

Possible routes of migration of Amazonian plants to Mesoamerica and the West Indies in pre-Columbian times.

Pre-Columbian Plant Migration

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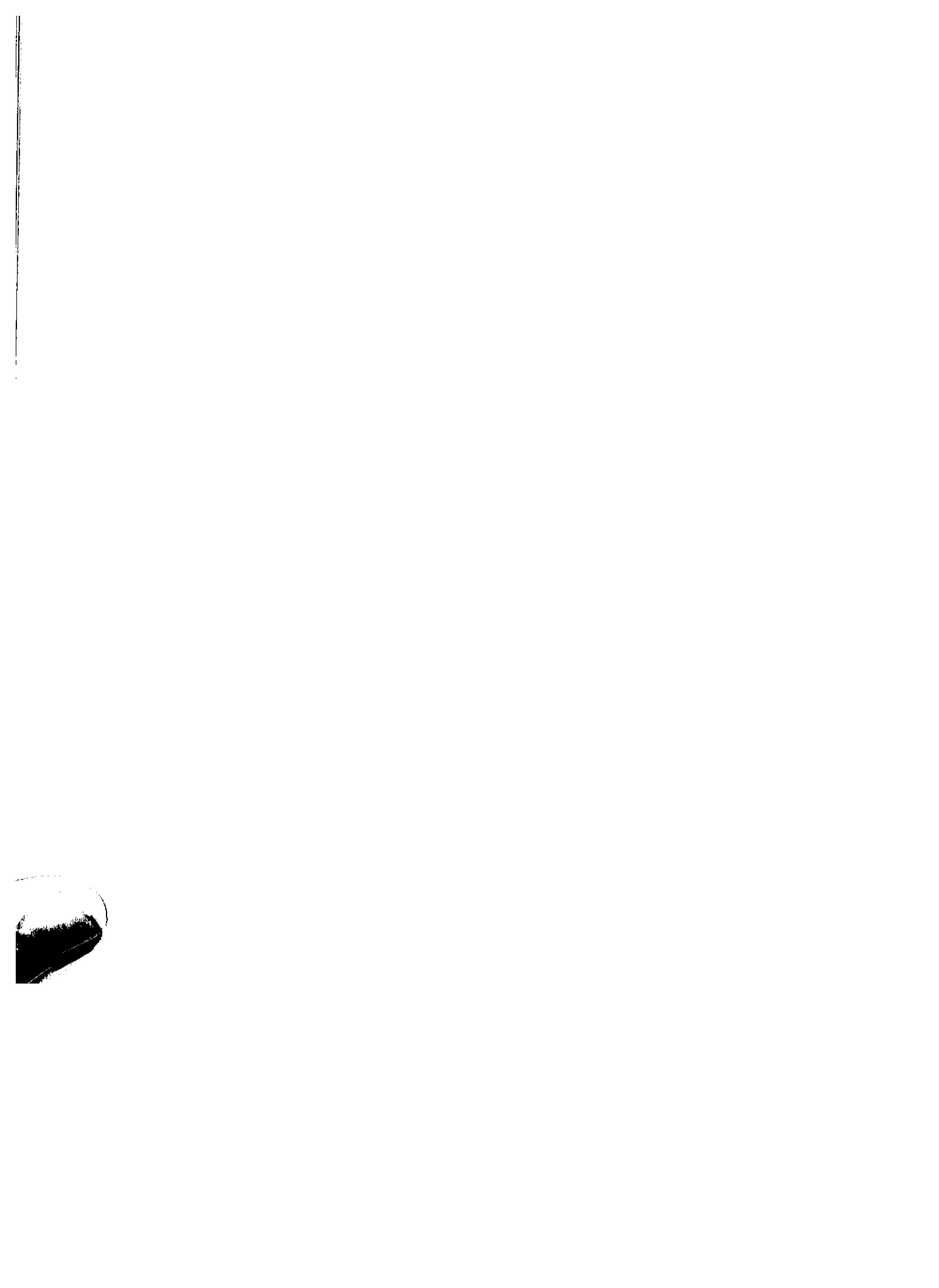
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The Origin, Evolution, and Diffusion of Coca,
Erythroxylum spp., in South and Central America

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A theoretical scenario for the origin, evolution, and diffusion of the cultivated cocas is presented. *E. coca* var. *coca*, Bolivian or Huánuco coca, occurred originally as a wild, possibly rare, species of the moist forests of the *montaña* in the central Andes, where its stimulating properties were discovered by early hunting and gathering peoples. The plant was brought into cultivation and diffused northward and southward into Ecuador and Bolivia, respectively, via the *montaña*.

E. coca var. *ipadu* was developed in the low, hot Amazon basin in response to shifting agricultural conditions among seminomadic tribes. Its low cocaine content and large leaf size led to the unique method of preparing Amazonian coca as a finely divided powder.

En este capítulo se presenta un escenario teórico sobre el origen, la evolución y la difusión de las cocas cultivadas. *E. coca* var. *coca*, coca boliviana o huánuca, fue originalmente una especie silvestre, probablemente poco conocida, de la selva húmeda de la *Montaña* en la parte central de los Andes, donde sus cualidades estimulantes fueron descubiertas por los primitivos habitantes que vivían de la caza y de la recolección. La planta fue cultivada y difundida hacia El Ecuador y Bolivia, via la *Montaña*.

E. coca var. *ipadu* se desarrolló en la cuenca baja y templada del Amazonas como resultado del cambio en las condiciones agrícolas entre las tribus semi-nómadas. Su bajo contenido en cocaína y el gran tamaño de sus hojas permitieron el desarrollo de un método único de preparar la coca como un rapé de partículas finas.

Drought-resistant Trujillo coca, *E. novogranatense* var. *truxillense*, arose in northern Peru or southern Ecuador. When coca was carried to new, drier habitats, and eventually reached arid coastal Ecuador, it appeared there in the Valdivian culture. It diffused southward to the coastal valleys of Peru and northward toward the mountains of Colombia, where it differentiated through geographic isolation and continuing human selection into Colombian coca, *E. novogranatense* var. *novogranatense*. Colombian coca was selected for self-compatibility to increase seed production, as well as for a broad ecological tolerance, and was eventually to spread to the Caribbean coast of Venezuela and Central America.

La coca de Trujillo, *E. novogranatense* var. *truxillense*, resistente o del sur del Ecuador. Al ser llevada la coca a nuevas y más secas regiones, y al alcanzar la árida costa del Ecuador, hizo su aparición durante la cultura de Valdivia. Se extendió hacia el sur hasta los valles costeros del Perú y hacia el norte hasta las montañas de Colombia, en donde debido al aislamiento geográfico y a la continua selección del hombre, se convirtió en la coca colombiana, *E. novogranatense* var. *novogranatense*. La coca colombiana fue seleccionada por su propia compatibilidad, tanto para aumentar la producción de las semillas como por su vasta tolerancia ecológica y con el tiempo llegó a alcanzar la costa caribeña de Venezuela y de la América Central.

Introduction

The origin and nature of the coca plant have long been subjects of controversy and uncertainty in botanical, medical, and pharmaceutical as well as in anthropological circles (Plowman 1979a, 1982). Still few workers deny the antiquity and continuing importance of the coca leaf and coca chewing throughout Andean South America and adjacent areas. Comprehensive studies that encompass the whole area of coca use are lacking, and the extent and variations of the coca habit throughout its long history remain unclear despite an enormous literature on the subject.

The basic pattern of coca use is relatively uniform throughout its area, although some minor variations do exist. Except in the Amazon basin, where coca is taken in powdered form, the whole, dried leaves are placed in the mouth, one or a few at a time. They are moistened with saliva and gradually worked into a quid about the size of a walnut. Coca leaves are not actually chewed; rather, the quid of softened leaves is held between the cheek and gums and sucked to extract the contained alkaloids and other substances. An alkaline material such as powdered lime or ashes is always added to the quid to facilitate the extraction and absorption of the alkaloids (fig. 1). The quid is kept in the mouth for about 45 minutes and then is spat out. The details of coca chewing and its pharmacological effects have been summarized in several recent publications (Burchard 1975; Grinspoon and Bakalar 1976; Antonil 1978; Fuchs 1978; Holmstedt et al. 1979; Rivier 1981; Bray and Dollery 1983).

The cheek bulge characteristic of coca chewers is frequently represented in pre-Columbian art and may be considered indicative of coca chewing. Similarly, the powdered lime added to the coca quid in many areas is carried in a bottle gourd or similar flask-like container from which the lime is removed with a small dipper stick. These and related coca-chewing paraphernalia in many cases may be used as cultural markers for the coca habit.

Until recently, many scholars have underestimated or overlooked entirely the importance of the existence of distinct varieties of coca. Although geographical, ecological, and morphological differences in

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coca varieties were recorded as early as the sixteenth century, their significance was not recognized until the 1970s (Rostworowski 1973; Antonil 1978; Plowman 1979a). Not until coca leaf became an important pharmaceutical product in the late nineteenth century did the botanical origins and varieties of coca become the subject of scientific inquiry (Plowman 1982).

Most anthropologists and archaeologists in the past embraced a monotypic view of coca, largely because botanical studies were published in unfamiliar botanical and pharmaceutical journals. As a result, their interpretations of the early history of coca in South American cultures were often simplistic, misguided, or erroneous. It is only through present collaborative efforts that a more thorough, multidisciplinary understanding of coca is now possible.



Figure 1. Contemporary coca chewer inserting powdered lime into coca quid, Balsas, Río Marañón, Dept. Amazonas, Peru. Photograph by the author.

In this contribution, the archaeological and early historical evidence for coca chewing in South and Central America is re-evaluated in view of a revised classification of the varieties of coca. By examining the archaeological evidence for each variety of coca separately, it is possible to clarify the early evolution and diffusion of coca in these areas.

