Reading 22
Rubber

Rubber, *Hevea brasiliensis* (Euphorbiaceae)

In intrigue and romance the rise (and partial fall) of the natural-rubber industry challenges that of the spice trade. The first European notice of rubber was by Columbus in the Caribbean and by Cortez in Mexico, where crude rubber balls were noted as playthings of the American Indians. More likely they were of *Castilla* rather than *Hevea* rubber. Rubber gained its appelation from the discovery, that "bouncy" tree-gum balls brought back to England from the New World could be used to "rub out" pencil marks on paper. Rubber became more than a curiosity in 1823, when Charles MacIntosh learned to waterproof fabric with it, and especially when Charles Goodyear learned to vulcanize it (heat it with sulfur to eliminate stickiness or "tackiness") in 1839. Interest first centered on *Landolphia* and other apocynaceous vines of equatorial Africa. The latex was obtained by cutting the vines at ground level, a practice that soon depleted supplies and, of course, wrote a finish to the African rubber boom. While the boom lasted, however, the exploitation of native peoples became a worldwide scandal. Peaceful tribes were taxed ever increasing quotas of rubber by their colonial overlords. If the quotas were not met, women were seized and men put in chains–even mutilated and left to die a lingering death as new sources of the rapidly disappearing rubber trees in the Congo jungles were sought. This was, unfortunately, a pattern again to be repeated in the upper Amazon at the height of the wild rubber boom there.

Soon the boom spread to the New World, where the species destined to become the world's main source of rubber, *Hevea brasiliensis*, grew wild in the Amazon Valley. *Castilla*, which grew in Central America and northern South America, had its moment of glory, and later *Funtumia* was introduced into the West Indies from Africa, but only to become another of the West Indian casualties, as *Hevea*, the genus most amenable to repeated tapping, came into its own. With only wild rubber to be had, and demand soaring because of the newly burgeoning automobile industry, rubber prices increased astronomically. In 1910 the price of rubber reached the all time high of $3.06 per pound, an especially heady price considering the value of the dollar in those days. No wonder those were tumultuous times.

As early as 1875 the competent British Colonial Service had engaged Henry A. Wickham to procure seeds of *Hevea brasiliensis* in Brazil, and Robert Cross to bring back seeds and plants of *Castilla* from Central America (Cross later went to Brazil for young trees of *Hevea*). An ocean liner was chartered to rush the perishable seeds to Kew in England, where a modest proportion were germinated and the seedlings shipped carefully to Ceylon and Singapore. There they were received initially with little enthusiasm. These few seedlings, however, were to spawn the tremendous rubber plantation industry of the Far East. But in the early 1900s the world still relied upon wild rubber from the Amazon. At that time the rubber capital of the world was Manaos, situated in the sweltering jungles thousands of miles up the Amazon River. At the height of the rubber boom, so great was the wealth flowing into Manaos that a tremendous opera house was erected there from construction materials imported from Italy. The boom was to be short-lived, however, for by the end of World War I the once-scorned rubber trees of the British colonies in the Far East had been widely planted and were of tappable age. These plantations yielded more rubber than the market could then consume. The price broke to 14 cents per pound, rose again as the "Stevenson plan" cartel restricted rubber production, then fell again to an all time low of 3 cents per pound in the depression years. With synthetic rubber now available, a ceiling of sorts exists on rubber prices, which are not likely again to become so chaotic and so susceptible to political maneuvering as in the early days of the industry.

