The Ethnobotany of Coca
(Erythroxylum spp.,
Erythroxylaceae)

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Of all the botanical wonders discovered in the New World by the first European explorers, few can compare with the coca plant for its fascinating history, its remarkable medicinal properties, and its continuing economic and political importance. For millions of South American natives, coca not only furnishes a mild stimulant and sustenance for working under harsh environmental conditions, but also serves as a universal and effective household remedy for a wide range of medical problems. The traditional use of coca also plays a crucial symbolic and religious role in Andean society. Its use is accompanied by complex rituals, ceremony and protocol, such that coca functions as a focus of cultural and social integration. It has been said that chewing coca is the most profound expression of Andean culture and that, if coca were taken away from the Indians, their traditional culture would rapidly disintegrate (Wagner, 1978; Carter et al., 1980a, 1980b).

In sharp contrast to the unifying and stabilizing effects of coca chewing on Andean culture is the disruptive and convoluted phenomenon of cocaine use in Western societies. Because all cocaine entering world markets is derived from coca leaves produced in South America, the staggering increase in demand for cocaine for recreational use has a direct impact on South American economies, politics and, ultimately and most tragically, on indigenous cultures. The widespread use of cocaine, either for pleasure or work, is a very different psychological experience than using coca in a traditional setting: the differences between the pharmacological effects of cocaine hydrochloride taken, say, intranasally, and the effects of chewing coca leaves have been emphasized repeatedly (Mortimer, 1901; Weil, 1975; Grinspoon & Bakalar, 1976; Antonil, 1978; inter alia). Yet many people still equate the use of coca with that of cocaine and fail to comprehend both the pharmacological and cultural differences between these two related yet unique substances. In modern societies, people are fairly well acquainted with both the pleasurable and deleterious effects of cocaine because of extensive news coverage of the cocaine "phenomenon" in recent years. Yet few people are aware
of the beneficial effects of coca chewing, of the importance of the use of coca in Andean life, or of the origin and evolution of the coca plant.

During the past decade, we have seen enormous progress in research on the history, chemistry, botany, and cultural importance of coca. Unfortunately, most of these studies have been overshadowed by a much greater profusion of studies on the pharmacology and chemistry of cocaine and on its physiological and psychological effects. It is my purpose here to present an overview of the botany, chemistry, and uses of coca by South American natives and to review pertinent research on coca which has appeared since approximately 1970. Areas of particular interest include recent studies on the botanical origins of coca, which until the 1970’s remained muddled and misunderstood even by taxonomic botanists; on the archeological record of coca, which, although rather scanty, had been largely misinterpreted by archeologists; and on the chemistry of the coca leaf, which had never been adequately analyzed because of earlier technical problems in making efficient extractions and quantitative measurements of the contained compounds. There has also been renewed interest in the effects of coca chewing, but we still know relatively little about the subtle and complex pharmacology of the experience. Lastly, there has been an effort on the part of anthropologists to document more completely the religious and cultural aspects of coca in traditional cultures.

One area of study which I will not consider here is the long and complex history of coca after the Spanish Conquest. This topic has been investigated in depth by many scholars over a long period of time but space limitations preclude discussing it here. The reader is referred to the following works in which new and noteworthy findings on the history of coca during the Colonial period are presented: Uscátegui, 1954; Gagliano, 1960, 1963, 1965, 1968, 1979; Patiño, 1967; Martín, 1970; Peña Begué, 1972; Burchard, 1976; Chávez Velásquez, 1977; Antonil, 1978; Carter et al., 1980a; Castro de la Mata, 1981; Bray & Dollery, 1983; Plowman, 1984).

Botany of coca

Many scholars have underestimated or overlooked entirely the importance of the existence of distinct varieties of coca. Although geographical, ecological, and morphological differences in coca varieties were recorded as early as the 16th century, their significance was not recognized until the 1970’s (Rostworowski, 1973; Antonil, 1978; Plowman, 1979a; Bray & Dollery, 1983). Not until coca leaf became an important pharmaceutical product in the late 19th century, did the botanical origins and varieties of coca become the object of scientific inquiry (Plowman, 1982).

The coca shrub belongs to the genus Erythroxylum P. Browne of the tropical plant family Erythroxylaceae. Most species of Erythroxylum are found in the American tropics with about 200 species, although the genus also occurs in Africa, Madagascar, India, tropical Asia, and Oceania. In the Old World, many wild species are employed in folk medicine (Hegnauer, 1981), but it is only in tropical America where Erythroxylum leaves are chewed extensively as a stimulant and where the plants attain major cultural importance (Martín, 1970; Mayer, 1978; Antonil, 1978; Carter et al., 1980a).

All cultivated coca is derived from two closely related South American species—Erythroxylum coca Lam. and E. novogranatense (Morris) Hieron. Whereas other neotropical wild species of Erythroxylum may be employed locally as medicines, discussions of “coca” should be confined to these two species.

Until relatively recently, only one species of coca—Erythroxylum coca—was generally recognized (Mortimer, 1901; Hegnauer & Fikenscher, 1960; Martin,
1970). However, evidence resulting from intense field and laboratory studies of coca, has accumulated during the past decade and demonstrates incontrovertibly that two distinct species of coca should be recognized (Schulz, 1907; Machado, 1972; Gentner, 1972; Plowman, 1979a; Rury, 1981, 1982; Bohm et al., 1982; Plowman & Rivier, 1983). In addition, each of the two species of cultivated coca has one variety, designated E. coca var. ipadi Plowman and E. novogranatense var. truxillense (Rusby) Plowman, respectively. The four cultivated cocas of South America are thus treated as follows: E. coca var. coca, E. coca var. ipadi, E. novogranatense var. novogranatense, and E. novogranatense var. truxillense.

All of the varieties of cultivated coca were domesticated independently in pre-Columbian times and are still employed by native coca chewers in South America. Each of them was known by a different native name before the Spanish popularized the now widespread term “coca.” Although they differ appreciably in the content of minor alkaloids and other chemical constituents, all of the cultivated cocas contain the alkaloid cocaine. Additional important differences among the four varieties, which hitherto have been overlooked, are found in their leaf and stem anatomy, ecology, geographical relationships, and in the methods of their cultivation and preparation for chewing. These differences reflect intensive human selection over a long period of time for specific traits and for successful cultivation in a variety of habitats in distinct geographic areas (Fig. 1).

Although certain wild species may yet be implicated in their evolutionary relationships (Plowman & Rivier, 1983), the four varieties of cultivated coca are more closely related to each other than to any other species of Erythroxylum. Superficially, the cultivated cocas are very similar morphologically, which explains in part earlier confusion in the identification of coca specimens, especially by non-specialists (Plowman, 1979b, 1982). The varieties can be distinguished by characters of the branching habit, bark, leaves, stipules, flowers, and fruits; but often, especially in the case of dried herbarium specimens, complete specimens may be necessary for positive identification. However, in most cases isolated coca leaves can now be identified to species if not to variety, especially if the provenance of the samples is known.

Recent studies have provided additional new characters that permit the accurate and positive identification of coca leaves, including archeological specimens. These studies focus on leaf anatomy (Rury, 1981, 1982; Rury & Plowman, 1984), flavonoids (Bohm et al., 1981), alkaloids (Rivier, 1981; Plowman & Rivier, 1983), reproductive biology and breeding relationships (Ganders, 1979; Bohm et al., 1982), and ecology and geographic distribution (Plowman, 1979a, 1979b, 1984). As a result of these investigations, the taxonomic and evolutionary relationships among the four cultivated cocas are now fairly well understood.

**Erythroxylum coca var. coca, Huánuco or Bolivian coca**

*Erythroxylum coca* consists of the wide-ranging and economically important Andean variety of *E. coca var. coca* and the geographically restricted Amazonian variety *E. coca var. ipadi*. *Erythroxylum coca var. coca* is often referred to as “Bolivian” or “Huánuco” coca, but neither of these terms conveys the extensive geographical range of the variety. For convenience, I will use the term “Huánuco coca” here.

*Erythroxylum coca var. coca*, a shrub 1 to 3 m tall (Fig. 2), grows mainly between 500 and 1500 m elevation but may reach 2000 m in some areas. It is cultivated in regions of moist, montane tropical forest along the eastern slopes of the Andes and in the wetter inter-Andean valleys, in the ecological zone known generally as
Fig. 1. Present distribution of the four varieties of cultivated coca (Erythroxylum spp.) based on herbarium collections.
“montaña” (Fig. 3). Because it has a fairly limited ecological range, Huánuco coca is little known outside its original area in South America. However, this variety is the principal commercial source of coca leaves and of most of the world's cocaine supply.
The geographical distribution of Huánuco coca extends from Ecuador south to Bolivia and northwesternmost Argentina (Fig. 1). Only in Ecuador, where suitable moist forest habitats occur on both sides of the Andes, does this variety reach the Pacific slope. It is unknown in Colombia or in the Amazon lowlands.

Throughout its range, Huánuco coca is found as wild-growing or feral individuals in the understory of primary or secondary forests, both near and remote from areas of present coca cultivation. It is well adapted to the montaña habitat where it appears to be a natural component of the forest understory and occurs sympatrically with several wild erythroxylums including *E. ured O. E. Schulz*, *E. manuacea* Mart., *E. macrocnemium* Mart., and *E. macronatum* Benth.

It is often impossible to distinguish between truly wild-growing *E. coca* var. *coca* and plants that have escaped from coca plantations or that persist after plantations are abandoned. There are apparently no barriers to gene flow between wild and cultivated populations, which freely interbreed when growing in proximity. The small red fruits are eaten by birds which disseminate the seeds throughout the montaña habitat. There are no essential structural differences between wild-growing and cultivated plants of *E. coca* var. *coca*, and this variety seems to be little altered morphologically, genetically, or physiologically through domestication. In this feature, *E. coca* var. *coca* differs fundamentally from many other cultivated plants, especially food plants, which may become isolated genetically from their wild progenitors and lose their ability to reproduce in the wild (Pickersgill & Heiser, 1976).