The Classification of Cultivated Coca

The coca shrub belongs to the genus *Erythroxylum* in the tropical plant family Erythroxylaceae. The greatest number of species of *Erythroxylum* (c. 200) is found in the American tropics, although the genus also occurs in Africa, Madagascar, India, tropical Asia, and Oceania. Many 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 (Martin 1970; Mayer 1978; Antonil 1978; Carter et al. 1980).

Two closely related South American species—*Erythroxylum coca* Lam. and *E. novogranatense* (Morris) Hieron.—are the sources of all cultivated coca. Whereas other 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 and Fikenscher 1960; Martin 1970). However, evidence accumulated in the last decade as a result of intense field and laboratory studies has demonstrated incontrovertibly that two distinct species of coca must be recognized (Machado 1972; Gentner 1972; Plowman 1979a; Rury 1981; Bohm et al. 1982; Plowman and Rivier 1983). In addition, each of the two species of cultivated coca has one distinct variety, designated *E. coca* var. *ipadu* 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. *ipadu*, *E. novogranatense* var. *novogranatense*, and *E. novogranatense* var. *truxillense* (fig. 2 and table 1).

All four cultivated cocas were domesticated 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." All the cultivated cocas contain the alkaloid cocaine, although they are now known to differ appreciably in the content of minor alkaloids and other chemical constituents. Additional important differences among the four varieties which hitherto have been overlooked, are found in their leaf and stem anatomy, ecology, geographical distribution, and breeding relationships as well as in 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 wide variety of habitats.

The four varieties of cultivated coca are more closely related to each other than to any other species of *Erythroxylum*, although certain wild species may yet be implicated in their evolutionary relationships (Plowman and Rivier 1983). Superficially, the cultivated cocas are very similar morphologically, which explains in part earlier confusion in the identification of coca specimens, especially by nonspecialists (Plowman 1979a, 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 archaeological specimens. These studies focus on leaf anatomy (Rury 1981), flavonoids (Bohm et al. 1981), cocaine content (Rivier 1981; Plowman and Rivier 1983), minor alkaloids (Rivier 1981; Plowman and Rivier 1983), reproductive biology and breeding relationships (Ganders 1979; Bohm et al. 1982), and ecology and geographic distribution (Plowman 1979a, b). As a result of these investigations, the taxonomic and evolutionary relationships among the four cultivated cocas are now fairly well understood.

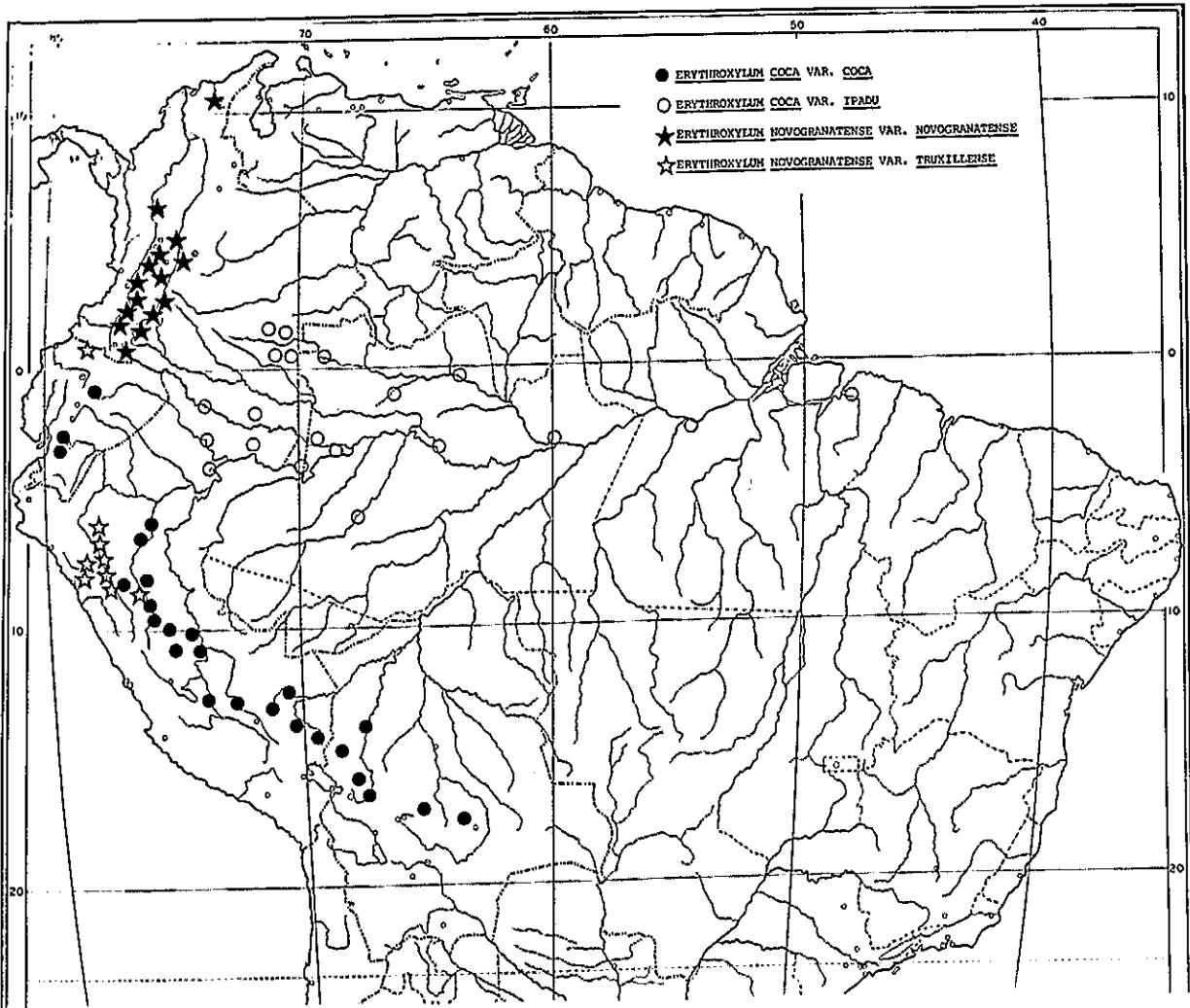


Figure 2. Present distribution of the four varieties of cultivated coca (*Erythroxylum* spp.) based on herbarium collections.

132 Table 1. General comparison of the four varieties of cultivated coca, *Erythroxylum* spp.

Character	<i>Erythroxylum novogranatense</i>		<i>Erythroxylum coca</i>	
	var. <i>novogranatense</i>	var. <i>truxillense</i>	var. <i>coca</i>	var. <i>ipadu</i>
Present distribution	Colombia	Northern Peru, Ecuador	Ecuador to Bolivia	Amazon Basin
Habitat	Dry to moist forest	Desert, thorn scrub	Premontane moist forest	Lowland rain forest
Branching	Erect and spreading	Erect and spreading	Erect and spreading	Erect-irrigate
Flowering branches	Leafy	Leafy	Leafless	Leafless or leafy
Bark of twigs	Smooth	Smooth	Warty	Warty
Ramenta	None	None or few	Well-developed	None or few
Stipules	Disintegrating	Marcescent or persistent	Persistent	Persistent
Stipular keel	Entire	Entire	Minutely fimbriate	Minutely fimbriate
Leaf shape	Oblong-elliptic to oblong-obovate	Narrowly elliptic to elliptic-lanceolate	Elliptic to broadly elliptic	Broadly elliptic
Medial ridge of adaxial midrib	Flat	Flat	Knife-edged	Knife-edged
Adaxial leaf lines	Present or absent	Present or absent	Present	Usually absent
Mature leaf color	Bright yellowish green	Medium green	Dark green	Dark green
Staminal cup margin	Entire	Entire	Denticulate or crenulate	Triangular-denticulate
Breeding behavior	Partially self-compatible	Self-incompatible	Self-incompatible	Self-incompatible
Methyl salicylate in leaves	Present	Present	Absent	Absent
Cocaine content of leaves (mean % dry weight) ^{a,b}	0.77, 0.47	0.72, 0.71	0.63, 0.73	0.25, 0.34
Cinnamoylcocaine content of leaves (mean % dry weight) ^a	0.379	0.231	0.068	0.005

a. Plowman and Rivier 1983.

b. Holmstedt et al. 1977.



Figure 3. Branch of Huánuco coca, *E. coca* var. *coca*, growing at San Francisco, Río Apurímac, Dept. Ayacucho, Peru. Photograph by the author.

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

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The species *Erythroxylum coca* consists of the wide-ranging and economically important Andean variety *E. coca* var. *coca* and the geographically restricted Amazonian variety *E. coca* var. *ipadu*. *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. This variety is the principal commercial source of coca leaves and of most of the world's cocaine supply (fig. 3).

Erythroxylum coca var. *coca* grows mainly between 500 and 1,500 m in elevation, but may reach 2,000 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 the montaña (fig. 4). Because it has a fairly limited ecological range, Huánuco coca is little known outside its original area in South America. For example, transplants of this variety to the dry Peruvian coast, even when sufficiently irrigated, were unsuccessful (R. Collantes, personal communication).

The geographical distribution of Huánuco coca extends from Ecuador south to Bolivia and northwesternmost Argentina (fig. 2). 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 lower Amazon basin.

Throughout its range, Huánuco coca is found as wild-growing or feral individuals growing 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 and appears to be a natural element of the forest understory, occurring sympatrically with several wild erythroxylums including *E. ulei* O. E. Schulz, *E. mamacoca* Mart., *E. macrocnemium* Mart., and *E. mucronatum* 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 eagerly eaten by birds, which disseminate the seeds throughout the montaña zone. There are no essential structural differences between wild-growing and cultivated plants of *E. coca*



Figure 4. Plantation of Huánuco coca, E. coca var. coca, at San Francisco, Río Apurímac, Dept. Ayacucho, Peru. Photograph by the author.

