The Huancapi story highlights one of the reasons for the existence of germplasm banks and the activities of plant collectors. Although peasant farmers understand the value of genetic diversity and will safeguard it as faithful custodians, they are—as the Huancapi story shows—unprepared to maintain it in the face of political and social catastrophe. *Ex situ* conservation must therefore play a role in conserving genetic resources for future generations.

With the collaboration of national potato programs in Latin America, CIP has assembled one of the largest potato collections in the world. Participating national programs not only donated duplicate sets of their national or institutional collections, but participated actively in potato collecting expeditions organized by CIP (see, story, p.45).

Maintaining this type of collection requires a high level of funding and annual vegetative propagation in the field. Land, labor, input, and irrigation costs are rising. The cost of maintaining stored tubers, true seed, and *in vitro* plantlets is also high.

Under present days of economic difficulties, many Latin American countries cannot maintain their national collections and, despite the good will of the national programs, many are facing partial or total losses of their collections. As a result, many national scientists and technicians with good training in the conservation of genetic resources are usually underpaid. Consequently, they often abandon their positions or even their professions, a process comparable to the erosion of the plant genetic resources they had been trained to stop.

One outgrowth of this evolutionary process was the selection of potatoes with outstanding culinary quality and taste.

The solution for safeguarding this genetic heritage lies with *ex situ* genebanks such as the one maintained at CIP. The maintenance of duplicate sets of the collection in several countries is part of the Center's conservation strategy. CIP is also helping national programs to restore collections that have been lost due to catastrophic crop failures, natural disasters or other reasons, such as terrorist activities. At the request of the National Agricultural University at La Molina and the National University of Cajamarca in Peru, CIP has recently returned about 1,000 Andean potato cultivars that represent most of the genetic diversity collected in that country. However, unless international funding is provided, the safety of national collections will continue to remain in doubt.

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Ethnobotanical Conservation and Plant Diversity in the Northwest Amazon

by Richard Evans Schultes

Introduction

Ethnobotany—the study of the knowledge and use of plants in primitive societies—is not new. It had its start when man first learned to classify his ambient vegetation into those species of use, those of little or no use, and those capable of making him ill or even killing him. The name *ethnobotany*, proposed in 1895, is a century old, but it has developed as a scientific field of research primarily during the past 70 years. Today this interdisciplinary field has expanded and there are many subdivisions: e.g. archaeoethnobotany, ethnoecology, ethnopharmacology, ethnomycology, and many others.

In recent times due to worldwide realization of the urgent need to protect the environment, the term *ethnobotanical conservation* has become widely used. It refers to the preservation of knowledge about plants and their properties that has grown up in primitive societies over millennia.

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One important aspect of this knowledge concerns the variations that exist within plant species and the relationship of one species to another: *biological diversity*.

This precious knowledge is rapidly disappearing with increasing acculturation and "westernization" of primitive societies in many parts of the world, particularly in the tropics, as a result of road-building, commercial industry, growing missionary penetration, wars, tourism and other activities. The loss of this knowledge in many areas, such as the Amazon, is more rapid than the loss of plants from the rampant destruction of millions of hectares of forests. It will be tragic from numerous points of view, especially in the progress of our understanding of biologoical diversity.

Polarization of Views on Contributions of Native Peoples

The discernment with which man in primitive societies studies and takes advantage of the plants of his environment has long been a source of admiration. There has been polarization of views regarding evaluation of ethnobotany: some specialists enthusiastically assert that native peoples everywhere have a special intuition enabling them to unlock the so-called secrets of the Plant Kingdom; others denigrate all aboriginal folklore as unscientific. Both viewpoints are erroneous. Much of incalculable value concerning the variations that exist within plant species can be learned from primitive societies.


Hevea brasiliensis, *the so-called "black bark" Pará rubber tree (Colombia).*
(Photo courtesy of R.E. Shultes)

The Northwest Amazon

The Amazon basin—supporting the largest rain forest in the world—is an area of 1,050,965 km^2. No accurate census of plant species has been made. The usual estimates place the figure between 35,000 and 50,000 species of higher plants, but botanists working in the region tend to suggest a higher figure, with an estimate as high as 80,000. There is no possibility of calculating the number of the lower plants, e.g. fungi and algae, since so little work has been done. The world's plants may total approximately 0.5 million species; if so, it is possible that the Amazonia has approximately 16 percent of the world's flora.