A small amount of wild rubber is still harvested in the Amazon Valley, most of it by lonely *seringueros*, living in thatched huts and crudely tapping distant trees that may still bear the tapping scars of the boom years. There was quite a revival of interest in wild rubber during World War II, when Japan gained control of the Far Eastern plantations, and a frantic search was made by the Allies for alternate plant sources for latex. Chemists, however, synthesized fairly short-chain rubberlike polymers from isoprene and butadiene in 1945, and things have never been the same with wild rubber since. However, these synthetic elastomers, although great for certain purposes, have never been so tough for hard-use tires as natural rubber; a generous proportion of the natural product is preferred for radial tires, for example. In competition with synthetics, natural rubber fell to about 20% of annual world production during the epoch of petroleum abundance, but demand exceeded supplies by 1980 and the proportion climbed back nearer to equality. Of the nearly 4 million metric tons of natural rubber that are produced annually, 90% comes from plantations and small holdings in the Orient (principally Sri Lanka, Malaysia, and Indonesia).

Tapping of wild rubber trees in the Amazon Valley has always been a wasteful and expensive procedure. The trees are not easily accessible, and much time and effort are spent in collecting the latex. Gouging of the bark with crude tools mutilates the trees and interferes with efficient continuing production. There are few processing centers, a necessity for economical mass handling of latex; instead, individual tappers have traditionally smoked the latex over open fires on paddles, forming it into huge balls, which in turn must be transported tremendous distances to market. Such a system can hardly compete with the highly efficient plantation growing of rubber in the Far East, where abundant, skilled, and inexpensive labor can tap and tend concentrated plantings. Moreover, trained botanists early initiated breeding and selection programs to develop high-yielding clones of *Hevea* that are especially amenable to tapping; these clones are much more productive than the wild trees of the New World. So much has tree quality been improved that during and after World War II, in an effort to re-establish rubber growing in Central America and South America, planting stock was zealously sought in the Far East. In less than a century that little-appreciated introduction from the New World had been thoroughly domesticated, one of the few documented cases of domestication of an important crop species.

The **jebong system**, the most efficient system of tapping, was developed on the Far Eastern plantations. A “panel” is opened half way round the tree, from the upper left to the lower right (since the latex canals in the bark spiral to the right, more canals are opened by a cut made in this way). Thin slices of bark are removed with each new tapping from the lower edge of the panel, to renew the flow of latex. More recently it has been demonstrated that tapping upward on the panel yields as much latex on a once-in-four-day tapping schedule as does tapping downward on a once-in-three-day schedule, Laborers are trained not to cut too deeply into the tree, so that the cambium will not be injured and will be able to regenerate new bark (Fig. 1). By the time tapping reaches ground level on one side, the opposite side is worked, after which the bark will have healed over the original panel and be ready for tapping again. Tapping is done early in the morning, when the flow of latex is greatest and showers are unlikely. A small spout is inserted at the lower end of the panel, which guides latex into an affixed cup. With high-yielding trees, as much as 1 metric ton of latex per year can be obtained per tree, although the intensity and season of tapping varies somewhat with local conditions. Good trees on well-tended plantations can endure tapping as frequently as every second day, except for a rest period during change of foliage.

The latex is carefully kept free of bark and dirt. At each tapping, latex coagulated on the cut is removed by band and kept separate as “scrap.” After tapping his quota of trees, the tapper retraces his route and carefully empties each cup of latex into a clean, covered pail, which is then taken to a central processing plant. The treatment of the latex varies with locality. In some places, latex is treated with an anticoagulant (usually ammonium hydroxide) and shipped in bulk to the location where it will be processed; more commonly, however, it is coagulated locally by the addition of acid. The soft coagulum is squeezed free of “serum,” and the resulting thin sheet is typically “smoked” in a special smoke house to dry and preserve it. Properly smoked rubber will not deteriorate, and it can be shipped to consuming markets as needs and prices dictate. This is a far cry from grimy smoking over an open fire, or coagulation by fermentation in ill-provided jungle camps. Coagulation formulas specified by the purchaser are often undertaken nowadays, and much raw rubber is shipped as “heveacrumb,” (compressed granular unsmoked crepe) rather than smoked sheet.