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 and Heiser 1976).

Erythroxylum coca var. *coca* is now thought to be a naturally occurring wild species of the montaña, from which the other three cultivated coças were ultimately 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 wild-growing Huánuco coca is frequently encountered. Subsequent range extensions northward to Ecuador and southward to Bolivia and Argentina probably occurred through man's cultivation.

Discovery and Early Cultivation of Huánuco 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 it 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 archaeological evidence (such as ceramic representations of coca chewers or coca-chewing paraphernalia) by several thousand years.

Archaeological Record of Huánuco Coca

Archaeological remains of preserved coca leaves have been reported from sites of the Late Preceramic period up to the modern era. Identification of archaeological coca is often difficult owing to the fragmentary nature and poor preservation of leaf material. Unfortunately, coca leaves recovered from many sites have not been preserved by archaeologists for later examination; many critical specimens are now completely lost or discarded.

Most specimens of archaeological coca originate from the dry Peruvian coast, where preservation of plant remains is optimal. In most cases these have been identified as *Erythroxylum coca* var. *coca*. However, earlier workers did not usually distinguish among different species and varieties of cultivated coca. Re-examination of extant archaeological coca leaves from coastal Peru revealed that they all represent Trujillo coca, *E. novogranatense* var. *truxillense*, which is now known to have a long history, if not its origin, in this arid environment (see the following discussion).

The discovery of archaeological coca in coastal Peru has prompted many authors, who were unaware of the existence of Trujillo coca, to suggest extensive, early trans-Andean trade in coca from the montaña to the coast (Sauer 1950; Lanning 1967; Lathrap et al. 1976; Klepinger et al. 1977; Cohen 1978; Dobkin de Rios and Cárdenas 1980). Although trade in montaña-grown coca to the coast may have occurred on a small scale, there is little evidence for it from archaeological coca remains. Mortimer (1901) illustrated coca leaves taken from an Inca mummy bundle found at Arica, Chile, which clearly represent *E. coca* var. *coca*. Since the Incas traded many items throughout their empire, this may not be an isolated instance of trans-Andean coca trade, but the lack of additional specimens of montaña-grown coca on the coast precludes further speculation.

MacNeish et al. (1975) suggested that "coca" may have been present in the Ayacucho region during the Preceramic Period 6 (4200–2500 B.C.). Since coca chewed in the highlands of Ayacucho originates in the tropical forests of the Río Apurímac, specimens recovered from this area would be expected to belong to *E. coca* var. *coca*. However, it is uncertain that the material reported by MacNeish was in fact coca. The specimens were recovered from human coprolites, which unlikely would be identifiable as *Erythroxylum* leaves, especially since coca quids are not generally swallowed. In any case, the original "coca" specimens from these excavations have been lost (V. M. Bryant, personal communication). Subsequent authors have accepted the early presence of coca at Ayacucho (cf. García Cook 1974) although some questioned it (Pearsall 1978). Unless additional evidence to the contrary is forthcoming, it should not be assumed that coca was present at these early sites.

Well-preserved leaves of *E. coca* var. *coca* have been recovered from a post-Conquest site at Huachichocana in Jujuy, Argentina (Fernández Distel 1974). Photographs of the specimens show that they belong to this variety, which was probably grown in montaña areas of Jujuy or adjacent Bolivia and transported to Huachichocana. Because of the generally humid conditions in the montaña and Andean highlands, archaeological coca is not to be expected from these areas, in spite of their having a long history of coca chewing.

There is comparatively little indirect archaeological evidence for coca from the general area where *E. coca* var. *coca* is used. In Bolivia, gold and ceramic artifacts depicting coca chewers have been discovered at Tiwanaku, that suggest that coca was in use there "perhaps as early as the fourth century A.D." (Carter et al. 1980). Since Tiwanaku lies less than 150 km from the coca-growing districts of the Bolivian Yungas, it is likely that *E. coca* var. *coca* was chewed there. Ponce Sanginés stated that coca trade from the Yungas to the Bolivian highlands was already flourishing in the fourth period of Tiwanaku (375–715 A.D.) (Carter et al. 1980).

As discussed later, numerous examples of coquero figurines and other coca-related artifacts have been excavated in coastal and highland Ecuador and adjacent Colombia. However, it is impossible to determine the variety of coca being used in these areas because of the lack of archaeological coca specimens in

Ecuador, the cultivation of more than one coca variety there, and the suggested long-distance trade networks that existed between montaña, highlands, and coast (Lathrap 1973; Myers 1976).

Historical Records for Huánuco Coca

The extent of pre-Conquest cultivation and production of coca in the montaña is known only in general terms, but undoubtedly stretched along the eastern flanks of the Andes from Ecuador to at least southern Bolivia. This area corresponds with the present distribution of *E. coca* var. *coca*, with the exception of Ecuador, where coca plantations were systematically eliminated by the Spanish colonial authorities and clergy. Cieza de León (1973:221) wrote that coca was cultivated from Huamanga (Dept. Ayacucho, Peru) south to La Plata (Potosí, Bolivia) during Inca times; it is inferred that Huánuco coca of the montaña zones between these points is meant. Coca production was already well established at the time of Conquest in the three areas of the montaña that remain major producers today, viz., Huánuco and Cuzco in Peru, and the Yungas in Bolivia (Patiño 1967; Burchard 1975, 1976; Carter et al. 1980). Certainly most if not all coca consumed in and traded from the Inca capital at Cuzco was grown in the region known as Antisuyu, the humid montaña areas to the east.

During the period of Inca domination, the rulers at Cuzco exercised widespread control over coca production in all parts of their empire, similar to their control over other agricultural products. The belief that the Incas maintained an exclusive monopoly over both cultivation and chewing of coca throughout their conquered territories has recently been questioned (Burchard 1975, 1976, 1978; Netherley 1976; Antonil 1978; Carter et al. 1980). The "myth" of the Inca coca monopoly was based on early chronicles that described patterns of Inca life at Cuzco, but these were not necessarily typical of the remainder of the empire. After occupation by the Incas, coca continued to be used in many of the outlying provinces in keeping with longstanding local traditions.

The word "coca" is derived from the Aymara word "khoka," a generic term for "tree" or "bush" (Rostworowski 1973). "Coca" is now widely used throughout the Central Andes and even in much of Colombia, where the word was introduced by the Spanish. In Peru, coca from the montaña (*E. coca* var. *coca*) was originally called mamox (also mamosh or mamus), a name that was replaced by coca soon after the Spanish Conquest.

Murra (1946) stated that coca cultivation and chewing was introduced into Ecuador with the Inca Conquest of the area, and was "quickly adopted by local groups." Although we now know that coca has a very ancient history in Ecuador, its cultivation and use in certain areas, such as Pimampiro (Río Chota, Prov. Imbabura), may have been intensified under Inca rule and extended to new areas (Patiño 1967; Myers 1976).

The critical social and economic role of coca in daily Andean life under the Incas and during the early Colonial period is well documented through the writings of early chroniclers (Acosta 1608; Poma de Ayala 1944; Cobo 1890-1895; Garcilaso de la Vega 1966; Matienzo 1967; Cieza de León 1973; *inter alia*), and these have been summarized by numerous authors (Mortimer 1901; Gutiérrez-Noriega 1944; Rowe 1946; Gutiérrez-Noriega and Zapata-Ortiz 1947; Gagliano 1960; Patiño 1967; Burchard 1975, 1976; Chávez Velásquez 1977; Carter et al. 1980, etc.). During the Colonial period, when coca became a key commodity in the operation of the lucrative Bolivian silver mines, production of Huánuco coca greatly increased in southern Peru and northern Bolivia (Gagliano 1960). This variety remains today an immensely valuable crop for the extraction of illicit cocaine.

Erythroxylum coca var. *ipadu*, Amazonian Coca

Although long neglected by or even unknown to many anthropologists, Amazonian coca, *Erythroxylum coca* var. *ipadu*, recently has been re-examined by botanists (Schultes 1957, 1981; Plowman 1979b, 1981; Rury 1981; Plowman and 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, Peru, and possibly Ecuador (see fig. 2). It is propagated by stem cuttings rather than by seeds, and entire plantations may represent a single clone; as such, it is well adapted to the pattern of shifting agriculture practiced by seminomadic 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 cocas (Bohm et al. 1981, 1982). The principal chemical difference in Amazonian coca is a consistently lower cocaine content; this variety usually contains only about half the concentrations found in other cultivated cocas (Holmstedt et al. 1977, 1979; Plowman and Rivier 1983). This low cocaine content has apparently led to the elaborate preparation of Amazonian coca leaves as a finely divided powder, to which is added the ashes of *Cecropia* leaves as an alkaline source. The powder is used in the form of a quid in the cheek by mixing the dry powder with saliva, similar to the chewing of other coca varieties. However, the Amazonian coca quid is completely swallowed as the leaf powder slowly dissolves (Schultes 1981; Plowman 1981).

Erythroxylum coca var. *ipadu* was unknown to Europeans until the middle of the eighteenth century. Details of its cultivation, use, and geographic distribution were not recorded until the present century. Amazonian coca has no archaeological 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 and is not further implicated in the more complex evolutionary interactions that exist among the cultivated cocas of the Andean area.

