecuador). In fact, most of the world's principal plantation crops are produced in regions far from their original homes.

When the Brazilians realized that the British plantation efforts were to be successful, they prohibited further exportation of

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The oldest tree of *Hevea brasiliensis* in Malaysia, from one of nine seeds planted in 1877. Photograph courtesy of Rubber Research Institute of Malaysia, Kuala Lumpur.

Trunk of *Hevea brasiliensis* with hypertrophied growth due to former tapping with *machadinho* ("little ax") in the Amazon of Brazil. P. Alvim photo.

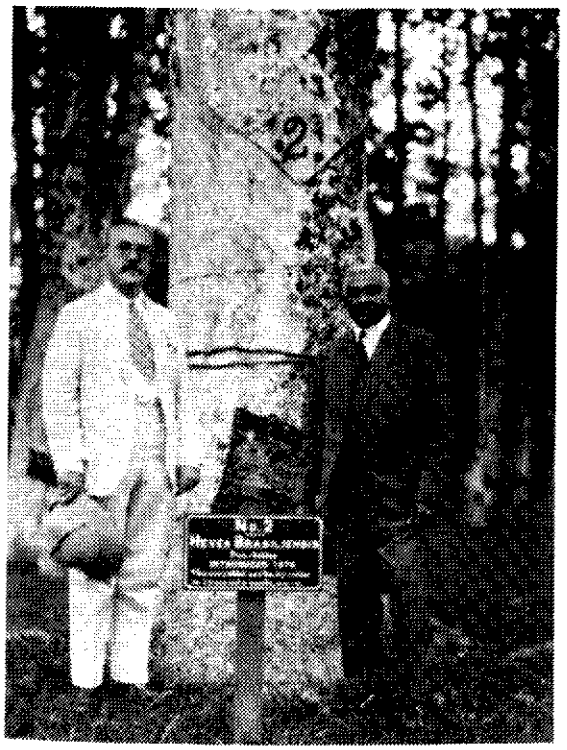
rubber seeds, and that prohibition held until very recently. Consequently, the vast rubber plantation system of the Old World was based primarily on these original seeds, which were collected from a single locality and from a single (and not the most promising) ecotype of *Hevea brasiliensis*. It is believed that the 70,000 seeds came from 26 original trees. In view of this, the enormous improvement in the commercial rubber tree in the space of 100 years seems incredible. The earliest plantation set out in Ceylon yielded 400–450 pounds of dry rubber per acre per year; there are new clones of the rubber tree that now yield more than 3000 pounds, and, with a recently developed chemical treatment of the bark, some clones may almost double that amount.

Many names of major importance are connected with the historical accomplishment of domesticating a wild tree of the humid Amazon. These include Aublet, Spruce, Macintosh, Goodyear, and Wickham, mentioned earlier. But Wickham and two others — Ridley and Cramer — were perhaps all-important in the creation of the great plantation industry that supplies the world with more than 98 percent of its natural rubbers. Wickham, who lived to a venerable old age, was rightfully knighted in the late 1920s for his part in the creation of the rubber industry.

Henry N. Ridley was appointed director of the Botanic Gardens in Singapore in 1888. It was my unexpected good fortune in 1950 to spend several days chatting with Ridley in his 95th year. He lived near Kew Gardens and was overjoyed to review some of his hopes, his trials, his successes in the early history of rubber in the Far East with a young botanist who was studying the numerous species and their ecotypes in the wild in South America. It was during these personal exchanges that I realized that Ridley was in fact one of the major founders of our modern rubber plantation industry.

When Ridley took up his position, he found only nine original trees and some 1000 young plants left from the original introductions to the Malay Straits in 1877. He immediately raised 8000 more plants from seed imported from Ceylon. These trees, from the original Wickham stock, became the mother trees of much of the rubber that eventually covered a large portion of Malaya.