This great wealth of species increases towards the west of the region and this part may, according to leading botanists working on phytogeographical studies in the area, perhaps be the least studied but also the richest part of the Amazonia.

We denote as the Northwest Amazon the area lying within Colombia, Ecuador, the northern Amazon drainage area of Peru and that part of Brazil adjacent to the borders of Colombia and Peru. This region, the waters of which eventually flow into the Amazon River, varies in altitude from 36,000 m or more on the eastern slopes of the Andes to the planada of about 1,000 m. The area is not a homogeneous rain forest, notwithstanding superficial impressions from an airplane! Rather, it is extraordinarily heterogeneous. Consequently, diversity should be expected to be greater here than in more homogeneous areas.

The region is also the home of an extremely large number of diverse Indian tribes of varying degrees of acculturation or non-acculturation. They speak a mosaic of very different languages and dialects classified (often with uncertainty) into at least 12 linguistic families. The 70,000 Indians in Amazonian Colombia alone belong to more than 50 ethnic groups.

This precious knowledge of the Plant Kingdom is rapidly disappearing with increasing acculturation and "westernization" of primitive societies in many parts of the world, particularly in the tropics.

When the Russian botanist Vavilov postulated major centers of origin of cultivated plants, Amazonia was not included (see story, p.7). Since this region has provided several of the world's most important economic plants, however, Amazonia should perhaps be considered a center. It is a region of origin of rubber (*Hevea brasiliensis*), cacao (*Theobroma cacao*), tapioca (*Manihot esculenta*), achiote (*Bixa orellana*), coca (*Erythroxylon coca*), pineapple (*Ananas comosus*), Brazil nut (*Bertholettia excelsa*), possibly the peach palm (*Guilielma speciosa*), the curare liana (*Chondrodendron tomentosum*) and others.

Examples: Indian Knowledge of Diversity in Plants

Probably most species—with the possible exception of strict endemics—have diversified into local geographical or ecological strains or races. This would seem to be particularly true of those species with wide distribution in such an extensive area as Amazonia.

Botanists seeking diversity find it helpful to engage in ethnobotanical questioning of native inhabitants. Below are some examples of the Indian knowledge of diversity in plants.

Peach Palm. *Guilielma speciosa* (also known as *Bactris gasipaes*). The peach palm—*chontaduro* in Colombian Amazonia—produces a highly nutritious fruit. Although the tree has been widely cultivated throughout the humid tropics of the Americas for a very long time, its exact place of origin is not known. It has not been found in an undoubted wild state. It is believed by some botanists that its original home was the Amazon of Peru.

Recently, an extensive program of collecting germplasm from as wide a region as possible has been undertaken. An extraordinary range of diversity was found with variation especially extensive in the Colombian Amazonia, where the Indians have clones lacking the usual stout spiny trunks and which produce unusually large and seedless fruits. Harvesting fruits is much easier from spineless palms. The Yukuna and Tanimuka Indians of the Miritiparaná River have numerous clones of this kind, and they celebrate the *chontaduro* harvest each April with a four-day ceremonial dance.

Pineapple. *Ananas comosus.* In the Witoto Indian country of the Karaparaná and Igaraparaná Rivers of the Colombian Amazonia, the natives plant and have names for more than 12 pineapple clones. The fruits vary greatly size, but all are very sweet with tender flesh. It is a region where the pineapple growing industry should carry out studies and collections of the diversity of this cultigen.

There is some uncertainty as to the original home of the pineapple, but the great diversity in northwest Amazonia might suggest that region.

