U.S. Department of Justice
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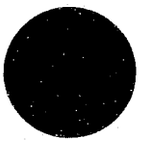

February 1991

Coca Cultivation and Cocaine Processing: An Overview

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Drug Enforcement Administration
Office of Intelligence
Strategic Intelligence Section
Latin America Unit

February 1991

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WARNING

Drug production, import/export, and consumption estimates contained herein may be preliminary and are not intended for use in testimony, speeches, or public dissemination. Data contained in the annual National Narcotics Intelligence Consumers Committee Report should be used for those purposes.

WARNING

Contents

Research for this report was completed in December, 1990.

Executive Summary

Two of the lesser understood aspects of the illicit cocaine traffic are the cultivation of the coca plant and the conversion of the coca leaf into cocaine hydrochloride (HCl). While the coca plant can be found throughout most of Latin America, varieties containing the cocaine alkaloid (the basis for cocaine HCl) are cultivated and converted primarily in Peru, Bolivia and Colombia.

There are two different species and several different varieties of coca plants which contain the cocaine alkaloid and these varieties prosper under quite different climatic conditions. At the same time, the methods used to cultivate and harvest coca leaf differ depending on climate, tradition, and other factors. The conversion of coca leaf into coca paste, cocaine base, and cocaine hydrochloride is also a varied process with many steps involved and many chemicals necessary.

The Coca Plant

It has been estimated that there are over 200 Erythroxylum species growing in the Western Hemisphere. Only 17 species can be utilized to produce cocaine. Fifteen of the 17 species contain relatively low levels of cocaine alkaloid and subsequently are not cultivated. In South America two species and two varieties within each of these species are cultivated. They are:

E. coca Species	E. novogranatense Species
var. coca	var. novogranatense
var. ipadu	var. truxillense

These varieties are traditionally cultivated in the areas identified in Table 1.

Table 1

Country	Variety
Bolivia	E. coca var. coca
Peru	E. coca var. coca, E. novogranatense var. truxillense, E. coca var. ipadu
Colombia	E. novogranatense var. novogranatense, E. coca var. ipadu, E. novogranatense var. truxillense

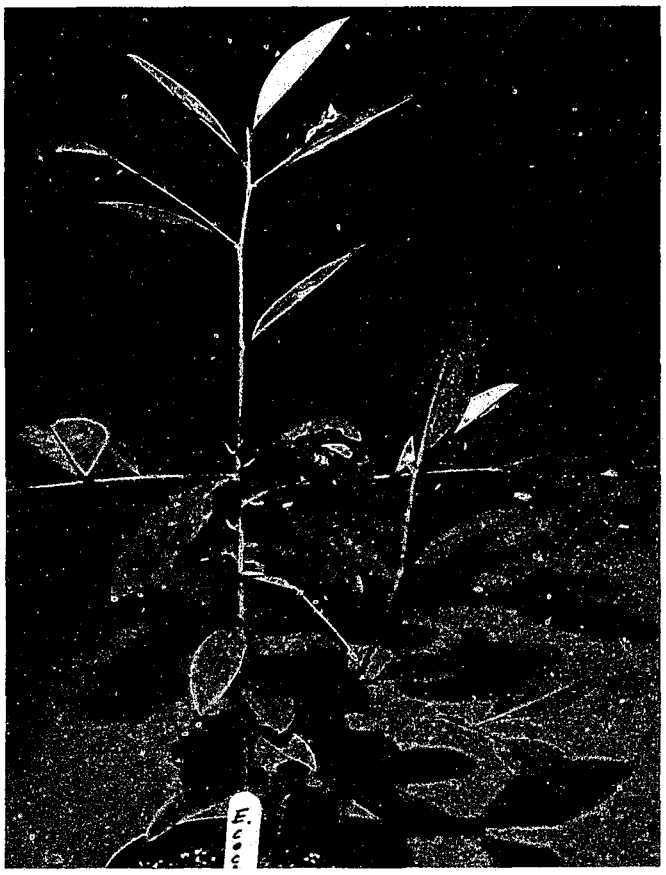
The most widely grown variety of coca is E. coca var. coca which is cultivated on the eastern slope of the Andes from Bolivia in the south to as far north as central Ecuador. This area of the Andes has a tropical climate and experiences high amounts of rainfall. Coca in this region is usually grown between 1,650 and 4,950 feet in elevation.

E. novogranatense var. novogranatense thrives in the drier regions of Colombia and, to a lesser extent, Venezuela. It is also grown at lower elevations where the climate is generally hotter. The main variety of E. novogranatense, var. truxillense, is grown up to an elevation of 4,950 feet. The last variety, E. coca var. ipadu, is found in southern Colombia, northeastern Peru, and western Brazil in the Amazon basin. E. coca var. ipadu is primarily cultivated by Indians for their own consumption and is not as high in cocaine alkaloids as the other three.

It is not an easy task, even for an expert, to readily distinguish between the different varieties of coca plants. One of the ways to identify the variety is to look at the leaves. Both varieties of E. coca (E. coca var. coca and E. coca var. ipadu) have broadly elliptic leaves. The leaf of var. ipadu has a rounded apex, whereas the apex of var. coca is more pointed. The leaf of var. coca is large, thick and dark green in color.