138 *Erythroxylum novogranatense*

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

Erythroxylum novogranatense consists of two well-defined varieties: *E. novogranatense* var. *truxillense*, Trujillo coca, and *E. novogranatense* var. *novogranatense*, Colombian coca. These varieties are more strongly differentiated from each other than is *E. coca* var. *coca* from *E. coca* var. *ipadu*. This suggests greater varietal isolation and antiquity for the varietal differentiation within *E. novogranatense* than has occurred in *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*. Although cocaine concentrations in *E. novogranatense* compare favorably with *E. coca* var. *coca*, both varieties of *E. novogranatense* produce high levels of the related alkaloid cinnamoylcocaine, which is found in only small amounts in *E. coca*. The essential oil methyl salicylate (wintergreen oil) is also a conspicuous constituent in the leaves of *E. novogranatense*, but has not been reported in *E. coca* (Plowman 1982; Plowman and Rivier 1983). The leaf flavonoids of *E. novogranatense* also differ from those of *E. coca* (Bohm et al. 1982). Last, breeding experiments between *E. coca* var. *coca* and the varieties of *E. novogranatense* have demonstrated genetic differentiation among these taxa that have further served to clarify 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 1,800-m elevation, and in the adjacent arid, upper Marañón River valley (see figs. 2 and 5). 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 in color, and more brittle than leaves of *E. coca*. Because it contains flavoring compounds not found in *E. coca*, Trujillo coca has long 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. Because it is difficult to extract and crystallize cocaine from Trujillo coca leaves, this variety has rarely been exploited for commercial cocaine production (Plowman 1982; Plowman and Rivier 1983).

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 crossed experimentally 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 that flowered showed only 50 percent pollen stainability and a much reduced seed set. This suggests at least partial reproductive isolation between the varieties of *E. novogranatense* resulting from their being isolated geographically in somewhat different habitats over a long period of time (Bohm et al. 1982).

Erythroxylum novogranatense var. *truxillense* was also 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



Figure 5. Plantation of Trujillo coca, E. novogranatense var. truxillense, at Simbal, Dept. La Libertad, Peru. Photograph by the author.

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 correctly placed 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 suggestive 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 selection pressures.

Archaeological Record of Trujillo Coca

Trujillo coca is the only variety of cultivated coca with any appreciable archaeological record. Because of its development as a drought-resistant cultigen and its eventual diffusion to the desert coast of Peru, its leaves and endocarps ("seeds") are well preserved in burials, along with other plant remains. As pointed out earlier, archaeological coca leaves from coastal Peru were usually misidentified as *Erythroxylum coca*. Harms (1922), who was familiar with the taxonomic studies on *Erythroxylum* by O. E. Schulz, was the first botanist to identify the small-leaved coca from coastal Peruvian sites as *E. novogranatense* and to question the reliability of previous identifications of archaeological coca.

The first evidence suggesting coca chewing on the Peruvian coast appears in the Late Preceramic Period (2500–1800 B.C.) as preserved coca leaves (species unidentified) and as coca-related artifacts. Engel (1957) reported a bottle gourd and three *Mytilus* shells, all containing powdered lime and presumed to be employed in coca chewing, from a burial at Culebras (Dept. Ancash). Bray and Dollery (1983) have dated this site at around 2000 B.C. Engel (1963:77) also found "leaves looking like coca" along with large deposits of burned lime at

the site of Asia 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, personal communication). Patterson (1971) excavated preserved coca leaves near Ancón (Dept. Lima) in the Gaviota phase dated between 1750 and 1900 B.C.; Cohen (1978) also reported coca from Ancón with a date of 1800–1400 B.C. Coca leaves were also 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 800 and 200 B.C. (Dillehay 1979). Dillehay (1979) suggested that coca grown in the Middle Chillón was also traded to the earlier coastal site at Garagay and presumably to the adjacent highlands as well. Unfortunately none of the earliest records of preserved "coca" have been identified botanically because none of the original specimens can be located.

Archaeological coca leaves from much later sites on the Peruvian coast have been available for study, and these all belong to the variety *E. novogranatense* var. *truxillense*, Trujillo coca. These include specimens from Vista Alegre in the Rimac Valley (Dept. Lima, approximately 1000–600 A.D.), which were illustrated by Towle (1961, plate IV, fig. 5); from the Yauca Valley (Dept. Arequipa, Late Horizon); from Nazca in the Taruga Valley (fig. 6) and from Monte Grande in the Río Grande Valley (Dept. Ica); and from Chacota near Arica in northernmost Chile (Late Horizon). These well-preserved specimens closely resemble modern Trujillo coca, except that they are in general smaller in size. Intact leaves of several of the archaeological samples available for study were cleared chemically to examine details of leaf venation. Venation patterns were identical to present-day Trujillo coca leaves (Rury and Plowman, in press). Similar conclusions were drawn from an earlier study on coca leaves from a pre-Inca grave at Nazca (Griffiths 1930). Coca endocarps referable to Trujillo coca were reported from Vista Alegre (Towle 1961) and were more recently excavated at Chilca (Dept. Lima, Late Intermediate period) by Jeffrey Parsons (personal communication).

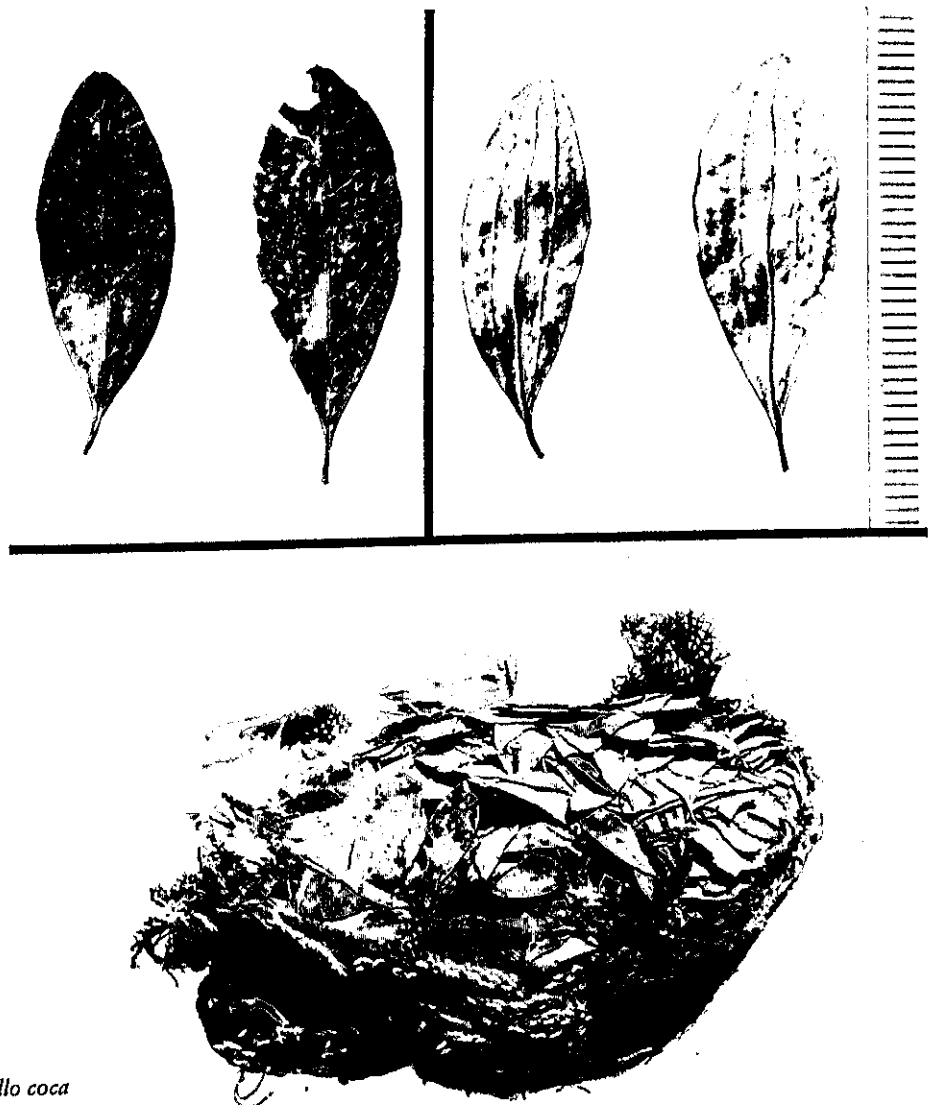


Figure 6. Archaeological Trujillo coca leaves (*Erythroxylum novogranatense* var. *trujillense*) from an Inca cemetery, Atarco II site, Nazca, Taruga Valley, Dept. Ica, Peru. Wattis Collection, Lowie Museum of Anthropology, University of California, Berkeley. Accession no. 16-13426. Above left: leaves showing upper surface. Above right: leaves showing lower surface. Millimeter scale. Below: Cotton bag containing Trujillo coca leaves. Centimeter scale. Photographs courtesy of Lowie Museum of Anthropology.



Figure 7. Archaeological lime gourds (*Lagenaria siccaria*) from coastal Peru. Larger decorated specimen from Huacho, Huaura Valley, ca. 1000–1475 A.D.; smaller undecorated specimen from Cajamarquilla, Rimac Valley, date uncertain. Peabody Museum of Archaeology and Ethnology, Harvard University. Photograph by the author.

Figure 8. Seated figure chewing coca, using lime gourd and dipper. Moche IV, c. 400 A.D., north coast of Peru. Museo Nacional de Antropología y Arqueología, Lima. Photograph courtesy of Museum of Cultural History, University of California, Los Angeles.





Figure 9. Ceramic jar depicting the head of a man chewing coca with cheek bulge, Chimu-Inca, c. 1465–1535 A.D., north coast of Peru. Peabody Museum of Archaeology and Ethnology, Harvard University. Photograph by the author.

Later evidence for coca chewing, including lime pots, lime dippers, and ceramic coca-chewing human figures, as well as occasional preserved leaves, has been discovered throughout the Peruvian coast from the early ceramic period to Inca times. Nazca, Moche, and Chimú ceramics depict numerous graphic examples of coca chewers with cheek bulges, often carrying lime gourds and dippers (Yacovleff and Herrera 1934; Jones 1974; Donnan 1978; Jeri 1980) (figs. 7, 8, 9).

