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Author(s): Richard Evans Schultes

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The Amazonia as a Source of New Economic Plants¹

RICHARD EVANS SCHULTES²

Those who understand and love the Amazon forest call it the *Green Heaven*. Those who misunderstand and despise it know it by the name of the *Green Hell*. A recent political figure has termed the Amazon a desert of trees which must be destroyed. Unfortunately this latter point of view seems now to be in the ascendancy.

Why should this vast area of 2,700,000 square miles be protected?

There are many reasons for the preservation of this last great wet tropical forest which may comprise as many as 100,000 species of plants. Today I want to discuss with you only one of these reasons—but one which, for the future of mankind, appears to me to be one of the most compelling: *its incalculable value as an untapped emporium of germ plasm for new economic plants*.

The great Russian botanist Vavilov postulated that there were eight major centres of the origin of cultivated plants.

Some botanists have pointed out that these centres nearly cover the world's surface. This is not, however, a valid criticism. Most of Africa, with the exception of Abyssinia, has given little to the store of man's economic plants. Australia has yielded no major species. All of North America north of Mexico has been singularly parsimonious. What about the tropical Amazon forests?

The tapioca plant, *Manihot esculenta*, appears to have originated in the Amazon. In pre-Columbian times, it had spread throughout tropical America. It now has taken its place as one of the dozen or thirteen major food plants of the world, having been accepted as the prime source of carbohydrate in many tropical parts of Africa and Asia. The cultivated pineapple, *Ananas comosus*, is thought to have originated in the western part of the Amazon Valley from wild types such as *A. microstachys*. Specialists now believe that the cultivated cacao tree, source of chocolate, arose through hybridization of wild species in the westernmost Amazon of Colombia and Ecuador. It is probable that the narcotic coca plant, *Erythroxylon Coca*, originated in the eastern or Amazonian slopes of the Ecuadorian Andes. The southwestern part of the Brazilian Amazon appears to be the home of achiote, *Bixa Orellana*, now widely cultivated throughout the tropics; it arose possibly from the wild *B. excelsa* of the Acre area. Another recently domesticated plant of the Amazon is timbó or barbasco, various species of *Lonchocarpus*, especially *L. utilis*, a main source of the insecticide rotenone. For many years now, the guaraná plant, *Paullinia cupana*, has been cultivated in the central part of the Amazon for the preparation of various caffeine-rich beverages. But undoubtedly no native of Amazonia has so altered human life around the globe as the Pará rubber tree, *Hevea brasiliensis*, one of the most recently domesticated of our major crops.

Were it only for the impact of three of these cultigens on modern living—

¹ Dr. Schultes' banquet address as Distinguished Economic Botanist, presented at the 20th Annual Meeting of the Society for Economic Botany, held at North Carolina State University, Raleigh, North Carolina, June 12, 1979.

² Paul C. Mangelsdorf Professor of Natural Sciences and Director, Botanical Museum, Harvard University, Cambridge, Massachusetts.

Manihot, *Theobroma* and *Hevea*—the tropical rain forest of the Amazon must be considered as one of the most important of the world centres of origin of cultivated plants.

Yet the end of potential new crop plants from Amazonia is not in sight. There is every possibility—nay, even probability—that the next half century will double or triple the number of Amazonian species introduced into agriculture and silviculture in tropical regions. And these new crops may represent several of the categories of economic plants, especially foods, fibres, medicines, suppliers of fats, oils and waxes, various toxic plants such as insecticides, woods, rubbers, resin- or gum-producers and sources of essential oils. It will be valuable perhaps to discuss a few which are already calling the attention of the scientific world to their potentialities.

In 1975, the National Academy of Sciences published a report of an ad hoc committee: *Underexploited Tropical Plants with Promising Economic Value*. Thirty-six species of some 400 were finally selected for urgent attention by the committee. While most of the species chosen are already in use—either in agriculture or exploited in the wild—several represent from all points of view plants which will be new to commercial consideration. About a dozen of these recommended plants are Amazonian.