Next Ridley began his celebrated experi-



Pieter J. S. Cramer (left). The identity of the other man is unknown. The tree is one of the original Wickham trees in the Botanical Garden, Ceylon. Photograph courtesy of Dr. O. S. Pires, Rubber Research Institute of Sri Lanka, Agalwatta, Sri Lanka.

ments on tapping methods. At that time trees in the Amazon were slashed according to a great variety of makeshift techniques, frequently to the detriment of the tree. The most prevalent method involved the use of the "machadinho" — a small ax used to make deep incisions in vertical lines up and down the trunk, causing eventually enormous hypertrophied tumors, which later prevented efficient tapping.

Ridley tried cutting off very thin layers of the bark with a sharp knife in a sloping channel, avoiding injury to the cambium, since in *Hevea* all of the latex-bearing vessels are external to the cambium. He began with the well-known herring-bone method and recommended infrequent tapping to allow the trees to rest. Eventually, he learned that more frequent tappings would not harm the tree and abandoned the herring-bone system and cut in slopes from right to left, since cuts in this direction were shown to give higher yields. Among numerous other discoveries, he experimentally showed the advantages of tapping done in the morning rather than the afternoon.

Ridley's advances, perhaps more than any other, assured success of the Asiatic plantation industry. By 1897 all tapping in Asia was based on Ridley's scheme of reopening the wound. The sudden increase in world demand for rubber further stimulated research into efficient and higher-yielding tapping techniques, in all aspects of which Ridley took part. His experiments led eventually to the spiral system of tapping, which today is nearly universal in plantation practice.

Ridley made another significant contribution to the rubber industry of the future in his campaign to establish rubber as a plantation crop. A series of events led him to this: a serious fall in the world price of tea, the devastating fungal disease of *Coffea arabica*, and poor results with cacao. Another factor was the increasing use of the automobile; automobile tires gradually became the greatest single consumer of the product. Ridley seized the opportunity, and soon planters were establishing rubber.

Again it was my good fortune in 1950, when Dr. P. J. S. Cramer was retired in Utrecht, Holland, to spend three days chatting with *oude Piet* ("old Pete"), as the uni-

When I started in 1888 in an attempt to
cultivate Rubber for profit it was com-
paratively little used to what it is today
And to what it will be in the future
In calculating the amount that would be
required in 1900 I calculated for bicycle-tyres
the poor mans carriage) but not for tyres for
motor vehicles as they were hardly invented
and I thought they would only be a rich
Mans toy for many years. However we (I
and my one assistant) were ready for all
eventualities in time for the boom.

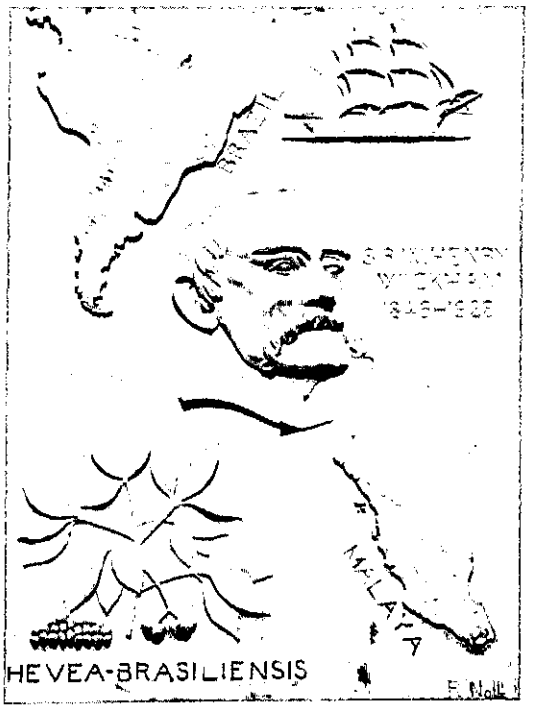
I shall be very interested in your discoveries
When you publish them. Your literature
of your programme has not come to hand
yet. I look forward to its arrival
I should like to see the photographs of
the dwarf variety you mention. It must
be a very curious plant

My wife sends her warmest greetings to you
and I too wish you the greatest success
and happiness in your work in Colombia

Yours sincerely
Henry N Ridley

versity students affectionately called him. We reviewed the initial introduction of *Hevea* stock to the Dutch East Indies from the British Malay Straits — material derived from the original Wickham seeds — and his early successful efforts to introduce from South America seeds of several other species of *Hevea* for eventual genetic studies. He told me about the difficulties he experienced in attempting to convince commercial developers that the planting of seeds (instead of using clonal material) was not the best way of establishing plantations of rubber trees. In these three days we experienced a remarkable camaraderie based on our very divergent experiences with *Hevea,* and I acquired an abiding understanding of the difficulties encountered by these pioneers: Ridley and Cramer.