Curiously, representations of the coca plant or coca leaves themselves have not been figured on pottery. Naranjo (1974) illustrated a Nazca vessel that he interpreted as depicting mythological personages carrying coca leaves in their hands and mouths. Although the plants depicted do superficially resemble stylized coca leaves, Yacovleff and Herrera (1934) have identified these frequently encountered Nazca motifs as *Capsicum* fruits, a determination with which Pickersgill (personal communication) and I concur.

There is sufficient evidence now to postulate that Trujillo coca was cultivated and chewed on the Peruvian coast at least by 2000 B.C., and possibly earlier. As will be discussed below, Trujillo coca probably did not originate in the coastal valleys of Peru but was introduced from further north in Ecuador or from the interior valleys of northern Peru. Once Trujillo coca became established as a crop on the Peruvian coast, the Central Andes became an area of two coca provinces with Huánuco coca cultivated in the montaña and Trujillo coca on the coast. Both varieties were probably traded to adjacent highland areas, where coca is consumed now, and probably was consumed in the past, in great quantities. Mortimer's (1901) report of *E. coca* var. *coca* in a burial at Arica suggests that some coca from the Bolivian montaña was traded to the coast. Similarly, Cieza de León (1973:221) recorded that the small-leaved coca from Trujillo was traded far to the south to the mines in Potosí (Bolivia). However, it may be assumed that most coca was obtained from those coca-growing districts in closest proximity.

Historical Records for Trujillo Coca

The two distinct kinds of coca in pre-Conquest Peru were already recognized in Inca times, and undoubtedly earlier, as pointed out by Patiño (1967), Rostworowski (1973), and others in reference to two early Spanish writers, Fray Martín de Murúa and Diego González Holguín. González Holguín wrote in 1608 of the two kinds of coca: "mamas coca, la coca de hojas grandes que mas preciada" (i.e., *E. coca* var. *coca*) and "tupa coca, la coca de hojas chicas" (i.e., *E. novogranatense* var. *truxillense*).

Murúa, writing at the same time, was more specific:

Tenían por muy gran regalo la coca de hoja menuda, que llamaban tupa coca que se dá en los Llanos; ésta era tenida y estimada de todos, y del Inga aceptada; de la cual usaba en su comer y la tenía en mucho, y la otra de la hoja grande se cría en los Andes, que llamaban *mumus*, coca desta comían estos indios la cual repartía el Inga entre otras mercedes.

Tupa, or "small-leaved coca," was grown in "los llanos," as the Peruvian coast was then known to the Spanish. The word "tupa" means "noble" in Quechua and refers possibly to a higher status afforded this variety on account of its better flavor. The mamas or *mumus* coca came from "los Andes" (i.e., the montaña) and had larger leaves.

The chronicler Juan de Matienzo (1967) wrote in 1567 at length on coca in Peru and referred primarily to the variety cultivated in the montaña (*E. coca* var. *coca*). However, he also mentioned a coastal variety that must refer to Trujillo coca:

... verdad es que los indios de los Llanos también usan de una coca, que es a manera de arrayán [*Myrtus communis* L., the classical myrtle], y pequeños los árboles o sepas, y creo que es la mesma semilla y entre ellos es de poco precio.

Rostworowski (1973) has eloquently demonstrated the historical distribution of Trujillo coca along the Peruvian coast during late Inca times. She cites unpublished documents that prove categorically that coca was cultivated from the Trujillo region on the north coast south to Arica. Specifically she points out the following localities of cultivation: Sinsicap and Collambal (Collambay) (Dept. La Libertad), upper Río Chancay (Dept. Lima), Quivi, Chillón Valley (Dept. Lima), Ica

Valley (Dept. Ica), and in the region of Tacna (Dept. Tacna) and Arica and Azapa (Chile). The economic importance of the coca fields at Quivi and their control by Inca administrators have been discussed in detail by Netherley (1976).

From the extensive archaeological and historical record, it is now well established that Trujillo coca was widely cultivated throughout the Pacific slopes in the coastal zone known in Inca times as the "chaupiyunga," those areas above the coastal fog belt up to about 1,800 m. Rostworowski (1973) cites the catastrophic cultural disruptions and depopulation of the coast immediately after the Spanish Conquest as responsible for the rapid abandonment of coca cultivation in most of coastal Peru.

Origins of Trujillo Coca

The area of origin of Trujillo coca remains unresolved. It is now believed that this variety gradually evolved from populations of *E. coca* var. *coca* in adapting to drier habitats in new areas. The most likely areas for this to occur are the more arid Andean valleys that lie adjacent to the wetter montaña habitats of Huánuco coca. Interspersed throughout the montaña are locally drier areas, such as Tarapoto and the valley of La Convención, where Huánuco coca can still be cultivated. However, cultivation of this variety stops abruptly when one reaches the arid, thorn-scrub areas of the upper Marañón and its tributaries in northern Peru. This is precisely the kind of habitat where plantations of Huánuco coca are replaced by the Trujillo variety.

At some early date, populations of *E. coca* var. *coca* were adapted to successively drier valleys through a long period of gradual selection for successful cultivation in these areas. Many intermediate forms must have developed during this time in isolated valleys, and some hybridization must have continued to take place among them. Eventually genetic barriers to such hybridization developed resulting in the genetically stable species *Erythroxylum novogranatense* (as var. *truxillense*). Although certain crucial areas in northern Peru remain to be explored for possible intermediates, no natural hybrids between *E. coca* var. *coca* and *E. novogranatense* var. *truxillense* have been located. Although the dating of the first appearance of Trujillo coca as a distinct variety is extremely speculative, it could have arisen as early as 4000 B.C.

Once Trujillo coca became established as a genetically stable species, it diffused to new arid areas that were previously inhospitable for coca cultivation. By about 2000 B.C., it reached the Peruvian coast by an as yet undetermined route, permitting coca cultivation for the first time in the coastal river valleys. The time lapse between the first origins of Trujillo coca and its recorded appearance in coastal Peru cannot be understood without considering the early history of coca in another crucial area to the north, present-day Ecuador.

146 The History and Distribution of Coca in Ecuador

Perhaps the earliest known record for coca chewing comes from the Valdivia culture on the Santa Elena Peninsula in southwestern coastal Ecuador. Small ceramic lime containers have been found there 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 (1000–300 B.C.), when it reached its maximum development. Also discovered at Valdivia was a small ceramic figurine of the Chagras style that clearly represents the prominent cheek bulge of a coca chewer. This piece is dated Late Valdivia (1600–1500 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 (Klepinger et al. 1977). Based on the archaeological evidence, it appears that coca cultivation and the habit of coca chewing were fully established in the Valdivia area by 3000 B.C.

Lathrap et al. (1976) apparently did not consider the existence of drought-resistant coca varieties when they wrote that the presence of coca chewing at Valdivia suggested well-established trade networks with agricultural communities in the moister forest regions to the east in the Andean foothills. Similarly, other authors believed that coca used at Valdivia was transported from the northern highlands of Ecuador (Myers 1976), or even from across the Andes from the montaña of the eastern slopes (Klepinger et al. 1977).

Following the initial early appearance of coca chewing throughout the Formative of Ecuador, evidence for the habit in the form of lime pots and coquero figurines are represented in all later phases up until Inca times, especially in the provinces of Manabí, Esmeraldas, and Carchi (and in department of Nariño in adjacent Colombia) (cf. Meggers 1966; Drolet 1974; Naranjo 1974; Jones 1974; Bray and Dollery 1983) (fig. 10). Of the Cañari culture, which occupied the southern Ecuadorian highlands about 1000 A.D., Meggers (1966:151–152) wrote that “in the warmer, lower valleys of the Alausí and Jubones rivers, enough coca was raised to supply the entire province.” Naranjo (1974) stated that the Río Coca in the Ecuadorian montaña

Figure 10. Seated figure chewing coca, showing characteristic cheek bulge. Painted pottery, Capulí style, ca. 800–1250 A.D., Pupiales, Dept. Nariño, Colombia. Museo de Oro, Bogotá. Photograph by Robert Feldman.



(Prov. Napo) derived its name from the extensive plantations of coca formerly grown there. At the time of Conquest, the cultivation and use of coca was widespread in Ecuador, a fact well documented from historical sources (summarized in Patiño 1967).

Unlike Peru, where early historical sources distinguished between two varieties of coca, we have no direct information on what varieties were being grown in Ecuador during Inca and earlier times. However, by examining the present distribution of coca varieties in Ecuador and applying what is known of their ecology, it is possible to speculate about the early development of coca in this area.

In 1978 a few, isolated populations of cultivated coca with small pointed leaves were found below the town of Maldonado in the province of Carchi near the Colombian border. These plants were grown for their leaves, which are still being chewed by a small number of mestizos of unknown ancestry. Subsequent botanical and chemical analysis showed definitely that this coca belonged to *E. novogranatense* var. *truxillense* (Plowman 1979b; Rury 1981; Bohm et al. 1982). Maldonado lies in the valley of the Río San Juan in an area of moist, montane forest, an unexpected habitat for Trujillo coca, which is otherwise found only in arid regions.

The discovery of Trujillo coca in Carchi may reflect a former, widespread distribution of this variety in western Ecuador. The virtual but fortunately incomplete disappearance of coca in Ecuador resulted from incessant prosecution of the coca habit by ecclesiastical and governmental officials that began in the sixteenth century (León 1952; Gagliano 1960, 1976; Naranjo 1974), and that continues today. The more densely populated and accessible coastal regions of Ecuador would have been especially vulnerable to these persecutions, along with any coca plantations that may have existed there.