*Erythroxylum coca* var. *coca* is now thought to be a naturally occurring wild species of the montaña, from which the other three cocas ultimately were derived.
as cultigens through human selection. Probably *E. coca* var. *coca* had a more limited distribution as a wild species, possibly in eastern Peru in the area centering on the Huallaga Valley, where it frequently is found growing wild. Subsequent range extensions northward to Ecuador and southward to Bolivia and Argentina probably occurred through man’s activities.

**ERYTHROXYLUM COCA VAR. IPADU, AMAZONIAN COCA**

Although long-neglected by anthropologists, Amazonian coca, *Erythroxylum coca* var. *ipadu*, recently has been re-examined by botanists (Prance, 1972; Plowman, 1979b, 1981; Schultes, 1981; Rury, 1981, 1982; Plowman & Rivier, 1983) and pharmacologists (Holmstedt et al., 1979). Amazonian coca is closely allied to *E. coca* var. *coca* from which it has originated in relatively recent times (Plowman, 1981). The Amazonian variety is cultivated on a small scale by a number of tribes of the upper Amazon in parts of Colombia, Brazil and Peru (Fig. 1). Propagated by stem cuttings, it is well adapted to the pattern of shifting agriculture practiced by semi-nomadic Amazonian peoples. Amazonian coca does not survive as a feral or escaped plant in the lowland Amazon and may be considered a true cultigen.

Amazonian coca is little differentiated from *E. coca* var. *coca*, and the two varieties appear to be fully interfertile. Amazonian coca contains the same leaf flavonoid profiles as the montaña variety. The leaf flavonoids have been found to be a useful and unvarying taxonomic character for identifying both cultivated and wild coca (Iohm et al., 1981, 1982). A surprising chemical difference in Amazonian coca is a consistently lower cocaine content; this variety usually contains only about half the concentrations found in other cultivated coca (Holmstedt et al., 1977, 1979; Plowman & Rivier, 1983).

*Erythroxylum coca* var. *ipadu* was unknown to Europeans until the middle of the 18th century. Details of its cultivation, use, and geographic distribution were not recorded until the present century. Amazonian coca has no archeological record with which to date its origin in Amazonia, but based on linguistic, ethnographic, historical and botanical evidence. Amazonian coca appears to be a relatively recent development. It surely evolved from stocks of *E. coca* var. *coca* introduced from the Andean foothills through selection for traits conducive to its cultivation in Amazonia. It is now geographically isolated from other coca varieties.

**ERYTHROXYLUM NOVOGRANATENSE**

*Erythroxylum novoigranatense* now is recognized as a distinct species of cultivated coca, although in the past it often was confused with, or considered a variety of, *E. coca* (Plowman, 1982). Appreciable evidence has accumulated that suggest that this species arose as a domesticated plant through human selection from *E. coca* var. *coca* (Bohm et al., 1982). *Erythroxylum novoigranatense* differs from *E. coca* var. *coca* in a number of morphological features. In addition to morphological, has evolved distinctive chemical and ecological traits and thus become genetical isolated from parental *E. coca* var. *coca*.

*Erythroxylum novoigranatense* consists of two well defined varieties: *E. novoigranatense* var. *truxillense*, Trujillo coca, and *E. novoigranatense* var. *novoigranatense*, Colombian coca. These varieties are more strongly differentiated from each other than *E. coca* var. *coca* is from *E. coca* var. *ipadu*. This suggests great antiquity for the varietal isolation and differentiation within *E. novoigranatense* than within *E. coca*.
Both varieties of *E. novogranatense* are known today only as cultivated plants. Both varieties are well adapted to arid conditions and usually are grown in areas where *E. coca* could not survive. In both alkaloid and flavonoid chemistry, *E. novogranatense* differs fundamentally from *E. coca* (Bohm et al., 1982; Plowman & Rivier, 1983). Breeding experiments between *E. coca* var. *coca* and the varieties of *E. novogranatense* have demonstrated genetic differentiation among these taxa, further clarifying their specific and varietal relationships (Bohm et al., 1982).

**Erythroxylum novogranatense var. truxillense, Trujillo coca**

Trujillo coca is cultivated today in the river valleys of the north coast of Peru between about 200 and 1800 m elevation and in the adjacent, arid, upper Marañón river valley (Fig. 1). It is grown today on a relatively small scale for coca chewing and as a flavoring for the soft drink Coca Cola®. Although it is a highly drought-resistant shrub, it still requires some irrigation throughout its range (Plowman, 1979b).

Trujillo coca bears a leaf that is smaller, lighter green, and more brittle than leaves of *E. coca* (Fig. 4). Because it contains flavoring compounds not found in *E. coca*, Trujillo coca long has been valued for coca-flavored wines and tonics. In the last century, it was highly prized in the European and North American pharmaceutical industry for medicinal preparations (Morris, 1889; Plowman, 1982).

Today, Trujillo coca is geographically and ecologically isolated from other coca varieties, and no hybrids between them have been found. However, *E. novogranatense* var. *truxillense* has been successfully crossed with both *E. coca* var. *coca* and *E. novogranatense* var. *novogranatense*. Successful crosses were obtained in both directions between *E. novogranatense* var. *novogranatense* and *E. novogranatense* var. *truxillense*. The resulting hybrids were vigorous and vegetatively normal and exhibited morphological characters intermediate between the two parents. However, most of the hybrids between these varieties which flowered showed only 50% pollen stainability and a much reduced seed set. This suggests at least partial reproductive isolation between the varieties of *E. novogranatense* resulting from their geographical isolation in somewhat different habitats over a long period of time (Bohm et al., 1982).

*Erythroxylum novogranatense* var. *truxillense* also was crossed with *E. coca* var. *coca*, but with limited success. Although F1 hybrids were obtained, these were morphologically and developmentally abnormal, and a number of them died as seedlings. They produced no flowers and clearly were ill-adapted for survival (Bohm et al., 1982). Although Trujillo coca is in several features intermediate between *E. coca* var. *coca* and *E. novogranatense* var. *novogranatense*, it is genetically much more closely related to the latter, with which it shares important chemical and ecological characters.

The leaf flavonoids of Trujillo coca reflect the intermediate nature of this variety. It shares with *E. coca* (both varieties) the 3-O-arabinosides of kaempferol and quercetin, which are absent in *E. novogranatense* var. *novogranatense*. However, both varieties of *E. novogranatense* contain the rare flavonoid ombuin-3-O-rutinoside, which is absent in *E. coca* (Bohm et al., 1982).

Based upon data currently available, Trujillo coca is placed correctly in the species *E. novogranatense* but must be recognized as a distinct variety within that species because of noted differences from the Colombian variety. Based upon genetic and geographical relationships, it is highly probable that Trujillo coca evolved directly from *E. coca* var. *coca* through intensive selection for cultivation in drier habitats and possibly for the more delicate and flavorful leaves and a
more robust, leafy habit. Trujillo coca subsequently gave rise to the Colombian variety of *E. novogranatense* in the northern Andes under similar conditions of geographic isolation and continuing human selection pressures.

**Erythroxylum novogranatense var. novogranatense, Colombian coca**

The fourth variety of cultivated coca is *Erythroxylum novogranatense var. novogranatense*, or “Colombian coca.” This variety is distinguished morphologically...
ically from other varieties by its bright yellow-green foliage and lack of persistent stipules. In dried leaf specimens, identifications may be more difficult and require anatomical study (Rury, 1981). Like Trujillo coca, this variety is well adapted to dry conditions and often is cultivated in the arid, inter-Andean valleys of Colombia and along the Caribbean coast (Fig. 1). However, it is also grown in moister parts of the Colombian Andes, especially at elevations of 1000 to 1800 m.

Unlike any of the other three coca varieties, Colombian coca is quite tolerant of diverse ecological conditions, and for this reason the variety was introduced widely in horticulture in the last century and distributed to many tropical countries, both as an ornamental and as a cocaine source (Plowman, 1979a, 1982). It became an important cash crop in Java during the early part of the 20th century, introduced there by enterprising Dutch colonial planters (Reens, 1919a, 1919b).

Colombian coca is isolated geographically from other coca varieties, in contrast to the more complex distribution patterns seen in Trujillo and Huánuco cocas. This isolation is accompanied by fundamental changes in flavonoid chemistry and reproductive biology of Colombian coca. In its leaf flavonoids, Colombian coca lacks the quercetin and kaempferol arabinosides found in E. novogranatense var. truxillense and E. coca var. coca, but it contains the rutinosides, including ombuin-3-O-rutinoside, which are present in E. novogranatense var. truxillense but lacking in E. coca var. coca (Bohm et al., 1982).

As mentioned earlier, Colombian coca will not cross with E. coca var. coca. It does produce vigorous hybrids with Trujillo coca, although the resulting hybrids showed reduced fertility (Bohm et al., 1982). This suggests that E. novogranatense var. novogranatense is genetically closely related to E. novogranatense var. truxillense even though some reproductive barriers between them have developed as a result of their geographic isolation. On the other hand, E. novogranatense var. novogranatense is genetically much more distant from E. coca var. coca. In their breeding mechanisms, most erythroxylums are strongly self-incompatible, distylous species. Colombian coca is exceptional in being partially self-compatible and isolated individuals may produce abundant viable seed. Self-compatibility is considered a derived state in plants with a heterostylous breeding system, a fact that favors the view that Colombian coca is the most specialized and most recently derived variety of the cultivated cocas (Bohm et al., 1982).

Colombian coca is known only as a cultivated plant and rarely, if ever, escapes from cultivation. Today it is grown on a small scale by isolated Indian tribes of the Colombian Andes, primarily in the Sierra Nevada de Santa Marta and in the Departments of Santander, Cauca, and Huila. It is not extensively cultivated for cocaine production owing to the same difficulties in extracting the alkaloid that are encountered with Trujillo coca leaves; rather, Colombian coca is employed mostly for chewing and as a household medicine. It is commonly planted as an ornamental and medicinal plant throughout Colombia.