Pará Rubber Tree *Hevea brasiliensis.* The genus of the Pará rubber tree has 10 species. Three species yield usable rubber and have been exploited in the wild: *Hevea brasiliensis*, source of the highest quality rubber; *H. benthamiana*, yielding a product almost as good; and *H. guianensis* and its variety *lutea*, producing a third-grade but usable rubber. The latex of the other species varies chemically, and high percentage of resins and low content of caoutchouc make the rubber hardly useful or, in some species, prevent coagulation. These relatives, however, may be of value in future breeding programs. At least six of the ten species exhibit distinct diversity in the wild.

The British established their Asiatic plantations with seed of *H. brasiliensis* gathered in the vicinity of Santarém in the eastern Amazonia. Extraordinary improvements in yield of rubber have been made in the past 115 years, and this one species now supplies 98 percent of the world's natural rubber. Experiments are now in progress to cross *H. brasiliensis* with some of the other species to see what results may possibly be advantageous to the rubber plantation industry. Ethnobotanical knowledge available from native rubber tappers in the Amazon may be of extreme significance to plant breeders.

While *H. brasiliensis* exhibits variation in many characters, none is perhaps of greater commercial importance to the plantation industry than the differences in bark color and texture. All rubber tappers distinguish three types of bark, wherever they occur: *Seringueira prêta* ("black rubber tree") with bark easy to cut, a deep purplish inner bark with a low concentration of stone cells and producing a thickish latex; *seringueira roja* or *seringueira vermelha* ("red rubber tree"), with a distinct reddish inner bark; and *seringueira branco* ("white rubber tree), yielding a thinner latex and a poorer grade of rubber, and with a light tan bark when cut.

We would do well to utilize the aboriginal knowledge of the vast flora of northwest Amazonia before it is lost and forever entombed in the culture that gave it birth.

This diversity is important. When Sir Henry Wickham succeeded in 1876 in sending out the first successful shipment of viable rubber seeds, he collected the seeds where the *branco* type predominates. Consequently, the plantation trees are almost all of this type. The superior *prêta* type is rarely seen in the eastern Amazon but predominates in the western parts of the basin.

Local diversity of *Hevea brasiliensis* has not been used to advantage in genetic work. If Wickham had been able to collect and send out seeds from a more western region, plantation rubber would be very different today. But transportation a century ago in the Amazon would have been so slow that the short-lived seeds of *H. brasiliensis* would not have germinated upon arrival in England, where the seeds were planted first in the Royal Botanic Gardens at Kew before their shipment to the Asiatic colonies.

Ethnobotanists Unable to Explain Enigmas in Aboriginal Perceptivity

There are enigmas in many of the wild plants in the Amazon that ethnobotanists have not been able successfully to explain. It concerns the Indians' recognition of "kinds" or "strains" of a species when there are no perceptible visible differences. Such variants are so well established in the Indians' classifications that they have distinguishing native names. And this skill of the Indians is manifest not only to those few of the 80,000 species native to the region that are economically important, but it is evident in the aboriginal classification of many plants with little or no significance in utilitarian, ceremonial, magical or mythological aspects of aboriginal life.

In most cases, it is impossible botanically to discern morphological differences by which taxonomic categories might be recognized, but the natives can tell at once and frequently on sight without feeling tasting, smelling, cutting, crushing, tearing or other physical manipulation, to which category a plant belongs. The "identification" of these "kinds" is a most complex interdisciplinary problem; but, whilst it is obviously of significance to anthropologists and psychologists, it is of extreme importance to the botanist and phytochemist, especially to biologists specializing in the study of diversity.

Little research on this fascinating aspect of ethnobotany has been attempted. Most "explanations" are pure conjecture. Some writers have assumed that these recognized named "varieties" may be nothing more than different parts of a large plant, age forms or plants growing in shade, sun or under other environmental conditions. It is very possible, particularly with food, medicinal, narcotic or toxic species, that some of these "strains" may represent chemical varieties. However, how can an Indian visually identify a chemovar and give it consistently the same name in his language? I have tested the accuracy of the natives in this respect on many occasions and have rarely found any doubt, hesitancy or error. And Indians of different tribes and living at appreciable distances from one another will identify these plant variants with amazing consistency.