One of the serious shortages in human nutrition—especially in heavily populated, underdeveloped tropical areas—is an adequate supply of edible oil. The Amazon flora is blessed with a number of oil-rich species, especially amongst the palms. Perhaps the most important of these oil-rich palms is *Jessenia polycarpa*, an abundant component of the Amazon forest, with other species occurring in the Guianas, Venezuela and Trinidad. Natives have for centuries been utilizing the oil which chemically resembles olive oil. The present high price of olive oil would seem to favour strongly the introduction of this palm into cultivation. An effort towards this end has been initiated by the Centro de Desarrollo “Las Gaviotas” in the Orinoquia of Colombia.

The very large and heavy clusters of fruit ripen twice a year; they consist of about 66 lb of fruit, from which about 3–6 lb of pure oil may be extracted. The purple fruit, 1½–1¾ in long, has a thin, edible pulp which contains the yellowish oil which is equally appropriate as a food or for the soap and cosmetics industries. The seeds also may be consumed as food and the milky residue from oil extraction—*yucuta*—may be consumed as a beverage.

Jessenia Bataua—known in Colombia as *milpesos* or *seje*, in Brazil as *pataua*, in Venezuela as *jagua*—grows both in inundated areas as well as in well drained soil above the annual flood level. It has never been cultivated, the minute amounts of oil that have entered local native markets always having been extracted from wild trees.

Another Amazonian palm of great potential as a cultivated plantation crop is babassú, *Orbignya Martiana*. This 60-ft tree, growing wild over more than 35,000,000 acres of the Amazon, produces abundant fruit containing kernels with up to 72% of an almost colourless oil very similar in composition and use to coconut oil. It can be used in margarine, shortening, general edibles, soap and detergents. The seed-cake remaining, containing 27% protein, is an excellent animal feed.

Production of kernel oil is enormous. One palm may produce a ton of nuts a year, 198 lb of which is kernel. Some trees in plantations have yielded 3,300 lb

of nuts a year, with each tree yielding four racemes annually. These racemes weigh from 31–198 lb and contain 200–600 fruits which resemble small coconuts. Each weighs from 5½–7 oz with 3–8 kernels, consisting of 60–70% oil.

The palm is slow maturing, beginning to yield in eight years and reaching maturity in 12 years. A tree may yield well for 75 years or longer. It grows on a wide variety of soils, well drained areas of alkaline or neutral soil, although it will thrive on siliceous soil.

While plantations have been established, little has been done to examine the variability of wild trees for use in breeding and selection programs of the germ plasm available. High-yielding types and strains with other desirable characteristics are waiting in the forests to be collected and introduced into germ plasm banks.

Other species of *Orbignya*, native to tropical American regions outside of the Amazon, are similar sources of oil and should likewise be considered in any program of improvement of babassú.

Guilielma speciosa—known in Brazil as pupunha, Colombia as chontaduro, Peru as pijuayo, Central America as pejibaye—has been planted as a dooryard tree throughout tropical America from earliest times. In fact, this palm is not known in the wild, and its original home, while undoubtedly American, is unknown.

There are many agricultural varieties of this tree, and a representative collection of germ plasm should be made preparatory to a program of improvement. For there is no doubt that the potential of *Guilielma speciosa* has hardly been tapped. The species will grow in tropical regions from sea level to 4,500 ft, preferring clay or clay-loam soils and a rainfall not exceeding about 900 in.

The fruit varies from 1–3½ in long and is borne on racemes weighing 280 lb and consisting of up to 300 individual fruits. It represents one of the most balanced foods of the tropics, containing carbohydrates, protein, oil, minerals, and vitamins. The edible part of the fruit is the starchy mesocarp which may be eaten boiled or from which a flour or meal can be made. Natives in the Amazon prepare a nutritious chicha or fermented drink from the mesocarp.

While this tree, a major economic plant in tropical America, supplies a principal food for many country people, the potentialities for extensive commercial production from plantations of improved types are very promising. Collection of seed and a classification and biological study of the many cultivars should be initiated. There are, especially in the Amazon regions, many cultivars with very desirable characteristics: e.g., trees devoid of the dense spines which normally clothe the trunks; and cultivars with unusually large fruits in which the seed aborts, leaving a fruit composed wholly of meal. Great potentialities lie unexploited towards the making of *Guilielma speciosa* one of the major plantation food plants of the tropics.

In addition to the palms, there are many promising oil-rich plants in the Amazon which have been exploited only on a primitive level and exclusively from wild trees. Several of the 15 species of *Caryocar* are good examples. The Amazonian *Caryocar villosum* is very promising due to its small size which favours harvesting of the fruit.