**Discovery and early cultivation of coca**

A scenario for man's first discovery and cultivation of coca in the montaña has been outlined earlier (Antonil. 1978; Plowman, 1979a; Bohm et al., 1982). The palatable, relatively tender, young leaves of E. coca var. coca must have been sampled first as a famine food by groups of nomadic hunter-gatherers who early inhabited the eastern Andes. At this time, coca existed as small, scattered populations in the montaña, similar to the distribution patterns of many wild species today. The stimulant and medicinal properties of the leaves were discovered, probably more than once, during this early period of experimentation. Once the stimulating effects of the leaves were known, they were routinely gathered from
the forest for daily use. Refinements in the use of coca, including sun-drying the leaves, holding them in the mouth as a quid, and the addition of an alkaline substance, gradually developed and became customary. Numerous alkaline sources have been employed in chewing coca and with other drugs such as tobacco. In the montaña, the simplest and most readily available alkaline source is the ashes prepared from a wide variety of plants (Plowman, 1980; Rivier, 1981).

As supplies of coca in the wild became insufficient to meet the needs of a growing, coca-chewing population, coca shrubs were transplanted from the wild, nearer to habitations, so that a constant supply of leaves would be available. In this context, coca must have been one of the earliest plants cultivated in the montaña and is implicated in the earliest development of agriculture in this area. The first use and cultivation of coca certainly antedates the first appearance of any archeological evidence (such as ceramic representations of coca chewers or coca-chewing paraphernalia) by several thousand years.

Archeological evidence for coca chewing

The earliest suggestion of coca chewing is found in the Valdivia Culture on the Santa Elena Peninsula in southwestern Ecuador. Here small ceramic lime containers believed to be used in coca chewing have been found that date to Valdivia Phase 4, about 2100 B.C. (uncorrected radiocarbon dating). A tradition of small, decorated lime pots extends through the Machalilla Culture to Chorrera times (300–1000 B.C.), when it reached its maximum development. A small, ceramic figurine of the Chagras style also was discovered at Valdivia that clearly represents the prominent cheek bulge of a coca chewer. This piece is dated Late Valdivia (1500–1600 B.C.) and is the earliest known example of a long Ecuadorian tradition of figurines depicting “coqueros” (Lathrap et al., 1976). Skulls containing heavy accumulations of dental calculus, interpreted as an indication of heavy coca chewing with lime, have been found in a late Chorrera cemetery on the Santa Elena Peninsula (Kleipinger et al., 1977). Based on the archeological evidence, it appears that the custom of coca chewing, and perhaps coca cultivation, was fully established in the Valdivia area by 3000 B.C.

Early evidence for coca chewing has been found also on the Peruvian coast in the Late Preceramic Period 6 (1800–2500 B.C.) in the form of artifacts employed in coca chewing and possibly of actual coca leaves, although the botanical material has not been identified taxonomically. Engel (1957) reported a bottle gourd and three Mytilus shells, all containing powdered lime thought to be used with coca, from a burial at Culebras (Dept. Ancash). Bray and Dollery (1983) have dated this site at around 2000 B.C. Engel (1963) also found “leaves looking like coca” along with large deposits of burnt lime at the site of Asía in the Omas Valley (Dept. Lima). Asia is radiocarbon dated at 1314 ± 100 B.C. but probably dates to about 1800 B.C. (M. Moseley, pers. comm.). Patterson (1971) excavated preserved coca leaves near Ancón (Dept. Lima) in the Gavilán phase dated between 1750 and 1900 B.C. Cohen (1978) also reported coca from Ancón with a date of 1400–1800 B.C. Coca was one of the items (along with maize and marine shells) stockpiled in a group of storage structures at Huancayo Alto in the Chillón Valley (Dept. Lima), dating between 200 and 800 B.C. (Lahaye, 1979). Unfortunately, none of these early records of preserved “coca” leaves has been botanically identified because none of the original specimens can be located.

Archeological coca leaves from more later sites, primarily burials, on the Peruvian coast have been available for study, and these all belong to the variety E. novogranatense var. truxillense, Truxillo coca (Fig. 5). These include specimens
from Vista Alegre in the Rimae Valley (Dept. Lima, approx. 600-1000 A.D.); from the Yauca Valley (Dept. Arequipa, Late Horizon); from Monte Grande in the Rio Grande Valley (Dept. Ica); and from Chacota near Arica in northernmost Chile (Late Horizon). A number of these specimens were studied anatomically and found to correspond closely with modern Trujillo coca, although generally the archeological leaves were smaller in size (Rury & Plowman, 1984). Coca endocarps referable to Trujillo coca were reported from Vista Alegre (Fowle, 1961) and more recently were excavated at Chicha (Dept. Lima, Late Intermediate Period) by Jeffrey Parsons (pers. comm.).

Later evidence for coca chewing, including lime pots, lime dippers, and ceramic coca-chewing human figurines, as well as occasional preserved leaves, has been found throughout the Peruvian coast from the early ceramic period to Inca times. Both Nazca and Moche ceramics depict numerous examples of coca chewers with cheek bulges, often carrying lime gourds and dippers (Yacovleff & Herrera, 1934; Jones, 1974; Donnan, 1978; Jeri, 1980) (Fig. 6).

Following the early appearance of coca chewing throughout the Formative in Ecuador, evidence for coca chewing in the form of lime pots and “coquero” figurines are represented in all later phases up until Inca times, especially in the provinces of Manabi, Esmeraldas, and Carchi (cf. Meggers, 1966; Drolet, 1974; Naranjo, 1974; Jones, 1974; Bray & Dollery, 1983) (Fig. 7).
Archeological evidence for widespread coca chewing in Colombia is well documented by a great many coca-related artifacts. During the first millennium A.D., the Quimbaya culture of the middle Cauca Valley (near the modern city of Pereira) produced numerous, beautifully crafted, gold lime pots, along with gold lime dippers. Some are furnished with gold-beaded necklaces so that they may be worn. In addition, gold figurines carrying gold lime pots in their hands have been recovered from this culture area (Jones, 1974; Antonil, 1978; Bray, 1978; Hemmings, 1978). Ceramic lime pots representing coca chewers are also known from Colombia (Fig. 8).

In the San Agustín culture in the Department of Huila in southern Colombia, a number of monolithic statues have been found that strongly suggest coca chewing by the presence of extended cheek bulges and small bags (for coca leaves) slung across their chests (Pérez de Barradas, 1941; Usacategui, 1954; Reichel-Dolmatoff, 1972; Antonil, 1978) (Fig. 9). One partially destroyed statue known as "El Coqueto" at El Tablón in the valley of San Andrés de Pisimbahá distinctly shows a
small pouch hanging from one side and a lime gourd from the other (Antonil, 1978). The San Agustín statues are dated approximately to the first millennium A.D. The town of San Agustín long has been, and continues to be, a major center of coca cultivation and distribution in the upper Magdalena Valley.
Although there is archeological evidence that coca also reached further north into Central America, these findings are of a considerably later date than those in South America. Lothrop (1937) reported a small, carved bone head with a prominent cheek bulge from Sitio Conte in the Cocle culture of Central Panama, which is dated between 500 and 700 A.D. This figurine closely resembles figurines from Manabi Province in coastal Ecuador as well as the early Valdivia figurine discussed above. Stone (1977) mentioned small figures of gold and stone from the Diquis region of Costa Rica that show the characteristic cheek bulges of coca chewers.

Only in coastal Peru can we identify the variety of coca being employed because of the remarkable preservation of delicate plant materials in the arid desert environment. Trujillo coca appears to be present here around 1800 B.C., although it probably evolved as a distinct variety elsewhere (Plowman, 1984). We have no direct evidence from archeological leaves, but it may be presumed that *E. coca* var. *coca* was being cultivated and utilized for chewing much earlier in the east Andean montaña of Peru and Bolivia. Both Trujillo and Huánuco coca probably were used in different parts of Ecuador, where appropriate dry and wet habitats for these varieties are present. Colombian coca certainly was the variety...
used in the mountains of Colombia, along the Caribbean coast and probably in Central America (Plowman, 1984).

The cultivation of coca

The several varieties of coca are grown under different ecological conditions and their methods of cultivation vary from region to region. Coca is grown on a much larger scale and in a more organized way in Peru and Bolivia than in Colombia or in Amazonia, where until recently there has been little commercial production.

Colombian coca (E. novogranatense var. novogranatense) is produced in relatively small plots, averaging perhaps one-half hectare (Antonil, 1978). Plantings are laid out on flat or gently sloping areas rather than on steep slopes as practiced in Peru and Bolivia. Although most plantations are found between 1000 and 2000 m elevation, the better quality coca (i.e., higher cocaine content and smaller leaf) is grown at the upper limits of cultivation. Colombian coca shrubs are allowed to grow much larger and bushier and are more dispersed within a planting, in contrast to Huánuco and Bolivianucas which are kept relatively small and are planted in neat, straight rows.
Colombian coca is grown exclusively from seed that is gathered in conjunction with the main harvests. The seeds are planted immediately in a shallow seed bed. When the young seedlings emerge, they are shaded from direct sun; they are not planted out until they are 20 to 30 cm tall. Plants are ready for harvesting after about two years. Depending on local conditions of climate and soil, leaves may be harvested two to three times per year. Each bush produces about 500 g of leaves per harvest (Bejarano, 1945). Throughout the mountains of Colombia (in contrast to the Colombian Amazon), coca is picked exclusively by women and children. Only the mature leaves are harvested, and they must not be overripe (Antonil, 1978). The middle-aged to oldest leaves on a branch have the highest cocaine content, whereas the youngest leaves have considerably lower values (Rivier, 1981). During harvesting, a branch is held in one hand while the ripe leaves are picked off one at a time with the other hand. As in the harvesting of all varieties of coca, it is very important not to damage or break the terminal buds on the twigs, since these will furnish the flush of leaves for the subsequent harvest.

TRUJILLO COCA

In coastal Peru and the upper Marañón valley, Trujillo coca (E. novogranatense var. truxillense) is cultivated in relatively flat areas along the valley bottoms known as “playas,” where the fields can be irrigated from rivers by means of irrigation canals or “aséquias.” Trujillo coca shrubs resemble Colombian coca in habit and are allowed to grow relatively large and bushy, with ample space left between
each plant. Fields must be irrigated regularly because Trujillo coca is grown exclusively under arid conditions; however, it is remarkably resistant to drought and survives long periods when no irrigation water is available. Because of the intense and desiccating solar radiation in the Peruvian desert, Trujillo coca often is provided with up to 50% shade by being planted under the leguminous tree *Inga sesilis* DC. (Fig. 10).