Until very recently, the area below Maldonado has been very isolated because of lack of roads, and it seems that the persistence of coca chewing there, along with the continuing existence of Trujillo coca, is a result of the area's inaccessibility. Other relict populations of Trujillo coca may still survive in parts of Pacific Ecuador, but these remain to be located. Murra (1948) mentioned that coca was cultivated by the Cayapa, a tropical lowland tribe of northwestern Ecuador, but we do not know if coca is still in use among this group, or what variety of coca was employed. It is of particular

interest that Colombian coca, *E. novogranatense* var. *novogranatense*, which occurs in southern Colombia, has never been found in Ecuador.

Erythroxylum coca var. *coca* also occurs in Ecuador, but it is now rarely encountered owing to the previously mentioned campaigns to eradicate coca. Cordeiro (1911) described coca plantations at Sanahuín in western Azuay Province. Julian Steyermark visited this locality on May 26, 1943, and collected specimens from a very old tree that clearly represents *E. coca* var. *coca*. In 1974, Wade Davis and I collected specimens of this variety under cultivation at Chilcales and Cochancay in Cañar Province. All these plantations were in the process of being destroyed by Interpol agents in 1974. A wild or feral plant of *E. coca* var. *coca* was also found by Schimff in 1933 at Naranjapata (Chimborazo Province), which is the only known record of coca growing outside cultivation in Ecuador (see fig. 2).

Naranjo (1974) illustrated recently collected coca leaves, identifiable as *E. coca* var. *coca*, from the valley of the Río Mira near Ibarra in northern Ecuador. These possibly represent relict populations of this variety remaining from formerly extensive plantations there. Patiño (1967) pointed out that Pimampiro, in the Río Mira drainage northeast of Ibarra and just below the upper limit of coca cultivation, was a famous coca-growing district in the late sixteenth century. Highland Indians from Otavalo, Latacunga, and even Pasto in southern Colombia made periodic visits to these plantations to assist in picking coca in exchange for supplies of the leaves. Myers (1976) suggested this locality as the possible source of coca chewed during Valdivia times, but the great time differential hardly lends credence to such a theory.

On the eastern slopes of the Ecuadorian Andes, coca is almost unknown. Besides Naranjo's (1974) belief that plantations existed along the Río Coca, there is little evidence of large-scale cultivation along the eastern slopes. However, it is likely that *E. coca* var. *coca* has been grown there, at least sporadically. León in 1952 stated that coca was still cultivated on a small scale at Curaray (Prov. Pastaza). In 1979, a specimen of *E. coca* var. *coca* was found cultivated at a Catholic mission north of the village of Tena (Prov. Napo), but this may represent a recent introduction. Still, there is little indication that the vast plantations of this variety found in the montaña of Peru and Bolivia ever existed in eastern Ecuador, perhaps because of the especially hostile tribes found in the Ecuadorian montaña.

In light of this overview of the varieties of coca in Ecuador, it is of interest to reconsider what variety or varieties of coca were being chewed in the Valdivia culture. Although the Santa Elena Peninsula itself is very arid and supports no permanent rivers, it would be possible to cultivate Trujillo coca along the river basins somewhat inland, for example, at the very early Loma Alta site that lies about 15 km up the Valdivia River. This area has a high water table, and according to Lathrap et al. (1976), could be farmed continuously without irrigation. Given an origin in the drier Andean valleys of northern Peru, Trujillo coca could easily have diffused to the Ecuadorian coast stepwise across the relatively low-elevation, highly dissected areas of the Andes in the north Peruvian departments of Amazonas and Cajamarca and in the provinces of Loja and El Oro in Ecuador.

Since I have demonstrated that *E. coca* var. *coca* is also present in parts of western Ecuador, and was probably more widespread in the past, it is also possible that this variety was present as early as Valdivia times and, as Lathrap et al. (1976) suggested, was traded from the moist western slopes to the Santa Elena Peninsula. However, without preserved archaeological coca specimens, or more precise historical and botanical data, the early patterns of diffusion of coca in Ecuador remain unresolved.

To summarize the history of coca in Ecuador, we know that coca chewing is very ancient and first represented archaeologically in this area, beginning in the early Formative. At the time of the Conquest, coca was cultivated extensively in western Ecuador and to a lesser degree on the eastern slopes of the Andes in the montaña. The leaf was chewed throughout the Ecuadorian Andes and was traded widely from areas of cultivation to highland areas. *Erythroxylum coca* var. *coca* is cultivated on both sides of the Andes in Ecuador, but the date of the first introduction of this variety is unknown. It is probable that its cultivation was increased during the period of Inca domination. Today it is found only very rarely and sporadically.

The discovery of Trujillo coca in northwestern Ecuador requires a re-evaluation of the early history of coca in western Ecuador. Dry climatic conditions near the coast would require cultivation of this variety, but *E. coca* var. *coca* could also have been traded westward from the moist forests of the Andean foothills. At present the date of the arrival of Trujillo coca in Ecuador is unknown. The absence of Colombian coca in Ecuador

suggests that this variety evolved further north and did not diffuse southward. Additional fieldwork is urgently needed to document the possible presence of relict coca plants in Ecuador.

Erythroxylum novogranatense var. *novogranatense*, Colombian Coca

The fourth variety of cultivated coca is *Erythroxylum novogranatense* var. *novogranatense*, or Colombian coca (fig. 11). This variety is distinguished morphologically from other varieties by its bright yellow-green foliage and lack of persistent stipules. In dried leaf specimens, identification 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. However, it is also grown in moister parts of the Colombian Andes, especially at elevations above 1,500 m (see fig. 2).

Unlike any of the other three coca varieties, Colombia coca is quite tolerant of diverse ecological conditions, and for this reason was the variety 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 twentieth century, introduced there by enterprising Dutch colonial planters (Reens 1919).

Colombian coca is isolated geographically from other coca varieties, in contrast to the complex distribution patterns seen in Trujillo and Huánuco cocas. This isolation has led to fundamental changes in the 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 contains the rutosides, including ombuin-3-O-rutinoside, that 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 fertile and 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



Figure 11. Cultivated shrub of Colombian coca, *E. novogranatense* var. *novogranatense*, in houseyard at Trapiche, Dept. Cauca, Colombia. Photograph by the author.

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 erythroxyliums 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; it 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 found 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.

Archaeological Record of Colombian Coca

No preserved archaeological leaves of Colombian coca have been reported, but a great many coca-related artifacts document the widespread use of coca in ancient Colombia. During the first millennium A.D., the Quimbaya culture of the middle Cauca valley (near the city of Pereira) produced numerous, beautifully crafted gold lime pots, known as poporos, along with gold lime dippers. Several of the poporos are quite large, measuring up to 23.4 cm tall and weighing over 1 kg; some of them are furnished with gold-beaded necklaces for wearing around the neck. It is generally believed that these elaborate vessels were the accoutrements of nobles or priests. In addition, gold figurines carrying gold lime pots in their hands have been recovered from this culture area (Jones 1974; Antonil 1978; Bray 1978; Hemming 1978).

In the San Agustín culture in the department of Huila in southern Colombia, several 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 1940; Uscátegui 1954; Reichel-Dolmatoff 1972; Antonil 1978) (fig. 12). One partially destroyed statue known as "El Coquero" at El Tablón in the valley of San Andrés de Pisimbalá 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. It is of interest that the town of San Agustín has long been and continues to be a major center of coca cultivation and distribution in the upper Magdalena Valley.

From the Colombian highlands, a Muisca mummy found in a cave at Pisba (Dept. Boyacá) was accompanied by a coca bag and a lime gourd and dipper; it dates from the Late period, after 1000 A.D., and was illustrated by Bray (1978). From the same period, artifacts from Sierra Nevada de Santa Marta document coca chewing in the Tairona culture. A miniature jar found near Ciénaga (Dept. Magdalena) depicts a coca chewer with a huge quid bulge in one cheek (Bray 1978). Ceramic coca-toasting pans, which are almost identical to pans used today by tribes of the Sierra Nevada de Santa Marta, have been recovered from Tairona sites (Reichel-Dolmatoff 1953).

Historical Records for Colombian Coca

At the time of the Spanish Conquest, Colombian coca was known throughout present-day Colombia and Venezuela by the indigenous name "hayo" or "jallo." The word "coca" was a later introduction by the Spanish from Peru. Tribes of the Sierra Nevada de Santa Marta still use the term "hayo" to refer to their cultivated coca, and many wild species of *Erythroxylum* in northern Colombia and Venezuela still bear this vernacular name.

Colombian coca had a much wider distribution before the Spanish takeover, and this had been documented by the earliest records. Coca was cultivated all along the major river systems of Colombia and in many smaller valleys throughout the mountains. It was grown in many areas along the north coast of South America from Cartagena east to Cumaná in Venezuela and possibly to Trinidad.

Figure 12. Guardian statue carved from stone, showing cheek bulges indicative of coca chewing, first millennium A.D., San Agustín, Dept. Huila, Colombia. Photograph by the author.



The first report of coca chewing in the Americas applies to Colombian coca and was written by Amérigo Vespucci in a letter to Renato II, Duke of Lorena. Vespucci disembarked on an unidentified "island" 15 leagues off the coast of South America, according to his calculations. He wrote that the Indians habitually chewed a certain green herb along with a white "flour." While chewing the herb, they added the "flour" to the mouth with a small stick. They carried two gourds at their belts, one for the herb and one for the "flour." Although Wilbert (1975) suggested this description might represent tobacco chewing, it most certainly refers to coca, coinciding in all details with present-day coca chewing on the northern coast of Colombia. The green "herb" is dried coca leaves; the "flour" is the powdered lime that is still carried universally in a small gourd.