Sir Henry Wickham, who successfully introduced *Hevea* rubber to the Far East, was so enthusiastic about the oil potentialities of *Caryocar villosum* that he sent seed of it to Asia a century ago.

The fruit of *Caryocar* is surrounded by a fibrous mesocarp. Ten percent of the weight of the fruit is starch. The several kernels in each fruit are coated with a yellow fat that yields a sweet oil, a good substitute for cooking fat and butter. The oil consists mainly of glyceride esters of palmitic and oleic acids.

There are other uses for *Caryocar* in the Amazon. Several species are employed in native medicine for purposes that have not yet been scientifically studied. One species of the northwest Amazon is valued as a fish poison, and there is preliminary evidence that the leaves are toxic to the dreaded leaf-cutting ant. The wood of another species is so durable that it is employed in shipbuilding.

Here is a genus well worth serious study on the part of economic botanists and allied scientists. We may confidently expect that the future will see plantations of one or several species of *Caryocar* established for the commercial benefit of the Amazon and the betterment of life in the tropics in general.

Still another oil-rich plant that has been neglected is *Caryodendron orinocense*, not actually an Amazon native but common in the Colombo-Venezuelan region of the upper Orinoco bordering on the northwest Amazon.

A member of the Euphorbiaceae, family of the Pará rubber tree and yuca, this medium-sized, fast-growing tree yields abundant annual harvests of edible, oil-rich seeds. Long exploited in the wild by natives, *Caryodendron* has only recently attracted the attention of commercial interests. The oil is valued for a wide range of uses, from cooking to soap-making and cosmetics. One of the promising characteristics of the tree is its ability to grow well on poor lateritic soils. It needs a hot, humid climate, from 300–1,000 ft altitude, where the drier season lasts at least four months; many areas of the western Amazon are appropriate for plantations of *Caryodendron orinocense*.

Before leaving this brief discussion of several oil-rich species of the Amazon, I should call your attention to a remarkable, but little known book: Celestino Pesce's *Oleaginosas da Amazonia* published in 1941 in Belém do Pará. This study, one of the most comprehensive ever published, offers the oil content of about 120 Amazon species, based on botanically identified specimens and sophisticated analyses carried out in the laboratories of São Paulo. It is a work that merits translation and re-publication in Spanish and English. I mention it here because of its extraordinary importance for the economic botany of the Amazon and because of its extreme rarity.

The miriti or moriche palm, *Mauritia flexuosa*, has many uses—food, drink, shelter, clothing, bedding—amongst the natives of the Amazon and Orinoco. It is undoubtedly the most abundant palm in tropical America. There have been few serious attempts to commercialize it for the the numerous products that might interest peoples in urbanized societies: oil and starch for food; a wine; cork; fibre for string, sacking, nets, hammocks; and timber.

Mauritia flexuosa grows in or near bogs or swamps which are of no use for usual types of agriculture. The tree may attain a height of 75 ft and have leaves as long as 10 ft. The scale-covered fruit which ripens a golden brown has a thin pulp, rich in vitamin C and with up to 9% of an edible oil which has more vitamin A than any oil known. The kernel, which is easy to crack, yields 50% of a light yellow oil similar to that of the African oil palm. The Indians prepare a sago-like starch from its pith and a wine from the fruits and from the sugar-rich sap and unopened flowers. A material which might be used instead of cork is obtained from the leaf stalk, and the young leaves yield a fine, strong thread-like fibre.

So little interest in domesticating miriti has been shown that almost nothing is known about its requirements or agronomic potentialities. Yet a palm of so many diverse uses merits the attention of agricultural specialists as a possible new economic crop plant for land of little value for conventional cultivated trees. Little is known of the range of variability of the numerous strains over its vast area of distribution, and there is even lack of agreement on the classification of the several species of the genus.

The need for wax increases each year. True waxes cannot be commercially synthesized. All sources of major waxes are wild, no plantations being involved in supplying waxes. Almost all important sources of waxes are trees of dry, even desert areas, some of them little appropriate for human habitation. The reason is obvious: most plants have high concentrations of wax primarily as a protection against excessive loss of water in xeric habitats.