Trujillo coca is harvested similarly to Colombian coca, but because about 75% of the Trujillo crop is sold for industrial purposes (Coca Cola production), the leaves may be harvested less carefully, with an entire branch being stripped of its leaves in one fell swoop. Trujillo coca may be harvested three times a year, usually in December, March or April, and July. During the Peruvian winter (June to September), the shrubs grow very slowly and produce the smallest crop of the year.

**Huánuco coca**

Huánuco or Bolivian coca (*E. coca var. coca*) is cultivated along the eastern flanks of the Andes from northern Peru to Bolivia (Figs. 1 & 3). This is an area of generally high rainfall and fertile soils, covered naturally by moist tropical forest. Although this variety is cultivated generally between 500 and 2000 m, the best quality and highest yields are produced at 1000 to 1500 m. The highest cocaine content in Huánuco coca is found in plants grown above 1500 m, but plants grow much slower at this altitude.
Plantations of *E. coca* var. *coca* may be constructed with or without terraces on steep mountainous slopes ("coca de la altura") (Figs. 11 & 12) or on flatter areas without terracing along valley bottoms ("coca de la playa"). Coca requires a well-drained soil; plantations on slopes are preferred and produce a better quality, stronger leaf. However, in some drier valleys, such as La Convención in Cuzco, coca de la playa has the advantage of available irrigation during the more marked dry season (July to October) (Gade, 1975).

New plantations, with or without terracing, are carefully constructed on newly cleared land (Fig. 12). Because of the high rainfall and steep slopes throughout much of the eastern Andes, soil erosion is a serious problem. Terraces constructed along the contours of the slopes help to prevent excessive run-off, but these must be constantly maintained. The best constructed terraces are found in the Yungas coca-growing region of Bolivia, but even here erosion has destroyed many areas for further production and many extant "cocalcs" are planted on poor rocky subsoils (Fig. 13).

After a field is prepared, new plantings are started in at least two different ways. Traditionally, seeds culled from a recent harvest are planted in a protected, shaded nursery ("almáciga") with a light covering of fine soil. The young seedlings gradually are exposed to more and more sunlight, and after about three to four months, they are ready to be set out in rows in the fields. Seedlings are planted fairly close together to allow for later thinning of unhealthy or diseased plants and for natural attrition. Density of plants varies from place to place. In the Peruvian departments of Ayacucho and Cuzco, coca shrubs are allowed to grow taller and are spaced further apart than in the Bolivian Yungas, where plantations resemble rows of low coca "hedges." In Cuzco and Huánuco, the young coca seedlings in a new plantation may be interplanted with manioc (*Manihot esculenta* L.), which serves as protective shade during the first nine months or so of growth.

In Huánuco, coca seeds may be planted directly out in the fields. Shallow holes 20 cm square and 40 cm apart are dug in rows running up and down the hillsides without terracing (Fig. 14). Manioc is often pre-planted in anticipation to provide shade for the young coca seedlings. Seeds are planted directly in the holes and thinned eventually to four plants per hole, which then are allowed to grow up in place. Because there is no terracing and plants are planted in rows running up and down the slopes, erosion is especially serious in Huánuco. Topsoil from a newly prepared field soon washes away. As the roots of the shrubs become exposed with the heavy rains, soil from between the rows is heaped up around the plants, resulting in gullying of the fields (Fig. 15). Although coca will produce surprisingly well under these conditions, the lateritic soil eventually becomes hard and will support little or no vegetation, including aggressive weeds, after coca is taken out of production.

Once established, a plantation of *E. coca* var. *coca* will start producing after one to two years and reach maximum productivity in about five years. If plantations are well maintained by weeding and erosion control, they may be productive for 40 years or more, although productivity decreases after 10 to 15 years (Albo, 1978). In most areas where *E. coca* var. *coca* is grown, three to four harvests a year are possible. In most areas, there is little or no fertilization of the plantations. In ecological terms, coca is an ideal crop for the steep, wet slopes of the eastern Andes since it is able to survive and remain productive for years on heavily leached soils that will support no other crop plants. In Huánuco, owners of large coca plantations ("fundos") employ modern agricultural methods by fertilizing their plantations and applying herbicides and insecticides (Plowman & Weil, 1979). These well managed cocalcs, which largely supply the clandestine cocaine market, may produce up to six crops a year.
Fig. 14. Typical construction of a new plantation of Huánuco coca (Erythroxylum coca var. coca) near Tingo María, Dept. Huánuco, Peru. Seeds are planted directly into the fields in shallow, square pits excavated in vertical rows on hillsides.

Figs. 15–16. 15. An old plantation of Huánuco coca (Erythroxylum coca var. coca) showing highly leached soil and gullying of fields, Tingo María, Dept. Huánuco, Peru. 16. Sun-drying of leaves of Trujillo coca (Erythroxylum novogranatense var. truxillense) at Collambay, Dept. La Libertad, Peru.
Production yields vary considerably from area to area. In Peru, yields in 1971 varied from 410 kg/hectare (Dept. Madre de Dios) to 1200 kg/hectare (Dept. San Martín), with a national average of 810 kg/hectare. Yields of Trujillo coca generally were higher than those of Huánuco coca (Daneri Pérez, 1974). In Bolivia, 1972 yields in the traditional coca districts of the Yungas averaged only 260 kg/ha, whereas the relatively new Chapare districts averaged 851 kg/ha (South, 1977).

**Amazonian coca**

In contrast to other varieties of cultivated coca, Amazonian coca (E. coca var. *ipadu*) is grown from stem cuttings. Entire plots may be derived from a single clone, and fertile seed rarely is produced. Vegetative propagation of Amazonian coca is an adaptation to the shifting slash-and-burn agriculture that is practiced among tribes in the Amazonian lowlands. Soils are poorer than in the Andes, and new fields must be cleared every two or three years. Stem cuttings up to 30 cm long and one cm in diameter are merely inserted into the ground of a newly cleared and burned field. Root formation is rapid, and within six weeks the new plants have leafed out. Plants are ready for first harvesting after about six months (Plowman, 1981).

**The preparation of coca leaves for chewing**

After harvesting, coca leaves of all varieties must be dried quickly and completely to preserve their flavor and texture for chewing and their alkaloid content.
for chewing and for cocaine extraction. Techniques of drying vary considerably depending on variety and geographical area.

**COLOMBIAN COCA**

Colombian coca (*E. novogranatense var. novogranatense*) always is dried by toasting in ceramic pans over a slow wood fire while constantly turning the leaves to prevent burning. The characteristic bright yellowish green color of the leaves changes to a yellowish brown during this process. The strong aroma of methyl salicylate present in the fresh leaves is largely lost during toasting and is replaced by a grassy, smoky flavor. When the leaves are completely dried and removed from the pan, they are extremely brittle and cannot be chewed in this state. As in the case of all coca in which the leaves are chewed whole, it is necessary to allow them to reabsorb ambient humidity until they become soft and pliable. This sometimes is referred to as "sweating." After it is picked, Colombian coca may be packed into large sacks and left to ferment slightly overnight before it is dried. This technique, along with pan-toasting, alters the taste as well as the chemical composition of the leaf, but the details of these chemical changes are unknown.

Most Colombian coca is consumed locally for the purpose of chewing by Indians and mestizos. Only in southern Colombia is there any significant commerce in coca leaves for chewing, and then only on a small scale. In spite of the problems of extracting cocaine from Colombian coca (Plowman & Rivier, 1983), there exists some illicit production in both the Sierra Nevada de Santa Marta and in the southern mountains. Most cocaine exported from Colombia, however, is processed there from crude cocaine paste manufactured in Peru, Bolivia, and recently the Amazon (see below under Huánuco coca).

**TRUJILLO COCA**

Trujillo coca (*E. novogranatense var. truxillense*), owing to the hot, dry climate where it is grown, always is sun-dried. The leaves are laid out on large cement or earthen patios and constantly turned until they are completely dry (Fig. 16). During the drying process, Trujillo coca emits an intense odor of wintergreen, which is immediately noticeable in storage rooms, even days after drying has been completed. The odor, however, diminishes rapidly and often is gone by the time the leaves reach the highland markets.

Trujillo coca represents about 6% of the "official" Peruvian crop, not counting illicit coca production for cocaine manufacture. Of all areas where coca is produced in Peru, those areas of Trujillo coca are most closely controlled by the government coca monopoly, the Empresa Nacional de la Coca (ENACO). Plantations are carefully overseen by ENACO officials, especially in the Department of La Libertad near Trujillo. Relatively little of the Trujillo crop is used for cocaine manufacture, but we have almost no information on Trujillo coca production in the remote areas of the upper Marañón valley.

Seventy-five percent of the Trujillo crop is destined for export to the United States for extraction of flavorings for the soft drink Coca Cola® and, as a by-product, for the extraction of pharmaceutical cocaine. Trujillo coca from the entire growing area of this variety is shipped to ENACO warehouses in Trujillo, where leaves from different areas are mixed together to produce a more uniform product (Fig. 17). These are then packed into bales of 80 kg each and shipped to New York from the port of Salaverry near Trujillo (Fig. 18). In 1970, over 450 metric tons of Trujillo coca were exported.
Fig. 18. Packing leaves of Trujillo coca (Erythroxylum novogranatense var. truxillense) into bales at the ENACO warehouses in Trujillo, Peru. These leaves are destined for export to New York for use as flavorings in Coca Cola.
Leaves of montaña-grown coca (*E. coca* var. *coca*) may be sun-dried or oven-dried. Depending on local climate and the time of year, leaves may be laid out on open patios to dry in the sun like Trujillo coca. Because of the constant threat of rains in many parts of the montaña, the crop frequently is damaged by moisture. If leaves become wet during the drying process, they quickly begin to ferment, turning brown and becoming highly unpalatable. Leaves of *E. coca* var. *coca* are most susceptible to deterioration of any of the varieties and rapidly undergo chemical changes during fermentation in which malodorous amines are produced. The presence of high levels of aromatic oils in Colombian and Trujillo coca may retard or prevent this decomposition, since these varieties deteriorate less rapidly. Coca that has been poorly dried is considered of lowest quality and commands the lowest price; it is unsuitable for chewing and has lost most of its alkaloid content.