The location of Vespucci's description has been variously interpreted. Navarrete (1880), followed by Bües (1935), Naranjo (1974), and others, placed the landfall in northern Brazil at the mouth of the Amazon River. Patiño (1967), citing Vespucci's comment that there was no fresh water available on the "island," located the coca chewers on the arid Paria Peninsula in eastern Venezuela. Vila (1972) carefully traced Vespucci's navigational course and determined that the landfall took place on the Guajira Peninsula in north-eastern Colombia and identified the coca chewers as Guajiro Indians. This tribe until recently both cultivated and chewed coca. Patiño (1967) pointed out that plantations of Colombian coca were found at Macuire on the Guajira Peninsula until the late nineteenth century, when they were destroyed by severe droughts. He also cited numerous additional historical documents that show that coca chewing was widespread among Indian tribes throughout northern Venezuela.

Many of the early Spanish chroniclers to visit Colombia described the extensive cultivation and use of coca immediately after the Conquest; some of the most important reports were made by Oviedo, Orejuela, Castellanos, Piedrahita, Simón, and Cieza de León (Pérez de Barradas 1940, 1957; Uscátegui 1954; Patiño 1967). Cieza de León (1973), who was also familiar with the coca used at Cuzco, specifically referred to a "small-leaved coca" that was chewed in the vicinity of the town of Antioquia in northeastern Colombia, and at Cali and Popayán in the south. This strongly suggests that the variety of coca prevalent in Colombia just after the Conquest was the same small-leaved variety used today, that is, *E. novogranatense* var. *novogranatense*.

Early descriptions of coca chewing from the Colombian mountains are entirely consistent with contemporary practices. Tribes along the north coast of Colombia prepared powdered lime by baking seashells. In the southern mountains, where shells were unavailable, a crude lime known as mambe was extracted from native limestone deposits found along the upper Río Magdalena, not far from San Agustín. In the Santa Marta region, the custom of adorning poporos by rubbing lime-laden saliva around the head of the gourd to form a thick rim of redeposited limestone was described in the last century (Mortimer 1901) and continues today, essentially unchanged. Representations of gourds with identical lime-encrusted rims are also depicted in modeled and painted Mochica vessels dating to about 500 A.D. (Kutscher 1955; Donnan 1978). Although lime gourds are still commonly used in northern Peru, the habit of sculpting the rim no longer exists. The curious disjunction of this custom between Santa Marta and the ancient Mochica has not been investigated.

Coca in the West Indies

The diffusion of coca chewing, which was so well established along the Caribbean coast of South America, to the West Indies and Central America would seem likely considering the cultural contacts that existed among these regions in pre-Conquest times. However, evidence for coca chewing in both these areas is extremely scanty.

In the West Indies there is no archaeological evidence for coca chewing. All inferences of its existence there stem from a single account written by Fray Ramón Pane in Hispaniola. Pane, on the order of Hernando Columbus, son of Christopher Columbus, investigated the native customs in Hispaniola and described the shamanistic healing rituals of the local Taino medicine men known as buhithus. Pane described the preparation of a drink made from three plants, one called güeyo o zacón and two unnamed ones. This drink was taken during the healing ceremony, apparently by both shaman and patients. Pane's account (Colón 1932:61) follows

Estando ya solos, toman algunas matas del güeyo, anchas, y otro hierba, envuelta en una hoja de cebolla, media cuarta de larga; la de las matas de güeyo es la que toman comunemente; amazada con la mano la reducen a pasta y luego se la ponen en la boca por la noche, para vomitar aquello que han comido, a fin de que no les haga daño. Entonces comienzan a entonar el canto mencionado, y tomando una antorcha beben aquel jugo . . .

If after the curing ceremony the patients died, it was sometimes necessary to give the dead person the juice of the leaf of the same güeyo to determine if the death was caused by the buhitihu for failing to observe the strict diet prescribed for both healer and patient (Colón 1932:63-64):

Queriendo saber si el enfermo ha muerto por culpa del médico, o porque no guardó la dieta como éste la ordenó, toman una hierba se llama güeyo, que tiene las hojas semejantes al basilicón, gruesa y larga, por otro nombre llamada zacón. Sacan el jugo de la hoja, cortan al muerto las uñas y los caballos que tiene encima de la frente, los reducen a polvo entre dos piedras, mezclan esto con el jugo de dicha hierba y lo dan a beber al muerto por la boca, o por la nariz, y haciendo esto preguntan al muerto si el médico fue ocasión de su muerte, y si observó la dieta.

After repeated opportunings by the family, the dead man might then begin to speak as if alive and answer whether the buhitihu failed to observe the diet, thereby causing the death. The dead man was then immolated in a great pyre.

Las Casas believed that the herb, which the Tainos frequently drank in the form of a juice, was coca, although he himself had never personally observed coca chewing (Loven 1935). Based on Pane's account, Loven (1935) concluded that coca was indeed in use in Hispaniola. He cited three reasons for this belief. Pane had mentioned that the güeyo resembled "basilicón," Mediterranean basil (*Ocimum basilicum* L.). Loven stated that coca leaves were very similar in form to basil. Although comparable in leaf size, basil differs markedly from coca in leaf shape; furthermore, basil is a herbaceous plant, coca a woody shrub. Second, Loven believed that the word "güeyo" was derived from the Venezuelan name for coca, "hayo," and that coca had been imported to Hispaniola from the Cumaná region of eastern Venezuela. However, there is no linguistic or phytogeographic evidence to support these statements.

Loven also commented on an early report by Gomara (1946), who wrote in 1552-1553 that the powder or juice of the leaves of a tree called hay were used to blacken the teeth by the Indians of Cumaná. He assumed that hay was a variant of hayo (and by implication güeyo) and referred to coca. Kirchhoff (1948) also mentioned the use of coca-leaf powder or coca-lime paste by the natives of this region for tooth blackening but pointed out certain contradictions in the practice from group to group. Humboldt (1884) questioned Gomara's report and suggested that hay may refer to some other stimulant or aromatic plants, including *Capsicum*, which was known by the similar terms "aji" or "ai." There are in fact no substantiated reports that the chewing of any variety of coca causes the teeth to turn black. It is likely that Gomara's account is in error and that he confused coca with another plant that was used for this purpose. Elsewhere in South America, leaves of several plants, notably the genus *Neea* in the Nyctaginaceae, are chewed both to blacken and to preserve the teeth (Bodley 1978).

Loven concluded that coca had diffused from Cumaná to the Tainos, but that these people had failed to learn the "complicated method of chewing" coca, and instead used the herb simply in liquid form. It is clear from his discussion that he knew little of either the mechanics or the effects of coca chewing. Even when coca is taken medicinally in the form of an infusion, the leaves are always dried prior to use.

Pane's account and Loven's interpretations have been accepted by later authors (cf. Gagliano 1976) as proof that coca had reached the Greater Antilles prior to the arrival of the Europeans. Although the identity of güeyo remains unresolved, it cannot be equated with coca for the reasons given here. It seems probable that coca reached the West Indies, at least as a trade item, but for unknown reasons the habit of coca chewing was not incorporated in Antillean cultures.

154 Coca in Central America

Evidence for coca chewing in Central America is somewhat more substantial, and it is certain that coca was used in at least some parts of this region. However, the northward extent of coca chewing (and cultivation), its distribution among different tribes, and the variety of coca employed are still largely unknown.

Archaeological evidence for coca chewing in Central America is sparse. For the area of Costa Rica, Stone (1977) mentioned small figures in stone and gold from the Diquis region that show the characteristic cheek bulges of coca chewers. Small, gourd-shaped clay vessels, often described as "needle cases," were also found containing "crushed seashells" (lime?).

Lothrop (1937) figured a small, carved bone head with a prominent cheek bulge from Sítio Conte in the Coclé culture of central Panama, which is dated between 500 and 700 A.D. This figure closely resembles figurines from Manabí province in coastal Ecuador as well as the early Valdivia figurine previously discussed. Lothrop believed that coca reached Panama from Ecuador or Peru rather than via the Caribbean coast of Venezuela and Colombia. Numerous other artifacts from Coclé, especially gold pieces, suggest strong stylistic ties with Colombia.

Historical accounts reveal that coca chewing was well established, at least in southern Central America. When Columbus landed on the western coast of Panama, he observed in the region of the Río Urira in Veraguas province that the Indians chewed a dry herb with a powdered substance (Colón 1947:296): "Mientras estaban allí, el cacique y sus principales no cesaban de meterse en la boca una hierba seca y de mascarla y a veces también tomaban cierto polvo que llevaban junto con la hierba seca, lo cual parece cosa fea." Although sketchy, this account closely resembles several of the early descriptions of coca chewing from South America. No other reports of coca chewing were recorded for Panama or Costa Rica.

The most complete description of coca chewing in Central America was made by Oviedo (1944:61) among the Indians who inhabited the Pacific coast of Nicaragua. They carried the dried leaves of a plant known as yaat in small calabashes carried around the neck. The leaves were held in the mouth in a quid to which was added lime made from seashells. This description of the chewing procedure and effects unmistakably matches the use of coca as practiced in South America, particularly in adjacent Colombia and Venezuela.

Stone (1977) and other authors have assigned Oviedo's coca chewers to the Nicarao, a Nahuatl-speaking tribe that occupied parts of western Nicaragua at the time of Conquest. She described the Nicarao as the most accomplished voyagers of Central America and credits them with introducing coca as well as the columnar cactus *Lemaireocereus griseus* (Haw.) Britt. et Rose into cultivation in Pacific Nicaragua from Venezuela. However, Oviedo, the sole source of this report, did not specify the Nicarao. The Nicaraguan coca chewers could have belonged to any one of a number of tribes present in this general area, including Chibcha-speaking groups. The Chibcha language extended south to Colombia and Ecuador (Lothrop 1926), and it may have been through this linguistic group that coca diffused north to Nicaragua.