There is one important exception: it is the maranthaceous plant *Calathea lutea*, a tall herb with large leaves that flourishes along the annually-flooded alluvial river banks of the Amazon. It is known by the Brazilian name cauassú. The wax occurs as a paper-thin layer on the nether surface of the leaf. The leaves grow to maturity in nine months and yield on the average 0.7 g of wax which can be easily removed without machinery. The wax contains a resin which, for some purposes, must be removed by solvents. The final product—cauassú wax—is similar to the finest carnaúba wax, produced by a slow-growing palm of the inhospitable deserts of northeastern Brazil, *Copernicia cerifera*, where human living is extremely difficult—and which can be used for the same purposes.

Calathea lutea is easily propagated either vegetatively or from seed. As many as 30,000 plants can be grown on an acre; and leaves may be harvested from the first year, followed by two harvests annually or a yield of about 70 lb of wax per acre. The plants can be cultivated in areas along rivers, where living is easy and where natives may grow other crops and are assured of a good source of fish for their diet, there is the hope that eventually cauassú wax might become a major cottage industry crop. There is even a hope that it might partially replace carnaúba wax in commerce, since the price of carnaúba is constantly increasing due to difficulties in its procurement.

Cauassú can be exploited immediately from wild stands without waiting for studies or the creation of plantations.

Of the numerous species of fruit trees worthy of attention for domestication, perhaps the most promising is uvilla or uva de monte in Colombia and Peru or puruma in Brazil: *Pourouma cecropiaefolia* of the Moraceae. This small bushy tree of the western Amazon of Brazil, Colombia and Peru, although extensively cultivated by the Indians as a dooryard crop, is not known in the wild state. It presumably is derived from one or several of the wild species of *Pourouma*, especially *P. sapida*, some of which have fruits which are edible, albeit inferior to those of the cultivated species.

The large racemes of purplish grape-like fruits begin to bear in three years and eventually put forth prolific harvests which last over three months in the wet season. The fruit, measuring up to 1¾ in in diameter, has a large pit and a sweet, almost colourless pulp; it can be eaten raw or fermented into a kind of wine.

There has been a complete dearth of agronomic studies on this tree, nor have any attempts ever been made to put it into plantations. Little is known of the

requirements of the plant, of the variation of the numerous varieties or strains nor of its nutritional value. Collection of all possible strains may give researchers much insight into high-yielding types, those with largest or sweetest fruits, fastest growers or other variations valuable for programs of selection and hybridization.

The list of potential candidates for domestication could be extended. But there are two additional ways in which the rich flora of the Amazon may be exploited for the benefit of tropical agriculture or silviculture. These uses are not so obvious but may, in the long run, be even more valuable to humankind. One concerns the potentialities inherent in modern phytochemistry, making it possible to discover wholly new chemical constituents of plants which may assume unparalleled importance in medicine or industry of the future. The other concerns the possibilities of changing or improving plants already established as domesticates by utilizing hitherto unknown characteristics inherent in some of the many local ecotypes or strains up to the present neglected in the course of domestication and cultivation. To illustrate the first, I would like to mention ethnopharmacological research amongst primitive societies of the Amazon. To illustrate the second, there is no better subject to discuss than the Pará rubber tree.

Only a small percentage of the world's flora of perhaps 500,000 species has been adequately analyzed for chemical composition. Even a much smaller percentage of the Amazonian flora has been phytochemically studied. Genera and even whole families have never even superficially been examined. Yet the vegetation is rich in biodynamic plants. Nowhere else in the world have native peoples made use of a greater assortment of plants in the preparation of such products as arrow poisons and ichthyotoxins. And many of the Indian tribes possess an extensive pharmacopoea of presumed medicinal plants. The use of hallucinogens and other narcotics and stimulants is extensive. Everything points to the fact that the Amazon's green cover is a veritable, almost limitless, chemical factory—and a chemical factory almost untouched, waiting for the attention of scientific research.

Before preparing this paper, I made a count of the number of new alkaloids isolated from Amazonian plants and reported in the literature during the last 10 years. This count, very superficial and most certainly far from complete, gave a total of 278 alkaloids—and we must remember that alkaloids are only one of many categories of secondary organic constituents in plants.