Because of the problems of drying large amounts of coca in the montaña, commercial growers in Huánuco now rely on large drying ovens ("secadores") fired by wood (Fig. 19). These often are two- or three-storied buildings with many layers of racks covered with porous cloth on which the leaves are placed. The fire is built in a furnace at ground level so that heat rises throughout the building. Large quantities of leaves can be dried thoroughly and quickly in as few as 12 hours. There are numerous secadores in the coca districts around Tingo María, and small growers often sell their fresh coca to the owners of the secadores for drying. A number of the larger and more conspicuous secadores around Tingo María have been closed by the authorities because of their association with illicit
coca production. Coca production in Huánuco far exceeds that which is required by native chewers.

High quality, montaña-grown coca is recognized by its light to medium green color and fresh, "coca" odor and flavor. Huánuco coca is prized for its uniform, intact, freshly dried leaves, which result from their being oven-dried and then sifted to remove smaller and broken leaves (Weil, 1976). There is considerable commerce in coca leaves for native chewing within Peru and Bolivia, since highland chewers often prefer leaves from one growing district or another. As with any vegetable product, coca consumers are highly sophisticated in their appreciation of coca quality and variety and most have specialized individual preferences.

One interesting variation in the preparation of montaña coca is known as "coca pisada" or "trampled coca." This process is employed in southern Peru in the coca-growing districts near Cuzco, in the Mantaro valley in Huancavelica, and probably elsewhere. Freshly harvested coca leaves are spread out on the drying patio or ground and then trampled by one or two barefoot workers or beaten with sticks or special pounders for about half an hour (Fig. 20); they are then dried normally in the sun. The pounding procedure causes the leaves to develop a dark, brownish color and special flavor, which is preferred by some chewers (Bües.
Coca vendors in the central market in Cuzco, Peru. The various bags contain coca of different quality and from different areas of southern Peru and northern Bolivia.

1911; Weil, 1976). This produces a type of fermentation in the leaves, but one that differs from fermentation caused by spoilage. Coca pisada is sold in the markets of Cuzco as “Cuzco negra” along with “Cuzco verde” and other varieties (Fig. 21).

As soon as montaña-grown coca is thoroughly dried, it is allowed to “sweat” to become pliable. It then is packed into large bales weighing about 60 kg. In Huánuco, the baling material is made from a specially woven, coarse woolen fabric known as “jerga”; in Cuzco, a muslin cloth is used. The choice of material is important because the packed leaves need to be protected from the elements during transportation, but at the same time must “breathe” to prevent fermentation. In commercial growing areas such as Cuzco and Huánuco, the leaves are pressed into bales with large, mechanical, hand-driven presses.

The faster the leaves destined for chewing are transported to the dry and cold high-altitude Sierra, the better their quality and commercial value are preserved. The serious problem of deterioration of coca during transport from the field to markets long has been recognized and was one of the chief obstacles to the introduction of coca to Europe in the 19th century (Lyons, 1885; Squibb, 1885; Rusby, 1888; Morris, 1889; Mortimer, 1901). The fantastic claims by South American explorers for the virtues of coca leaves could not be matched by the stale and moldy leaves that reached Europe after a months-long sea voyage. Traditionally, coca was transported from the montaña to the highlands by llama caravans or by human bearers; this largely has been replaced today by trucks and in some cases mule trains.

Throughout the montaña, a growing percentage of coca production is diverted
for making crude cocaine paste or base ("pasta"), which is readily prepared from dried leaves under primitive conditions in the areas of cultivation. Clandestine factories ("cocinas" or "pozos") are numerous in the expanding coca districts of Tingo María in Peru and Chapare and Santa Cruz in Bolivia. Only a few common chemical reagents are necessary for extracting cocaine paste, including sodium carbonate, kerosene, and sulfuric acid. Dried coca leaves are reduced in bulk by 200 to 400 times in making the paste, which is in turn easily transported to more sophisticated laboratories in urban areas, where the paste is further purified into cocaine hydrochloride. No one knows the extent of illicit coca production in the montaña. Estimates vary wildly from one source to another, and no recent estimates appear to be reliable because of a tendency of government agencies to underestimate or overestimate production, depending on their vested interests. For example, in Peru alone estimates of coca production vary between 20 and 50 million kg of leaves per year. In 1974, Bolivia produced 12 million kg which was double the production for 1971 (South, 1977). For 1978, Bolivia officially reported a production of 19.5 million kg of coca leaves, but the amount consumed for chewing was not known (United Nations, 1980).

**Amazonian Coca**

In the western Amazon, the leaves of *E. coca* var. *ipadu*, Amazonian coca, are dried by toasting over a slow fire in special ceramic bowls or pans (Fig. 22), a method similar to that employed for Colombian coca. Amazonian coca leaves are harvested and prepared daily because of the rapid spoilage of coca in the tropical lowlands. The leaves are toasted to dryness, then reduced to a fine powder by pounding in a special mortar and pestle ("pilón"), followed by careful sifting (Prance, 1972; Plowman, 1981; Schultes, 1981) (Fig. 23). The reason for preparing Amazonian coca as a powder, in contrast to the chewing of whole coca leaves elsewhere, probably is a consequence of the larger, unwieldy leaf size and low cocaine content of Amazonian coca (Plowman, 1981; Plowman & Rivier, 1983).

Until recently, there was no commercial production of Amazonian coca, and it was virtually unknown except to a handful of botanists and anthropologists working in the Northwest Amazon. However, in the mid-1970's, Colombian cocaine traffickers discovered coca in use among certain Amazonian tribes. Although the Amazonian variety is much lower in cocaine content than Peruvian and Bolivian montaña coca, the Colombians found that it was easier to extract cocaine from the Amazonian variety than from the traditional coca grown in the mountains of Colombia (i.e., *E. novogranatense* var. *novogranatense*). Cocaine entrepreneurs moved into those areas of Amazonian Colombia where coca was used traditionally on a small scale by a few Indian tribes. Encouraged by strong economic incentives, these tribes began growing more coca and selling it to the Colombian nationals, who began making not only cocaine paste but also pure cocaine hydrochloride in Amazonian laboratories. Traditional areas of coca use in the territories of Amazonas and Vaupés were exploited first. Subsequently, Amazonian coca was taken to the "llanos" of eastern Colombia where plantations were started in remote areas of the Departments of Meta and Guaviare. The effect on the traditional cultures of the area, as well as on the traditional and healthful use of coca, has been devastating. Visitors to the area report that social and cultural disintegration has proceeded at an alarming pace, as the Colombian "mafia" has taken complete control of some indigenous areas (B. Moser, C. & S. Hugh-Jones & A. Weil, pers. comm.).
The chemistry of coca

Although at least 15 different alkaloids have been reported from the leaves of the cultivated coca (Willaman & Schubert, 1961; Turner et al., 1981a) and frequently are cited in the literature, their existence in the living plant recently has been questioned (Rivier, 1981; Plowman & Rivier, 1983). In a detailed study of all four varieties of cultivated coca, only cocaine and cinnamoylcocaine were measured by GC-MS (Plowman & Rivier, 1983). The natural occurrence of the other reported alkaloids in coca remains to be demonstrated with carefully evaluated methods using modern analytical techniques on fresh and/or well-preserved plant materials; these other alkaloids may in fact prove to be artifacts of the storage and extraction procedures.

In the most complete alkaloid analysis of coca to date (Plowman & Rivier, 1983), the dried leaves of the four cultivated varieties were examined for alkaloids using stable isotope internal standard procedures for quantification. The leaves of *Erythroxylum coca* var. *coca* showed a mean of 0.63% cocaine (30 samples), which compares favorably with earlier reports of the alkaloid content of this
variety (Ciullardi, 1949; Machado, 1972; Holmstedt et al., 1977; Turner et al., 1981b). The sample of this variety with the highest amount of cocaine (0.96%) came from Chinchao (Huánuco, Peru), an area where coca is grown near the upper altitudinal limits of cultivation (1600–1800 m). This lends credence to the belief that, although coca grows slowly at such altitudes, it produces a more potent leaf.
Leaves of *E. coca* var. *ipadu*, Amazonian coca, contained the lowest amounts of cocaine with a mean of only 0.25% (6 samples). The cocaine content of this lowland variety is consistently low, even when grown under controlled laboratory conditions, and appears to be genetically controlled (Plowman, 1981; Plowman & Rivier, 1983).

Leaves of both varieties of *E. novogranatense* produced higher concentrations of cocaine than the “classical” variety, *E. coca* var. *coca*. Colombian coca (*E. novogranatense* var. *novogranatense*) yielded a mean of 0.77% cocaine (3 samples), and Trujillo coca (*E. novogranatense* var. *truxillense*) showed a mean of 0.72% cocaine (14 samples). The highest cocaine concentration (1.02%) of all the cultivated cocas was found in a sample of Trujillo coca (Plowman 5600) collected at Simbal near Trujillo, Peru. This finding contradicts an earlier belief that Trujillo coca is lower in cocaine content than other varieties (Mortimer, 1901; Machado, 1980).

Both cis- and trans-cinnamoylcocaine are found in all four varieties of cultivated coca. Cinnamoylcocaine always is found together with cocaine and never alone. Both varieties of *E. novogranatense* contained much higher concentrations of cinnamoylcocaine than either variety of *E. coca*. In both varieties of *E. novogranatense*, the amount of cinnamoylcocaines may exceed that of cocaine, although the ratios between the alkaloids varied widely from sample to sample.

Several earlier workers recognized the high percentage of what was then called “uncrystallizable cocaine,” especially in Java coca (*E. novogranatense* var. *novogranatense*) (Morris, 1889; Hesse, 1891; Mortimer, 1901; Reens, 1919a). The uncrystallizable fraction of these varieties now is thought to contain the cinnamoylcarboxylic acids. Using methods employed at the turn of the century, chemists found difficulty in extracting and purifying pharmaceutical cocaine from leaves of *E. novogranatense*. Cocaine was produced from Java coca by first hydrolyzing the relatively high amounts of total alkaloid to ephedrine and then semi-synthesizing cocaine from this base.