When the Dutch had established a plantation crop from material originating in Penang, Malaysia, Cramer carried out the first variation analyses on *Hevea brasiliensis.* These early studies indicated that the species is extremely variable, especially with respect to yield of latex, an important commercial consideration. Through his analyses Cramer demonstrated the impossibility of predicting yield of rubber from plantations established on seed material, mainly because of cross pollination. He predicted that vegetative selection, cloning, and generative selection or breeding would lead to improvements in yield. All his predictions proved true. Cramer's studies led to the eventual vegetative reproduction of high-yielding clones, which today is basic to all rubber-plantation practice.



Plaque commemorating Sir Henry Wickham's successful introduction of seeds of *Hevea brasiliensis* from the Amazon in 1876. Photograph courtesy of the Rubber Research Institute of Malaysia, Kuala Lumpur.

Later, in 1918, Cramer patented a method of marketing budwood from high-yield cloned trees, which *ad infinitum* would provide the basis of plantation material. He also invented the Testatex knife, patented in 1931. This knife has a vertical series of V-shaped blades, and when pressed into the stem or trunk of young nursery plants measured the length of the "drip" of the exuding latex, thereby indicating yield potential long before the trees matured at seven years.

The famous Colombian author José Eustacio Rivera wrote one of the great novels of

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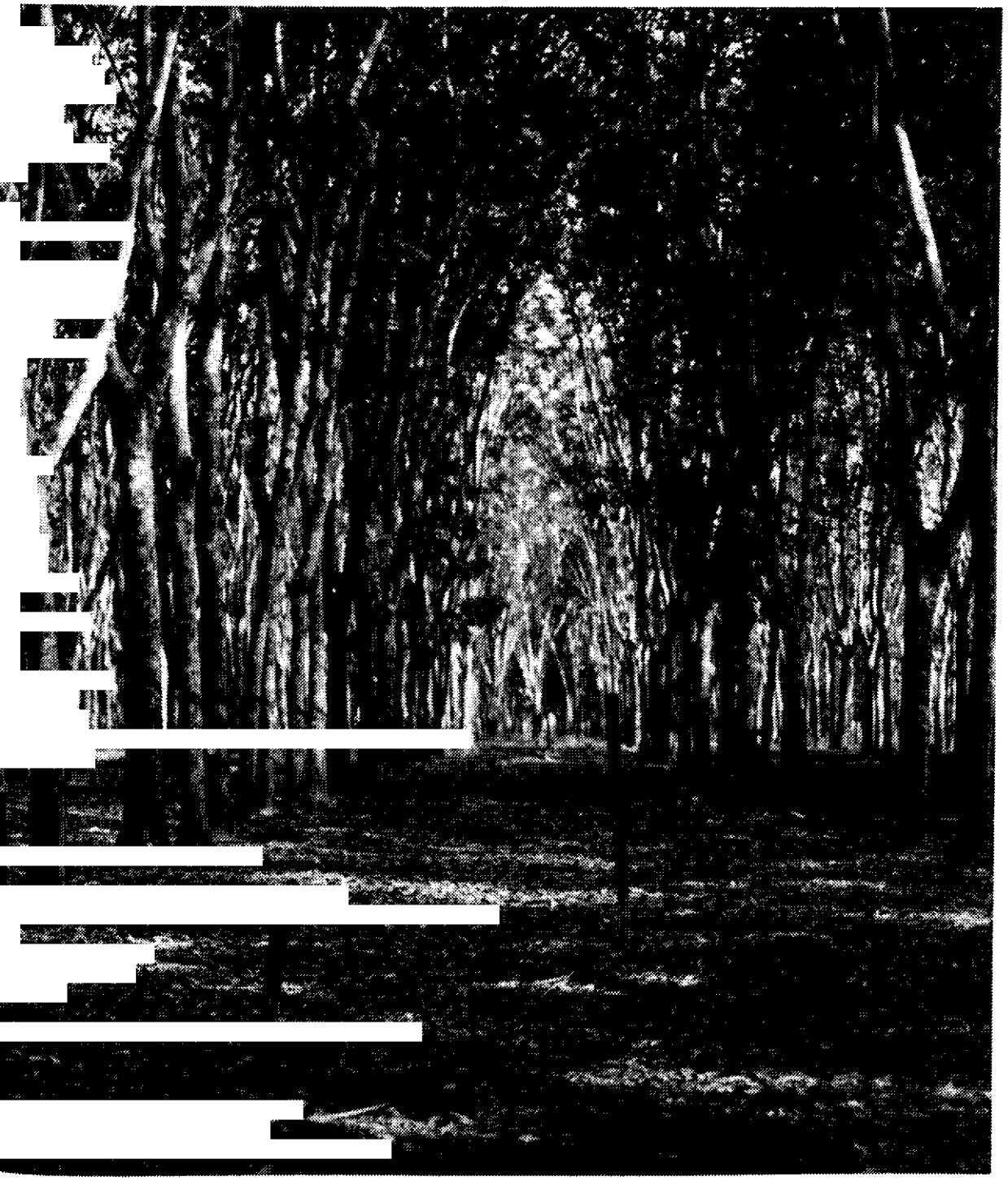
Letter to the author from Henry N. Ridley in his 95th year.