High-yielding *Hevea* clones are perpetuated vegetatively, especially by budding. So technically specialized has propagation become that “composite” trees are often created from separate, exceptionally good root stocks, high-yielding trunks, and vigorous tops. A trunk from a high-yielding clone is budded to a proven root stock and grafted with a vigorous top that is especially efficient photosynthetically. A plantation tree can be tapped when 5 years old, but peak yields don’t come until it is at least 12 years of age. Usually the tree is abandoned when it is about 25 years old, mainly because better types will have been bred by then. Research has indicated just which are the best fertilizer regimens and cover crops for the particular locality. Usually, in addition to the major fertility elements, iron and manganese are required for vigorous growth, and occasionally other minor elements. Thus, in contrast to what is generally true of tropical tree crops, as much is known about the requirements of plantation-grown rubber trees as is known about the requirements of almost any agricultural annual. It has even been found that very light applications of 2,4-D or such growth regulators as ethephon just below the tapping cut can increase the yield as much as 30% without damaging the tree.

Fortunately for the Far Eastern plantations, *Hevea* diseases inherent in the Brazilian homeland were not transported with Wickham’s seeds to England, and thence on to Ceylon in 1876. As improved stock is reintroduced into the New World, it often suffers from leaf blight and other diseases, which prevent the establishment of economic plantings. Thus for the New World rubber industry, additional research is necessary to develop clones adapted to New World conditions. Because it is expensive and difficult to control diseases with fungicidal sprays, the most practical approach has been to develop disease-resistant clones through selection and breeding. Two

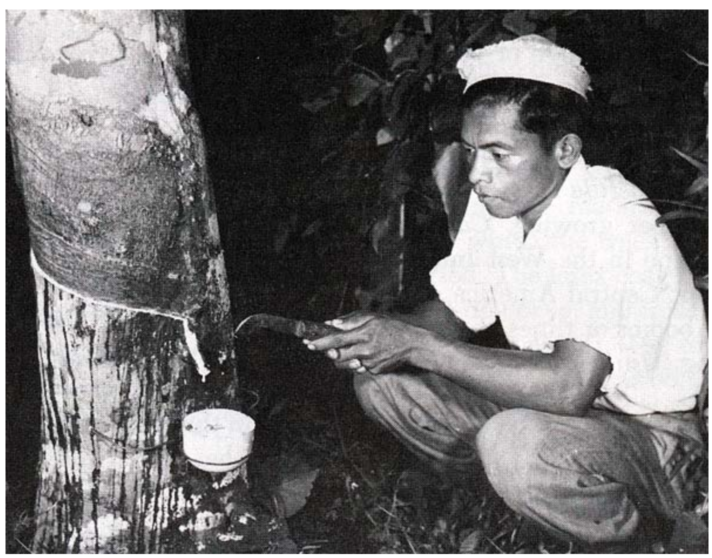

Fig. 1. Rubber tapper using special jebong knife that scores the bark deeply enough to cause latex to flow without damaging the tree. [Courtesy USDA.]

other *Hevea* species yielding latex in commercial quantity, *H. benthamiana* and *H. guianensis*, are used in crosses, and they contribute to a much broader germplasm base than was represented by Wickham's original collections.

Panama rubber, *Castilla* (Moraceae)

Several species of *Castilla* have been utilized for rubber. Indeed, the first reports of rubber from the New World, by the French geographer Charles Marie de la Condamine, who explored the Amazon in 1734, probably referred to *Castilla* rather than *Hevea*. La Condamine called the extract *caoutchouc*, but reported the Guiana Indian name of *heve*, which later led the French botanist Jean Baptiste Christophe Fusée Aublet to name a different genus *Hevea*, mistakenly believing it to be the species reported by la Condamine.