In addition to alkaloids, coca leaves contain a wide variety of other constituents, many of which are incompletely known (Hegnauer, 1981). Both varieties of *E. novogranatense* contain high concentrations of methyl salicylate (wintergreen oil) (Romburgh, 1894, 1895; Reens, 1919a) and probably other aromatic oils that give a distinctive flavor to the dried leaves and provide the basis for the use of Trujillo coca as a flavoring in beverages. Only minute amounts of methyl salicylate have been reported from *E. coca* (Romburgh, 1894, 1895). An array of flavonoids derived from quercetin and kaempferol also have been identified in the cultivated cocas and are useful taxonomic markers. The flavonoids of both varieties of *E. coca* are identical, but those of the two varieties of *E. novogranatense* differ both from one another and from *E. coca*. Both varieties of *E. novogranatense* contain the rare flavonoid ombuin-5-O-rutinoside, which is absent from *E. coca* (Bohm et al., 1981). None of the flavonoids of coca is known to be pharmacologically active.

During the 1940’s, a small group of public health officials in Peru campaigned vehemently against the native use of coca, which they perceived to be detrimental to the health of the Indians. One of their arguments was that coca chewing resulted in malnutrition because they believed that coqueros chewed coca in lieu of food (cf. Saenz, 1941; Gutiérrez-Noriega & Zapata Ortíz, 1948; Kuczinski-Goddard & Paz Soldán, 1948; Zapata Ortíz, 1970). These arguments have been refuted repeatedly as unscientific (Burchard, 1975; Grinspoon & Bakalar, 1976; Carter et al., 1980a). During the 1970’s, a number of studies demonstrated that coca leaves in fact contain impressive amounts of vitamins and minerals (Machado, 1972;
Duke et al., 1975; Carter et al., 1980a). In one study (Duke et al., 1975), the amounts of 15 nutrients in coca leaves were compared to averages of these nutrients present in 50 Latin American foods. Coca was found to be higher in calories (305 per 100 g vs. 279), protein (18.9 g vs. 11.4 g), carbohydrate (46.2 g vs. 37.1 g), fiber (14.4 g vs. 3.2 g), calcium (1540 mg vs. 99 mg), phosphorus (911 mg vs. 279 mg), iron (45.8 mg vs. 3.6 mg), vitamin A (11,000 IU vs. 135 IU), and riboflavin (1.91 mg vs. 0.18 mg). Based on these data, 100 g of Bolivian coca leaves would more than satisfy the Recommended Dietary Allowance for reference man and woman in calcium, iron, phosphorus, vitamin A, and riboflavin. Picón-Reátegui (1976) pointed out that vitamin A intake in Andean populations is very low, so the extremely high vitamin A content in coca leaves would supplement this deficiency significantly. However, since the time when the nutritional value of coca was proved, no researchers have conducted studies on the actual or potential contribution of coca in native diets. A quid of finely powdered Amazonian coca gradually dissolves with saliva and may be completely ingested, and the intake of nutrients in this case would be higher than in chewing whole leaves.

Coca chewing

THE MECHANICS OF COCA CHEWING

Coca leaves are chewed in a relatively uniform manner throughout their area of use, although there exist numerous minor variations. The greatest divergence from the normal pattern is found in the Amazon, where coca is used in powdered form. In the Andes, the act of chewing coca is accompanied by a complex series of rituals that are deeply embedded in traditional Quechua life. These are discussed in detail later.

Coca always is dried before use; this facilitates the rapid release of the chemical constituents from the leaves during chewing. The dried leaves are placed in the mouth one or a few at a time and slowly moistened with saliva. Almost immediately, a rich green juice issues from the leaves and they become soft and pliable. They are then moved about the mouth with the tongue and rolled into a ball or quid and pushed into one cheek. Coca is never actually chewed, but rather the moistened quid of leaves is sucked upon to extract the juices, which slowly trickle into the stomach. In South America, a number of words are used specifically to denote coca chewing: "mambear" (Colombia); "chacchar," "acullicar," "pijchar" (Peru, Bolivia); "coquear" and "mascar" (general).

The juice that emanates from the quid is distinctive in flavor and depends somewhat on the variety of coca. Generally, coca has a grassy or hay-like taste, with a hint of wintergreen in Trujillo coca. During the earliest stages of chewing, all coca varieties are distinctly bitter because of the presence of alkaloids. This bitterness is counteracted by the addition of an alkali substance, such as powdered lime or ashes—or even baking soda (sodium bicarbonate) among non-native chewers. The alkali not only "sweetens" the chew but also noticeably potentiates its effects, both in numbing the cheeks and tongue (through the anesthetic effect of cocaine) and by increasing the stimulating effect. Additional doses of alkali periodically are added to the quid to maintain its effect on the chew; more leaves also may be added until the quid reaches an optimal size for the chewer.

The amount of time the coca quid is kept in the mouth varies, depending on the individual user, from about 30 to 90 minutes, after which the quid is spat out. Amount and duration of chewing depends in part upon the cost and availability of leaves in a particular region. The amount of coca chewed also varies according to individual taste, ranging generally from 25 to 75 g of leaves per day.
transfer the lime from the gourd to the quid in the check (Fig. 26). In southern Colombia, the Paez Indians merely pour the powdered lime from their gourd onto the palm or back of the hand and toss it onto the quid in the mouth. But in southern Cauca, the lime normally is not pulverized, but is used in the form of a hard lump. Small pieces are bitten off and inserted into the quid (Antonil, 1978).

In the Sierra Nevada de Santa Marta on the Caribbean coast of Colombia, Indians of the Kogi and Ika tribes continue to use coca in centuries-old, traditional patterns (Reichel-Dolmatoff, 1953; Ochiai, 1978). Only the men of these tribes
chew coca, which they carry in elaborate woven bags slung around the shoulders. The gourds used in this area are particularly large and phallic in shape, a reflection of the sexual symbolism that coca chewing reflects among these groups. While chewing coca, the coca-laden saliva mixed with lime habitually is rubbed with the limestick around the end of the gourd. The lime precipitates as calcium carbonate and gradually builds up to form a thick rim in the form of a cylinder or disc (Mariani, 1890; Reichel-Dolmatoff, 1950; Moser & Taylor, 1965; Billip, 1979). The rim is carefully trimmed and molded and is a symbol of pride and status, since it demonstrates a man’s dedication to coca chewing. A painted Moche vessel dated about 500 A.D. from the north coast of Peru shows three coca chewers using nearly identical lime gourds with large, disc-like rims (Kutscher, 1955: 8–9). According to Jones (1974), these coque ros were thought to be “foreigners” because of their triangular cheek markings and dangling ear ornaments; whether or not they might have come from what is today Colombia is not known. However, it does suggest that the curious custom of fashioning elaborate rims on lime gourds was more widespread in the past and that there may have been cultural contacts between Peru and Colombia at an early date.

In the Andean highlands and montaña of southern Peru and Bolivia and in the Amazon basin, the preferred alkaline substance for coca chewing is made from ashes of a variety of plants and plant parts. This admixture usually takes the form of a moist black paste or, when dried, a grey rock-like substance. It is known as “lluipa” or “tocra” in Peru and “lejia” or “lluma” (“llucta”) in Bolivia. The
Fig. 26. Peruvian mestizo adding powdered lime to his coca quid with a small stick. The lime is carried in the small gourd in his hand. Balsas, Río Marañón, Dept. Amazonas, Peru.

dividing line in the Andes between the northern lime-gourd-using coca chewers and the southern llipta users lies approximately at the border of the Peruvian departments of Huánuco and Pasco. Along the Pacific coast, the use of lime and lime gourds appears to be universal.
Llipta is prepared from a large number of plant species (Fig. 25). In a given area and habitat, one or a few llipta sources will be preferred. In the high Andes, the preferred plant ash comes from two species of cultivated Chenopods, which are *Chenopodium quinoa* Willd., "quinua," and *C. pallidicaule* Aellen, "cañihua." Also in the highlands, llipta may be made from the roots of faba beans (*Vicia faba* L.) and from the stems and fruits of several species of columnar cacti in the genera *Cereus*, *Trichocereus*, and *Cleistocactus*. In the tropical montaña of the eastern Andes, maize cobs, *Musa* roots, and cacao pods commonly are burned to make llipta. In both areas numerous wild plants also are exploited and preferred locally by coca chewers. To prepare llipta, the plant is burned thoroughly to a fine ash and then mixed with water. Starchy potato water may be used to hold the ash together. The resulting pasty mass then is molded into cakes in a variety of shapes and sizes depending on local custom. Llipta may be flavored with various spices such as anise or chili peppers (Mortimer, 1901; Antonil, 1978). In order to use llipta, a small piece of the hardened cake is broken off and inserted with the fingers into the quid. One must be careful not to let the llipta touch the inner surfaces of the cheek since it may cause painful burns. The quality of llipta varies appreciably and may be extremely alkaline and caustic, or mild, very hard and rock-like, or soft and crumbly. Hard llipta dissolves slowly, and one piece may serve to supply an entire chew with alkali, without the frequent reapplications that are necessary when chewing coca with powdered lime.

In the Amazon basin and Andean foothills, ashes of *Cecropia* or *Pourouma* trees are used as the alkaline source for coca chewing. The Mashco of the southern Peruvian montaña burn the trunks of a *Cecropia* species to ashes; these are finely pulverized and stored in a bamboo tube. The ash then is added to the quid of whole coca leaves with a small stick, not unlike the use of a lime gourd and lime stick in coastal Peru (Califano & Fernández Distel, 1978). In the Beni area of northern Bolivia, ashes are prepared from the spathe of the "motacú" palm (*Schelaea princeps* [Mart.] Karst.) and are stored in a cow's horn. A small-leaved form of *E. coca* var. *coca* is chewed in this area as a quid of whole leaves to which the motacú ash is added (Le Cointe, 1934; Davis, 1983). A number of tribes in the southern montaña, including Campa, Machiguenga, Mashco, and Chimane, chew whole coca leaves with ashes. Further north in the "selva" areas of lowland Amazonia, coca always is chewed as powder, pre-mixed with finely sifted *Cecropia* or *Pourouma* leaf ashes (Plowman, 1981; Schultes, 1981) or with banana leaf ashes (France, 1972). Only Amazonian coca, *E. coca* var. *ipadu*, is prepared in powdered form.