From my own field studies, I have a list which, up to the present, comprises more than 1,300 species employed by natives in the northwest Amazon as medicines, poisons or narcotics—and the list is not yet complete. Most, if not all, of these species are biodynamic, but we know the active principles in only a few; in a few more we may guess from chemotaxonomic relationships what the active constituents may be. How great a challenge! There is no way of calculating how many new chemical structures—some possibly of great importance to human life and health—lurk yet undiscovered in the flora of the Amazon. It would seem that this potentiality alone might suffice to preserve from extinction the Amazon forests as well as the indigenous cultures privy to deep knowledge of the properties of their ambient vegetation.

Even in the case of well established economic plants the Amazonia may offer still untapped sources of germ plasm which could be utilized in programs of improvement. This aspect of the Amazonian flora may represent one of the

strongest arguments for protection of its rich and unique vegetation. While the value and wisdom of such an examination of wild strains has been amply indicated in several notable instances, e.g., with *Manihot* and *Theobroma*, there is probably no better example than that provided by *Hevea*.

Hevea has enjoyed only a century of domestication—that is only one hundred years of manipulation by man. Yet the changes wrought in human living by this single new crop plant have been nothing short of remarkable. The first plantations set out from seed in the Far East yielded about 450 lb of dry rubber per acre per year. Clones are now available that yield 3,000 lb, while new chemical treatments applicable during tapping of the trees can increase this figure to approximately 6,000—an improvement of 13.3 times! What makes this change much more startling, however, is the very limited germ plasm of the original material.

In 1876, when Sir Henry Wickham succeeded in introducing *Hevea brasiliensis* into cultivation, few botanists or agronomists would ever have dared to envision such an accomplishment.

Wickham gathered some 70,000 seeds from trees near Santarém, a locality at the mouth of the Tapajóz River, some 400 miles upstream on the Amazon River. These seeds were rushed to England by steamer and planted in greenhouses at the Royal Botanic Gardens at Kew. Approximately 2,000 germinated. Of these, only 26 reached maturity in the Far East and became the basis of the millions of acres of plantations that now supply virtually all of the natural rubber used in the world. For no further introduction of seed of *Hevea brasiliensis* of any significance was possible until relatively recently, because of the embargo imposed by the Brazilian government until the period of the Second World War.

There are many strains or ecotypes of *Hevea brasiliensis* in the vast Amazonia. The material gathered by Wickham does not represent the best strain available in the wild for quality or yield of rubber. If the Wickham trees had been taken, for example, from a strain from the Território do Acre in the southwesternmost part of the Amazonia, one of the finest highland ecotypes yielding a superior type of rubber, one cannot imagine how much greater the present plantation rubber might have been. But living material of all of the wild ecotypes of *Hevea brasiliensis* should be available in nurseries for long-term genetic work and for programs of selection for specific characteristics that may in the future be desirable.

And then one must not forget the other species of *Hevea* and their potential interest for the future of the rubber industry. There are, in addition to *Hevea brasiliensis*, nine other species, three of which—*H. Benthamiana* and *H. guianensis*—yield a rubber of commercial value. The remaining species—*Hevea pauciflora*, *H. rigidifolia*, *H. nitida*, *H. Spruceana*—have a latex poor in the caoutchouc hydrocarbon, giving a rubber of no commercial value. But material of all these species and their ecotypes should be available for other characteristics—e.g., disease resistance—of value in genetic programs of the future. And with the present proliferation of elastomers and plastics, chemists frequently need various kinds of latex, in themselves of no use, but valuable as “fillers” to mix with the synthetic products to alter their physical properties. Who can tell whether or not the future may not see plantations established of *Hevea Spruceana*, a species with a watery, tacky resinous latex which refuses to coagulate easily and which yields a product devoid of commercial interest as rubber? There may come a day when its so-called “inferior” latex may be needed in large production and when

this species will be set out in plantations. Furthermore, the uses of natural rubber are proliferating so fast that there is every expectation that perhaps latexes and rubbers now known and commercially available will not be adequate to satisfy the needs of future technology.

The Amazonian flora offers us an emporium of germ plasm incredibly rich and varied and comprising thousands of genera of plants, some of which will have uses in the future that we today cannot imagine. For the good of our descendants, for the progress of civilization and perhaps even for the survival of the human race, it behooves us—nay, we have the obligation—to protect this nonrenewable gift of Nature.

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