In the heyday of the natural-rubber boom, high hopes were held for *Castilla*. Royal Botanic Garden botanists, testing rubber species in Trinidad, felt that the rapid growth and wide tolerance of *Castilla* indicated that it might be of greater promise than *Hevea*. But they were proved wrong. Following enthusiastic (and often black market) distribution of planting stock in the West Indies, the combination of inexperience in growing and tapping, the lack of knowledge about handling latex, the vagaries in the price of rubber, and insufficient research, led to complete demoralization of not only the *Castilla* rubber industry, but of all plantation rubber growing. *Castilla elastica* still grows as an escape in the West Indies, and it grows wild throughout Central America and northern South America. In booms or times of emergency, there is some tapping. Usually, however, the wild trees are felled and the latex is drained. The latex canals in *Castilla*, unlike those in *Hevea*, are continuous, and not amenable to frequent tappings as with the jebong system. A large tree can yield several gallons of latex, which can be processed into as much as 32 kilograms (70 pounds) of rubber.

Manicoba, *Manihot* spp. (Euphorbiaceae)

Several species of this genus, especially *M. dichotoma* and *M. piauhyensis*, grow wild in the arid sections of northeastern Brazil and yield a good rubber latex, but only in small quantities. The trees have been exploited only in times of emergency and when rubber prices are high. There have been only desultory attempts to cultivate the tree, so that tapping has largely been of an exploitative unscientific nature, involving a series of gashes from top to bottom of the tree in a fashion that causes the latex to drain progressively downward into a receptacle at the base. The bark is hard, not suitable to jebong tapping; and, in the desertlike *caatinga* of Brazil, growth is slow and replenishment of tree stands is poor.

Mangabeira, *Hancornia* (Apocynaceae)

Like manicoba, mangabeira (especially *H. speciosa*, native to the sandy coastal belts from eastern Brazil south into Paraguay) has served as a source of a rubber latex during times of emergency. The quality is not as good as that of other rubbers, and the small trees of the scrub forest provide relatively small yields for the effort expended in gathering the latex.

Palay rubber, *Cryptostegia grandiflora* (Apocynaceae)

This and other species from Madagascar have been introduced into Central America as a promising source of rubber. The plants are sprawling vines, and the latex is typically gathered by cutting off the tips of the stems and hand-gathering the small drops of exudate. Attempts made during

World War II to grow the plant extensively and to develop mechanized harvesting proved a failure; consequently, interest in this widely naturalized "weed" as a source of rubber has died.

Guayule, *Parthenium argentatum* (Compositae)
Guayule, native to Mexico and the southwestern United States, had been a limited source of rubber before World War II, and it contributed a little (but vital) supply to the war effort. It was hoped that extensive stands could be cultivated eventually as a field crop in semiarid regions, and the rubber could be retrieved by maceration of the harvested foliage. Although progress has been made in developing strains of acceptable yield, many practical difficulties have prevented guayule production from becoming competitive with other sources. But there is still much interest in developing the species as a field crop that might make industrial nations less dependent on distant tropical sources of rubber.

Other rubber sources
A great many other genera have been tried from time to time as possible sources of rubber. In the family Apocynaceae, *Alstonia*, *Apocynum*, *Forsteronia*, *Funtumia*, *Landolphia*, *Mascarenhasia*, *Odontadenia*, and *Tabernaemontana* have all been tried. So have various milkweeds, *Asclepias* spp. (Asclepiadaceae), and figs, *Ficus* spp. (Moraceae). In the family Compositae, Russian dandelion (*Taraxacum kok-saghyz*), various goldenrods (*Solidago* spp.), and plants of a number of other genera have been investigated. *Euphorbia*, *Sapium*, and other genera of the family Euphorbiaceae have at times shown promise, too. The USDA's Northern Regional Research Center at Peoria, Illinois, has investigated scores of rubber bearing species as potential crop plants, with the thought of multiple (solvent) extractions better to utilize the whole biomass: *Monarda* spp. (Labiatae) and other mints have ranked surprisingly high, and even the pokeweeds, *Phytolacca* spp. (Phytolaccaceae), seem quite useable.