Rivier (1981) measured the pH and buffer capacity of 17 different samples of coca alkali admixtures, including lime, llipta, and *Cecropia* leaf ashes, among others. The pH of these substances ranged from 10.1 in llipta made from quinua stems to 12.8 in lime made from marine shells. Llipta contains high amounts of calcium, magnesium, and potassium salts, the proportions varying according to the source (Gosse, 1861; Cruz Sánchez & Guillén, 1948; Baker & Mazess, 1963). Baker and Mazess (1963) believe that the calcium contained in llipta ingested during coca chewing is an important source of this element in the diet of coca chewers.

Besides the addition of alkaline substances, a number of other plants may be used along with coca. The most important of these is tobacco, a drug that is found almost universally among tribes that use coca. Contemporary Andean coca chewers frequently smoke cigarettes while chewing coca or even smoke as a substitute for coca when chewing is not possible (Fine, 1960). A soft tobacco paste is made in a number of areas and added to the coca quid by means of a small needle.
This custom is especially conspicuous in the Sierra Nevada de Santa Marta and in the northwest Amazon, where the tobacco paste is called “ambira” and “ampiri,” respectively (Uscátegui, 1954). Tobacco paste is prepared by slowly cooking tender tobacco leaves with water; a “bush salt” made from the ashes of one of a number of plants then is added to the resulting syrupy paste. In the Amazon, the addition of tobacco paste at the beginning of a chew of powdered coca stimulates salivation and greatly facilitates the formation of a quid from the powder (Plown, 1981). Tobacco in snuff form is used with coca by the Mashco in the Peruvian montaña (Califano & Fernández Distel, 1978) and by several tribes in Colombia (Uscátegui, 1961).

A little known but interesting coca admixture comes from a bignoniaceous vine, Mussatia hyacinthina (Standl.) Sandw., known as “chamairo” (Plowman, 1980; Davis, 1983). The bark of the stem of this liana is added to the quid of whole coca leaves among the Campa and Machiguenga of eastern Peru and also among the Chimane and other groups of northern lowland Bolivia. Chamairo is used as a flavoring and sweetener for the coca quid and also may be chewed alone (with ashes but without coca) as a stimulant and medicine. In northern Peru, Trujillo coca quids may be flavored with the dried leaflets of Abrus precatorius L., known locally as “mishquina” or “miski miski.” The foliage of Tagetes pusilla HBK. is used with quids of E. coca var. coca in southern Peru, and the aromatic resin of Protium heptaphyllum (Aubl.) March is employed in the Colombian Amazon to flavor Amazonian coca powder (Schultes, 1957).

THE EFFECTS OF COCA CHEWING

The primary effect of chewing coca is a mild stimulation of the central nervous system resulting from the assimilation of cocaine from the leaves (Holmstedt et al., 1979). Some workers (Montesinos, 1965; Burchard, 1975) have suggested that the ecgonine derivatives of cocaine may play a role in the combined effects of coca chewing, but their interesting theories have not been confirmed by controlled experiments. In addition, the minor alkaloids presumed to be present in the coca leaf have been implicated in the effects of coca chewing (Mortimer, 1901; Martin, 1970), but little is known of the biological activity of these compounds. Rivier (1981) has shown that the only other alkaloid present in coca leaves at significant levels (greater than 1% of amount of cocaine) is cinnamoylcocaine, and this compound is not known to be pharmacologically active. If other alkaloids are indeed present, they exist only as trace constituents.

During coca chewing, free cocaine base is absorbed rapidly through the buccal mucosa in the mouth and to some extent in the gastrointestinal tract. Cocaine is measurable in blood plasma five minutes after coca chewing begins, which gives a measure of the rapidity of cocaine assimilation. Peak levels in plasma are reached one to two hours after chewing begins (Holmstedt et al., 1979), although the major subjective effects are felt within the first half hour of chewing. Peak blood levels of cocaine ingested during coca chewing are highly variable and depend upon several factors, including dose and concentration of cocaine in the leaf material, absence or presence of alkali admixtures, and individual experience of the chewer, among others. Blood levels of cocaine during chewing may approximate, but generally are lower than, those found after intranasal administration of cocaine (cf. Javaid et al., 1978; Holmstedt et al., 1979; Paly et al., 1980). Surprisingly, no modern detailed pharmacological studies of coca chewing in native coca chewers yet have been conducted, although numerous such studies have been conducted on cocaine users.
The stimulation experienced during coca chewing gives a sense of increased energy and strength, a suppression of the sensation of fatigue, an elevation of mood or mild euphoria, and a sense of well being and contentment. Coca also produces a temporary loss of appetite. Owing to the release of cocaine in the mouth during chewing, there is a pronounced numbing sensation of the cheeks and tongue, which results from the anesthetic action of cocaine. There is no evidence that coca chewing results in tolerance or physiological dependence, nor does it show any acute or chronic deleterious effects (Weil, 1975; Grinspoon & Bakalar, 1976; Carter et al., 1980a).

Even though cocaine is the principal and most powerful constituent of coca leaves, the complex effects of chewing coca leaves, especially those that are exploited in medicine, cannot be equated with the comparatively straightforward effects of using cocaine. As mentioned earlier, coca is a complex mixture of chemicals, including alkaloids, essential oils, flavonoids, vitamins and minerals, and other natural leaf constituents, many of which still never have been examined in coca. For example, coca has a soothing effect on disorders of the stomach and intestinal tract and is used in folk medicine for a wide spectrum of complaints. Montesinos (1965) suggested that ecegonine, a breakdown product of cocaine, may relax directly intestinal smooth muscle, and the beneficial effects on digestion of the volatile oils, such as methyl salicylate, are well known. Furthermore, coca stimulates oral secretions and may change secretion in other parts of the gastrointestinal tract (Weil, 1981). In spite of these possibilities, coca's mechanism of action on the gastrointestinal tract remains unknown.

Burchard (1975) and Bolton (1976) have suggested that coca chewing affects carbohydrate metabolism among Andean coca chewers, who typically live on high starch diets. Burchard believes that coca may protect against the development of hyperglycemia and of reactive hypoglycemia following oral glucose loads ingested by Andean chewers and suggests that this effect may involve ecegonine, one of the products of cocaine hydrolysis. Although experimental evidence for these metabolic effects is lacking, Weil (1981) suggests that coca be tested as a possible treatment for diabetes.

As many workers have pointed out, it is completely erroneous to equate the pharmacological effect of coca chewing with that of the use of highly concentrated cocaine (Mortimer, 1901; Martin, 1970; Grinspoon & Bakalar, 1976; Weil, 1981). However, until the complex chemistry of coca leaves and the pharmacology of their constituents are studied in detail, the highly beneficial, yet subtle, medicinal and restorative effects of coca remain unsubstantiated by modern medical studies.

**Uses of coca as a stimulant and medicine**

Whether in the high Andean altiplano or in the Amazonian lowlands, coca is employed principally for work (Burchard, 1975; Carter et al., 1980a; Plowman, 1981). Workers will take several breaks during the daily work schedule to rest and chew coca, not unlike the "coffee break" in Western society. Coca chewers maintain that coca gives them more vigor and strength and assuages feelings of hunger, thirst, cold (in the highlands), and fatigue. Coca is chewed by rural people in all kinds of professions that require physical work, especially farmers, herders, and miners in the highlands and by farmers, fisherman, and hunters in the lowlands. Coca is especially highly regarded when making long journeys on foot, both through the rugged mountains of the high Andes and through the Amazonian forests. It rarely is possible to carry adequate supplies of food on such treks, and coca is considered the best form of sustenance; this fact was recognized by the
earliest European observers in South America (cf. Mortimer, 1901; Martin, 1970). In such situations, coca temporarily postpones the necessity for food. But it never takes the place of food. Even today, coca is preferred by long-distance truck drivers in the Andes to keep them alert on dangerous mountain roads and to sustain them for long periods.

Miners in Peru and Bolivia always have depended on coca to protect them during their unhealthy and exhausting work. After an initial period of condemnation and prohibition of coca, the early Spanish administrators realized that only with coca could the Indians be forced to work in the silver mines. Miners believe that coca helps them in a number of ways: as an energizer, as a filter against the penetrating dust and toxic gases, as a stimulant to combat drowsiness, and as an almost magical substance that reduces hunger (Carter et al., 1980a, 1981). Under the harsh environmental conditions in the high Andes and lowland Amazon, coca chewers believe that only coca gives them the strength to do their work, to maintain good health, and to protect them from disease.

The second most important use of coca is as a medicine, and this use is inextricable from the Indians' belief that coca is a protector and preserver of health. It is significant that many South Americans, Indians and non-Indians, who do not regularly chew coca leaves as a stimulant, will cultivate the plant and use the leaves medicinally. As an internal medicine, coca is both taken as an infusion and chewed as a quid. Probably the most important medicinal use of coca is for problems of the gastrointestinal tract. It is the remedy of choice for dysentery, stomachache, stomach ulcers, indigestion, cramps, diarrhea, and other painful conditions (Martin, 1970; Fabrega & Manning, 1972; Hulshof, 1978; Carter et al., 1980a, 1981; Weil, 1981; Grinspoon & Bakalar, 1981). Coca also is used commonly, by Indians, mestizos and foreigners alike, for the treatment of the symptoms of altitude sickness, or "soroche," which include nausea, dizziness, cramps, and severe headaches. A related use of coca is to counteract motion sickness, a use that has received little attention in the literature (Weil, 1981).

Owing to the anesthetic effects of cocaine, coca leaves are an excellent home remedy for toothache (Hulshof, 1978). Coca also serves as a dentifrice, and it is commonly believed that coca helps to protect teeth and gums from decay and disease and to keep the teeth white (Martin, 1970; Weil, 1981). Coca frequently is used to ease rheumatic pains, taken both in an infusion and simultaneously as a poultice over the affected part (Martin, 1970; Hulshof, 1978; Carter et al., 1981). Coca poultices also are applied externally for headaches, sore throats, wounds, broken bones, and irritations to the eyes. Coca also is widely employed for numerous minor and miscellaneous ailments, such as hangovers, hemorrhage, amenorrhea, asthma, constipation, and general debilitation (Gagliano, 1979; Grinspoon & Bakalar, 1981; Weil, 1981). Of special importance to the Indian, coca is an extremely valuable remedy for a number of Andean "folk" or "traditional" illnesses, which lie outside the realm of Western medicine yet play a major role in the Andean medical belief system (Fabrega & Manning, 1972; Carter et al., 1980a, 1981). In Peru, these illnesses include "soka," a condition of weakness, fatigue, and malaise; "fiero," a chronic wasting disease; "locura," severe mental disturbances; and others. Similar illnesses, often attributed to supernatural or magical causes, are recognized in Bolivia. Coca, often used in conjunction with other medicinal herbs, is a primary remedy in treating such disorders (Carter et al., 1980a, 1981). The importance of coca in relation to these diseases is closely associated with its reputed magical properties and role in religious life.