Typical trunk of the hallucinogenic liana, Banisteriopsis caapi *(Colombia).*

(Photo courtesy of R.E. Schultes)

Stimulants and Hallucinogens

There are no better examples of this aboriginal perceptivity than 1) *yoco, Paullinia yoco,* the caffeine-rich stimulant of the westernmost Amazonia of Colombia and Ecuador and 2) *yajé, Banisteriopsis caapi,* the source of the hallucinogenic drink variously known in western Amazonia as *ayahuasca, caafi, natema,* or *pinde.*

Paullinia yoco. Reports of travellers and anthropological writers have long mentioned *yoco.* In the 1920s, a Belgian scientist analyzed material of *yoco* from the Colombian Putumayo and reported its caffeine content; but it was mistakenly identified. In 1942, the plant was described as a species new to science.

Early information reported that two "kinds" were recognized by the natives: *yoco blanco* and *yoco colorado.* They often grow side by side. A recent collection has the Kofán Indian name *totoa-yoco* ("white yoco") and indicates that it contains more latex than other types and is therefore the best type. Another collection reported that *harmi yoco* is the strongest, but in neither case are there any characteristics that would enable an Indian to see differences from a distance. A very recent collection called *yoco de brufo* ("sorcerer's yoco") has unusually large leaves, but since the leaves of this liana are hardly visible far up in the crown of forest trees, one wonders how a native can easily see them from the ground, yet they can immediately and invariably name the variant with accuracy.

Furthermore, there are many more aboriginally named "kinds" of *yoco.* The named variants now number fourteen: *yoco*; *yoco blanco* ("white yoco"); *cananguche yoco* ("yoco of the Mauritia palm"); *huarmi yoco*; *po yoco*; *tigre yoco*; ("yoco of the jaguar"); *taruco yoco*; *taruco yoco*; *totoa yoco* ("white yoco"); *verde yoco* ("green yoco"); *yage yoco* or *yoco yage* (yoco of the hallucinogen *Banisteriopsis*); *yoco colorado* ("red yoco"), *yoco-cu* (reddish yoco"); *yoco de brufo* ("sorcerer's yoco"); *yoco negro* ("black yoco"). Two of these names might suggest that they are used with other plants, but this cannot explain the Indians' uncanny ability to distinguish the kind of *yoco.*

Scientific studies have done little to advance our knowledge of the Indians' skill in recognizing the variants which exist.

Here is, then, an excellent example of the value of ethnobotany in our search for biological diversity for, according to the natives, there are differences, and the accuracy of their naming of these "kinds" in the forest before even approaching and touching the liana attest to their deep acquaintance with their wild plants.

Banisteriopsis Caapi. This potent hallucinogen is a stout forest liana, but it is so frequently used in native ceremonies that it is often cultivated.

Vague references to the ceremonial use of this drug appeared in early missionary writings of the late 1600s, but little was known about its source, until, in 1858, a geographer described the preparation of the hallucinogenic drink and reported that its source was the bark of a forest liana. In 1853, Spruce, a British plant explorer, definitively identified its source with voucher specimens. Since the early scientific work, many specialists and, unfortunately, popular writers have published on this narcotic.

We now know that it is prepared basically from the liana *Banisteriopsis Caapi,* but that, to strengthen and lengthen its narcotic effects, the Indians often add the leaves of other plants to the beverage.

The drink prepared from the bark of *Banisteriopsis Caapi* is hallucinogenic even without additives, containing several beta-carboline alkaloids. With the two most widely used additives, however, other types of alkaloids—the tryptamines—enter the drink.

The tryptamines are active when taken

orally only when taken with a monoamine oxydase inhibitor: the beta-carbolines in the liana are monoamine oxydase inhibitors! These two additives are the leaves of *Psychotria virides* or the leaves of *Diplopteris Cabrerana*. How did these indigenous peoples find in their 80,000 species the two that, with their unusual chemical attributes, could increase and lengthen the basic hallucinogenic drink prepared from another species?