A modern plantation of *Hevea brasiliensis* in Malaysia. Photograph courtesy of Rubber Research Institute of Malaysia, Kuala Lumpur.



Latin America on life on the Amazon during the rubber boom. The title, *La Voragine* (*The Vortex*), refers to the belief that the jungle mysteriously swallows up the rubber tappers. One magnificent passage describes the almost fearful worship of the rubber tree in those days: "I have been a rubber tapper. I am a rubber tapper. I have lived in the muddy swamps in the solitude of the forests with my crew of malaria-ridden men cutting the bark of the trees that have white blood like that of the gods."

If we consider the changes for the good of mankind that "white blood" brought about when the rubber tree was finally domesticated, perhaps we might agree that it was actually blood of the gods!

Selected Readings

Bangham, W. N. 1945. "Rubber Returns to Latin America." In *New Crops for the New World*, edited by C. M. Wilson. New York: Macmillan.

Barlow, C. 1978. *The Natural Rubber Industry.* Selangor, Malaysia: Oxford University Press.

Collier, R. 1968. *The River that God Forgot.* London: Collins.

Dijkman, M. J. 1951. *Hevea: Thirty Years of Research in the Far East.* Coral Gables, Florida: University of Miami Press.

Drabble, J. H. 1973. *Rubber in Malaya 1876–1922: The Genesis of the Industry.* Kuala Lumpur, Malaysia: Oxford University Press.

Hardenburg, W. E. 1912. *The Putumayo: The Devil's Paradise.* London: T. Fisher Unwin.

Polhamus, L. G. 1962. *Rubber: Botany, Production and Utilization.* New York: Interscience Publishers.

Schultes, R. E. 1977a. "Wild *Hevea:* An Untapped Source of Germ Plasm." *Journal of the Rubber Research Institute of Sri Lanka,* 54: 227–57.

———. 1977b. "The Odyssey of the Cultivated Rubber Tree." *Endeavour* (New Series) 1 (3/4): 133–38.

———. 1970. "The History of Taxonomic Studies in *Hevea.*" *Regnum Vegetabile,* 71: 229–93.

Singleton-Gates, P., and M. Girodias. 1959. *The Black Diaries of Roger Casement.* New York: Grove Press.

Wilson, C. M. 1943. *Trees and Test Tubes: The Story of Rubber.* New York: Henry Holt.

Woodroffe, J. F., and H. H. Smith. 1915. *The Rubber Industry of the Amazon and How Its Supremacy Can Be Maintained.* London: John Bale, Sons, and Danilson.

Wycherley, P. R. 1968. "Introduction of *Hevea* to the Orient." *The Planter* (Kuala Lumpur), 44: 127–37.

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