Immediately after the Spanish takeover of Central America, coca chewing disappeared completely north of Colombia, along with all vestiges of cultivated coca plantations. Today Colombian coca is widely cultivated in all the Central American republics, but only as an ornamental plant or in experimental plantations in agricultural institutes. The immediate origin of these plants is unknown, but they may have been introduced through horticulture during the present century (cf. Plowman 1982). Colombian coca grows very well in Central America, particularly in the drier regions of Guatemala, Honduras, and El Salvador.

Because the data are so incomplete, it is difficult to assess the diffusion and impact of coca on Central American cultures. It seems certain from the historical record that coca chewing reached at least to Nicaragua, and from the archaeological record that it was present in Panama for at least 1,000 years. Which variety of coca was grown in lower Central America is entirely open to question. Ecological considerations are unrewarding because the areas where coca chewing was reported occupy both moist forest (Coclé, Veraguas) and dry habitats (Pacific Nicaragua).

Cultural contacts between the coast of Ecuador and various parts of the Pacific coast of Central America have existed since the Formative and are well documented (Lothrop 1926; Bushnell 1951; Meggers et al. 1965; Lathrap 1966; Paulsen 1971; Lathrap et al. 1976). It is likely that cultivated plants diffused at an early date along with ceramic and other artistic styles. Since I have suggested that Trujillo coca was grown at an early date in coastal Ecuador, it is possible that this variety diffused at an early date to drier areas in Central America such as the Nicoya Peninsula of Costa Rica and Pacific Nicaragua. West (1961) cited historical accounts that demonstrate the existence of large sea-going vessels that sailed between Manabí and the Pacific coast of Central America prior to the Conquest.

However, considering the close geographical proximity between Colombia and the areas of coca use in lower Central America, a gradual pattern of diffusion by land remains a strong possibility. If this were the case, Colombian coca would have been the variety that reached Central America. Since this variety has a wide ecological tolerance, it could have been grown in both dry and moist habitats from Panama to Nicaragua, with the exception of the wettest lowland areas.

Perhaps the most intriguing question in the northward diffusion of coca, whichever the variety employed, is why it did not reach still farther north into Mexico along with other cultigens of South American origin such as tobacco, achiote, and cacao. Antonil (1978) suggested that there was simply not enough time for such diffusion to take place prior to the cataclysmic disruptions caused by the arrival of the Europeans. However, this argument becomes untenable when we consider the antiquity of coca in Central America (over 1,000 years) and the fact that other cultigens did in fact reach Mexico.

One factor, a biological one, stands out, which may have limited the northward diffusion of coca, both in Central America and into the West Indies. The seeds of all varieties of cultivated coca are very short-lived and die of desiccation if they are not planted within one or two weeks of harvest. This feature has been pointed out as evidence for the origin of cultivated cocas from the montaña-adapted *E. coca* var. *coca*, since the seeds of most tropical forest species have no dormancy period or protection against desiccation (Plowman 1979a; Böhm et al. 1982). It would have been difficult to preserve the viability of coca seeds during long sea voyages. On the other hand, crops such as maize or tobacco have seeds that can be stored for longer periods and that easily could have survived such travels.

It is improbable, then, that coca could have made "quantum leaps" in spreading to distant areas. Instead, it could diffuse only at a much slower pace by being traded overland through tribe-to-tribe or village-to-village exchanges. This may explain, at least in part, the reticent extension of coca northward in Central America and its absence in the Greater Antilles.

156 Conclusion

Recent botanical studies on coca have redefined the earlier, simplistic view that coca consisted of a single species, *Erythroxylum coca*. Four distinct varieties of coca are now recognized, each of which occupies different geographical and ecological areas in South America. All four varieties were employed for coca chewing in the past, and archaeological evidence for coca use in many areas can now be assigned to a specific variety.

Erythroxylum coca var. *coca*, Huánuco coca, still occurs as a wild or feral plant in the east Andean montaña, where it continues to be a major cultivated crop. This variety was taken into cultivation at an early date, perhaps 7,000 years ago, and gradually diffused throughout the eastern Andes from Ecuador to Bolivia. *Erythroxylum coca* var. *ipadu*, Amazonian coca, is a closely related form that was domesticated in the western Amazon by tribes of the lowland tropical forest in relatively recent times.

Erythroxylum novogranatense var. *truxillense*, Trujillo coca, evolved from *E. coca* var. *coca* in response to attempts to grow coca in more arid environments. The area of origin of Trujillo coca is uncertain but it probably originated in the drier Andean valleys of northern Peru or southern Ecuador. Trujillo coca diffused to coastal Peru by at least 2,000 B.C. and was widely cultivated there at the time of the Conquest. Most archaeological coca remains found on the Peruvian coast belong to this variety.

Erythroxylum novogranatense var. *novogranatense*, Colombian coca, arose in the northern Andes from ancestral stocks of Trujillo coca. It first appears in the archaeological record during the first millennium A.D. and was extensively cultivated throughout Colombia and parts of Venezuela at the time of Conquest.

The earliest archaeological evidence for coca chewing comes from the Valdivia culture in coastal Ecuador, and it is believed that coca has been in use in Ecuador for at least 5,000 years. Subsequent discoveries show that the plant has a long and complex history in Ecuador. Both Huánuco and Trujillo coca have been found growing in Ecuador, but the pre-Columbian distribution of these varieties there is not known. The central geographical location and ecological and cultural diversity found in Ecuador indicate that this area played a key role in the early evolution and diffusion of coca.

Although earlier writers suggested that coca was used in the West Indies, there is no archaeological or credible historical evidence to substantiate this view. It is certain, however, that coca did reach Central America, at least as far north as Nicaragua, based on archaeological discoveries and historical records. We do not know what variety or varieties of coca were being cultivated in Central America, or to what extent coca was used by the native inhabitants. The slow diffusion of coca northward, when compared to other cultivated plants of South American origin, may be a result of the very short period of viability of the seeds of coca, which would not survive long sea journeys or inhospitable climates. This remains a subject for future inquiry.

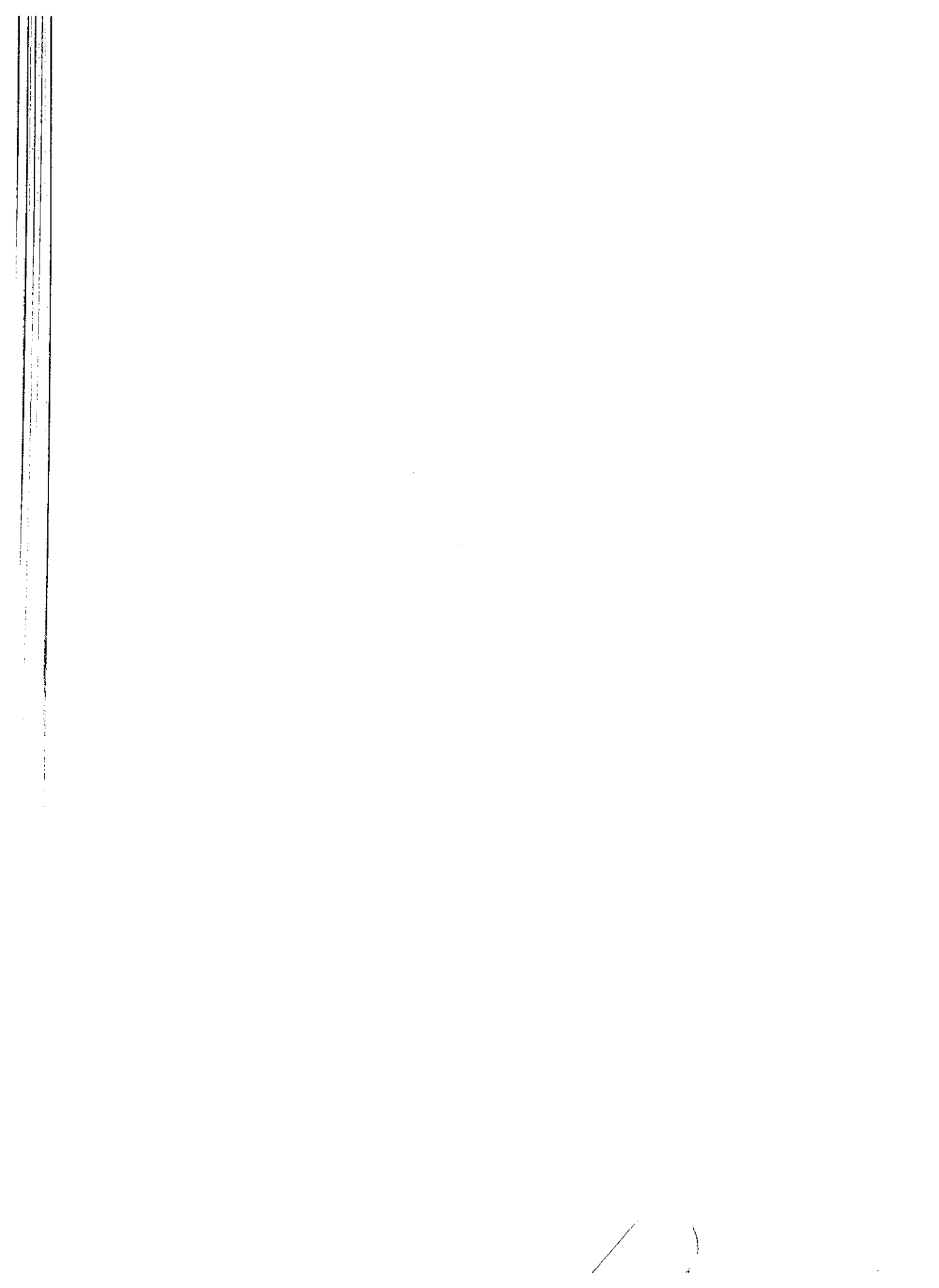
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