There is no doubt that Indians in the northwest Amazon can identify various "kinds" of *caapi* or *ayahuasca* and at a distance, without feeling, tasting, smelling or cutting the liana. In a number of field experiences, I have appreciated this skill of the natives. Many studies have noted this peculiar native ability, and there is a long list of names to designate these numerous variants. The natives insist that they can utilize these different "kinds" of caapi to prepare drinks of sundry strengths, for different purposes or in connection with various ceremonies, dances or magico-religious needs or for whatever the partaker wishes to kill in the hunt. At least thirty "kinds" are recognized and have native epithets in the western Amazonia.

A list of these epithets, each indicating a special type of the source plant but with no morphological differences that a botanist might use for a subspecific classification, are the following. *Yajé*; *amarrón*; *huasca* ("vine of the boa"); *inde huasca*; *yajé del monte* ("wild yajé"); *yajé sembrado* (cultivated yajé"); *wai-yajé*; *beji-yagé*; *wahi-yagé so-om-wa-wai-yagé*; *kwa-ku-yagé*; *sese-yagé*; *usebo-yagé*; *we-ki-yagé*; *rami-wetsen* ("yellow arahuasca"); *shurio-shinipa* ("red ayahuasca"); *ayahuasca negra* ("black ayahuasca"); *shillinto ayahuasca* ("yellow ayaluasca," which is used only medicinally in Peru); *ayahuasca amarilla* ("yellow ayahuasca").

Conclusions

These few examples indicate the intensely meticulous knowledge of their plants that rubber tappers and indigenous peoples of the northwest Amazonia possess. Biological diversity is usually not easy to discern, even by botanists involved in the study of special groups of plants. By contacting aboriginal peoples, specialists may well be able to discover variants not easily discernible. We would do well to utilize this knowledge before it is lost and forever entombed in the culture that gave it birth. Time to use this tremendously important aid is running out. Here is where ethnobotanical conservation can be of value to research in studies and collection of biological diversity of many wild or cultivated species.

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Conservation of Genetic Resources *In Situ*

by Eduardo Lleras

Conservation of useful plant genetic resources *in situ* is often been confused with wider conservation of nature. However, they are distinct activities. While nature conservation is primarily concerned with conservation of ecosystems and with avoiding loss of species within them, *in situ* conservation of genetic resources is, in Otto Frankel's words, "the continued maintenance of a population within the community to which it belongs, in the environment to which it is adapted."

Genetic reserves are thus defined as dynamic units of conservation of the genetic variability of specific populations of species of present or potential use. They act as natural reservoirs of genes under constant selective pressure.

Genetic reserves were always envisioned as basic to the conservation of wild species with potential for future use, or of wild relatives of crop plants. Today it is accepted that *in situ* conservation may also play an important role for species under various degrees of management. The following types can be recognized:

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The existence of a great part of the genetic variability in the Americas depends on landraces in the hands of small farmers and Amerindian communities.

- *little or no management*: for wild species or populations of wild relatives of crop plants, in which the main concern is that population size and structure maintain genetic diversity, e.g. national parks, sanctuaries, etc;
- *moderate management*: for wild or semiwild resources used by human communities with minimum disturbance of the natural populations, e.g. extractive reserves (see story, p.89);
- *intermediate management*: for situations in which a resource is used extensively, and in which human interference plays an important role in maintaining the balance of the system, e.g. natural grasslands grazed by domesticated animals; and
- *intensive management*: usually for domesticated or semidomesticated species, for which man is an all important factor, responsible partially or totally for population and community structure, and even survival of the species, e.g. for landraces of many crops.

It is becoming increasingly clear that, whenever possible, conservation of populations in natural habitats may be one of the most adequate strategies. Besides being the most cost-effective because in most cases no very complex actions are needed, it is the soundest biologically. For perennials, it is also the most time-effective, as germplasm is usually represented by mature plants, reducing the waiting period between genebank regeneration and first crop to zero. As a rule of thumb, when seed longevity is shorter than the reproductive cycle of the species, *in situ* conservation should be given serious consideration.

Integrated *In Situ* Conservation Program

Figure 1 shows the flow of activities envisioned for an integrated program for *in situ* conservation. Three main types of activities are proposed:

- *Information, Documentation, and Monitoring* (squares): including a geographical information system, a data center