Since the turn of the century, the importance of coca as a medicinal plant largely has been ignored by Western scientists, who identified the coca leaf with cocaine
and preferred to experiment with the pure, isolated compound. As a result, coca leaves completely disappeared as a pharmaceutical product and no longer were available for investigation in the United States or in Europe. Ironically, even today physicians' narcotics licenses in the United States clearly state that they have permission to dispense coca leaves. In the mid-1970's, interest in the therapeutic value of coca was rekindled among scientists as part of a general reawakening of interest in coca. Today coca again is being studied for possible applications in modern medicine. Weil (1981) has recommended that coca be studied for several therapeutic applications, including: 1, for painful and spasmodic conditions of the entire gastrointestinal tract; 2, as a substitute stimulant for coffee in persons who suffer gastrointestinal problems from its use or who are overly dependent on caffeine; 3, as a fast-acting antidepressant and mood elevator without toxic side effects; 4, as a treatment for acute motion sickness; 5, as an adjunctive therapy in programs of weight reduction and physical fitness; 6, as a symptomatic treatment of toothache and sores in the mouth; 7, as a substitute stimulant to weaken users of amphetamines and cocaine from those drugs, which are more dangerous and have higher abuse potential; and 8, as a tonic and normalizer of body functions.

The role of coca in religious and social life

Coca plays a central role in the daily lives of many different groups of South American Indians, not only as a stimulant and medicine, but also as a unifying cultural and religious symbol. The very act of chewing coca in Andean communities is an ancient and basic cultural tradition by which the Indian identifies and reaffirms his or her place in the world. It should be noted that in many areas, such as the Sierra Nevada de Santa Marta in Colombia and in the Amazon basin, women are forbidden by custom to chew coca, but in other areas, especially in the high Andes of Peru and Bolivia, women use coca with as much relish as men.

In Peru and Bolivia, the traditional act of chewing coca involves a complex series of personal rituals and etiquette. The first step is to select two or three leaves from the coca bag. These are known as “k'intu.” They are carefully placed one on top of the other between the thumb and index finger. The k'intu is brought in front of the mouth and blown lightly upon, and simultaneously the coqero invokes the local gods and spirits of the hills and sacred places around him. This act is known as “puku y.” The leaves then may be used to form a quid for chewing or may be crushed and blown away with additional prayers and incantations (Gifford & Hoggarth, 1976; Wagner, 1978). Wagner (1978) has described how these seemingly simple ritual acts of using coca serve to orient the Quechua Indian in a broader cultural context of time and space and in his religious studies and social affairs.

In traditional Andean communities, coca is present at nearly every public and private event or activity. It is a requisite symbol of friendship and good faith at all popular and religious festivals, engagements and weddings, baptisms, funerals, inaugurations of public officials, and formal and informal meetings at which contracts are formalized and business arrangements made (Quijada Jara, 1950; Frisiancho Pineda, 1973; Gifford & Hoggarth, 1976; Carter et al., 1980a). Offerings of coca are necessary to propitiate the gods on many occasions, such as the planting of crops, insuring a productive harvest, or laying the cornerstone for a new house (Martin, 1970). There is essentially no domestic or social act that is not solemnized by making offerings of, or by chewing, coca (Quijada Jara, 1950). Coca is considered a spiritual protector for traveling in unfamiliar territory where strange and malevolent spirits abound (Quijada Jara, 1950; Wagner, 1978).
Coca always has been a major means of exchange in trade networks throughout the Andes, particularly between the tropical montaña and the high sierra and altiplano regions. Such trade networks apparently are descended from Inca times or earlier (Burchard, 1974). Long-distance trade in coca became even more extensive during the Colonial period after the Spanish took control of coca production to supply the silver mines at Potosí in Bolivia (Gagliano, 1960).

Coca is a medium of exchange not only of products but also as a symbol of friendship. Wherever coca is chewed, exchanges of coca leaves or coca powder are considered the most gracious form of greeting when people meet while traveling. Such exchanges form an immediate bond of friendship and trust and are accompanied always by the usual formalities of coca etiquette. Gifts of coca are often offered by a young man to a girl's parents to obtain their consent for marriage (Martin, 1970), and bundles of coca will be included in the dowry (Gifford & Hoggarth, 1976).

The religious and shamanistic use of coca probably is very ancient and originated from the psychoactivity produced by chewing the leaves (Martin, 1970). Ritual coca chewing enabled shamans and priests to meditate, to enter trance-like states, or to communicate with the supernatural world, even though coca produces slight mental distortion compared to hallucinogenic plants such as Datura and Banisteriopsis or even tobacco.

Many sacred practices associated with coca chewing have disappeared among tribes whose numbers were decimated or who lost their cultural identity after the Spanish Conquest. However, such ceremonies involving coca still exist among the Kogi and related tribes of the Sierra Nevada de Santa Marta in northern Colombia. These rituals have been carefully documented by the Colombian anthropologist Reichel-Dolmatoff (1950). Only the men among the Kogi are permitted to cultivate and chew coca although women are responsible for harvesting the leaves. Kogi men describe the most important effect of coca chewing as mental lucidity, which they value for ceremonial meetings, personal rituals, and religious activities in general. They assert that coca makes their bodies tingle and refreshes their memory so that they can speak, chant, and recite for hours on end. They consider the suppression of hunger caused by coca chewing a great advantage but not because they lack food. To the Kogi, fasting is a prerequisite for all religious ceremonies, and by consuming only coca, they are better able "to speak of the Ancients." According to Reichel-Dolmatoff, "the ideal of the Kogi male would be to eat nothing but coca, to abstain totally from sex, never to sleep and to speak all his life of the 'Ancients', that is, to chant, to dance and to recite."

In both Andean and Amazonian cultures, reverence for coca is reflected in its widespread use in divination, both for shamanistic healing practices and for predicting the future. These two general applications of divination are inextricably linked together in daily life. Divination is a very ancient custom among South American Indians and, in spite of relentless persecution by the Spanish clergy following the Conquest, it remains widely practiced today. The Andean Indian relies on divination for many purposes but primarily for diagnosing disease and finding a cure, for predicting the outcome of economic situations and future events in general, and for assuaging his constant fears of the spirit world which surrounds him (Contreras Hernández, 1972; Carter et al., 1980a). Although there are numerous means of divination employed in the Andes, divination with coca leaves is the most common and most respected (Carter et al., 1980a).

Diviners fall into many different categories according to their specialties and abilities and are known by an assortment of native names. "Yatiri," meaning
"one who knows," is probably the most widespread term in both Quechua and Aymara. Many diviners have congenital deformities or have been (or claim to have been) struck by lightning (Carter et al., 1980a).

The act of divining or "reading" coca leaves takes many forms. It may be a formal ceremony performed by a specialist or an informal or personal act performed by an individual coquero. Indians who chew coca are intensely aware of the signs latent in the leaves they chew; in their form and color, in the taste and form of the chewed quid, or in the saliva which issues from it.

Formal divination involves the consultation of a knowledgeable yatiri at a specific time and place. A special woven cloth, the "cocatari" (Aymara) or "uncuña" (Quechua), is placed on the ground. A small handful of selected leaves is allowed to drop upon the cloth. The reading of the leaves depends upon many features of the leaves, including their color, shape, size, deformities, spots, holes, and creases as well as their spatial relationship to one another. Depending on all these factors, the leaves will symbolize death, bad or good luck, money, evil spells, a safe journey, or other things or will suggest the diagnosis or cure of an illness (Contreras Hernández, 1972; Frisancho Pineda, 1973; Carter et al., 1980a).

According to Manin (1970), diviners among the Incas would chew coca leaves and spit the juice into their palms with the two longest fingers extended. If the juice ran down both fingers equally, it was a good sign; if it ran down unequally, it was a bad one. Other diviners would burn coca leaves with llama fat and observe the way they burned.

Among the Campa of eastern Peru, coca is used by the shaman to determine the perpetrator of witchcraft. The shaman spits coca into his hand, shakes it, and ascertains the guilty party through its configuration (Ordinaire, 1892). The neighboring Machiguenga of the Peruvian montaña carve small idols out of coca wood. They believe that coca comes from benevolent spirits called "saanka'rite" and that it has the ability to reveal the future. For example, if a man chews coca and does not taste its sweetness, it is a sign of impending misfortune (Baer, 1970). Coca is also used in divination among tribes of the Northwest Amazon who use coca in powdered form. Future events may be foreseen by blowing a spoonful of coca powder into the air and observing the way it falls to the ground.

In Colombia, the Paez Indians of Cauca Department also employ coca in divination (Uscátegui, 1954), as did Chibcha priests in the central highlands at the time of the Spanish Conquest (Martin, 1970).

To summarize the importance of coca in Indian life, I would like to quote the eloquent remarks of Wagner (1978: 878): "... 'to chew coca' is part of the process through which the Quechuas absorb the depth of their culture and learn to understand what it means to be a Runa, a participant in traditional Quechua culture" (translation from Spanish mine) and of Martin (1970: 424): "Only appreciating the use of coca from the point of view of the Indian's cultural heritage, their beliefs and the necessities of their daily lives can give a proper perspective on the meaning of coca to these people."

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Literature Cited


Le Cointe, P. 1934. A Amazônia Brasileira III: Árvores e plantas utés. Livraria Clássica, Belém, Brazil.


Mariani, A. 1890. Coca and its therapeutic application. J. N. Jaros, New York.


Quijada Jara, S. 1950. La coca en las costumbres indígenas. Published by the author. Huancaayo, Peru.

Reens, E. 1919a. La coca de Java: Monographie historique, botanique, chimique et pharmacologique. Lucien Declume, Lons-le-Saunier, France.