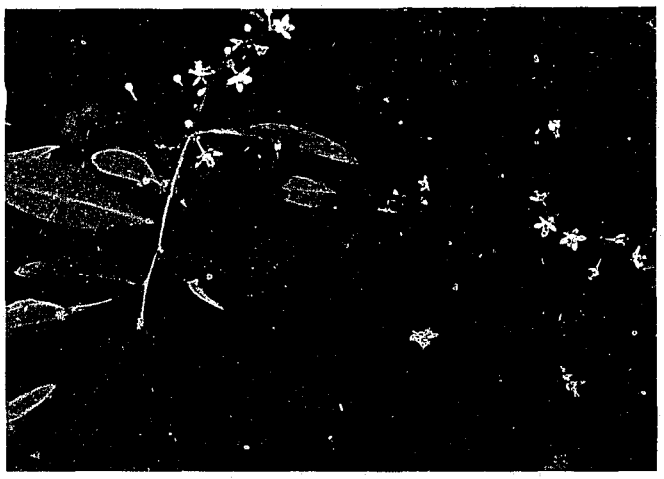
The leaf of E. novogranatense var. novogranatense is pale green with a rounded apex and is somewhat narrower and thinner than the leaf of var. ipadu and var. coca. E. novogranatense var. truxillense is very similar to var. novogranatense except that it does not possess the lines parallel to the central vein of the leaf that are characteristic to so many varieties of coca plant.

The cocaine alkaloid content of the E. coca and the E. novogranatense species also serves to distinguish between these species and the many other species of wild coca that grow in Latin America. These other species contain much lower levels of cocaine alkaloid. The usual cocaine alkaloid content of a sample of coca leaf material is between 0.1 and 0.8 percent. The cocaine alkaloid content can go much higher, however, as was shown in one sample of coca leaf from the Chapare region in Bolivia that measured 1.2 percent. Coca grown on the upper slopes of the Andes also contain more cocaine alkaloids than coca grown in low-lying areas. It is therefore believed that the best quality coca is grown at higher altitudes.



Erythroxylum coca var: coca.

Erythroxylum novogranatense var: novogranatense.



Erythroxylum coca var: truxillense.

Erythroxylum coca var: ipadu.

Cultivation

While methods of cultivating the coca plant are similar in many ways throughout Peru, Bolivia, and Colombia, there are differences in techniques because of terrain, tradition, and other factors.

Some coca plantations have been in existence for years. In other areas, however, such as Peru's Upper Huallaga Valley, new plantations are being established daily. A typical farmer who is preparing a field for coca will usually pick an area that slopes slightly so that water will not drown his plants. He will then begin clearing his field, normally by cutting trees and stumps and setting fire to the debris, a clearing method known as slash and burn. The felled trees are left in the field and the coca is simply planted around them. The farmer has no motivation to move the logs since there is no market for the timber. Logs are absent from the older fields because of rot or because the farmer gradually cleared his field.

Once the field is cleared for cultivation, the farmer can ready his crop for planting. The first step in cultivation generally begins with the seed. Seeds are usually gathered from December through March from plants ranging from two to three years in age. They are often poured into water at the onset to identify bad seeds, which will usually float to the top and are discarded.

The good seeds are planted in small plots that are kept shaded from the sun. Seeds are sown about two inches apart at a depth of approximately one half inch in humus-enriched soil. These seedbeds are kept well watered and weeded frequently and the seeds will usually germinate within 20 to 30 days. Sometimes the seeds are presoaked in water to hasten germination which will then occur in about ten days.

Seedlings usually reach transplanting size in about two months. At this age they are about 12 inches tall. While the measurements vary, seedlings generally are planted in holes about a foot deep and about one and-one-half feet from each other within rows about three feet apart.

Another popular method of establishing new fields of E. ipadu involves taking a cutting from an established coca bush and planting it in the ground. This method (cloning) is getting more popular as it gives the farmer a head start. There are two methods of planting a cutting. One involves sticking several branches a couple of feet long into the ground. The other method is to cut three or four inch cuttings from a branch, each one with protruding smaller branches. The cutting is soaked in water a day or so and then planted in loose, fertile soil. It is reported that coca leaf can be harvested from these plants within six months and seeds develop on these plants after one year but the seeds lack embryos and are not viable.

A coca plant cultivated from seed will generally reach full maturity and its leaves harvested between 12 and 24 months after being transplanted. Even though coca growing in the wild has been known to reach heights of up to 30 feet, that which is cultivated is almost always pruned back to facilitate harvesting the coca leaf. Cultivated fields are usually kept at a height of three to six feet. All picking of coca leaf is done by hand. Harvesters have to be very quick in their work yet careful not to damage the leaf buds on the bush while stripping off the leaves. Leaves are said to be ready for harvest when they take on a yellowish tint and have a tendency to crack when bent.

Coca leaf can be harvested between two and six times per year depending on climatic conditions. Coca growing at lower altitudes will usually be harvested more often than coca growing at higher altitudes. The most abundant harvest, sometimes accounting for about half of the total yearly harvest, takes place after the rains in March. Subsequent harvests take place in June/July and November, the normal dry season in South America. Some harvesting, however, takes place all year round.

When the leaves are harvested, they are put in sacks and taken to a closed room and spread out on the floor. The next day, the leaves are taken to a flat area, where they are spread in thin layers on a tarpaulin in direct sunlight and left to dry. If there is a lot of sunshine and minimal cloud cover, the drying phase can be completed in six hours. During inclement weather, it takes much longer because at the first sign of rain the leaves are gathered up and taken into shelter. If a load of coca leaves is caught by a rainstorm during drying, it could ruin the whole load. This is because the leaves will ferment if the moisture goes over 14 percent. This tends to cause a breakdown of the cocaine alkaloids.

After the drying phase is completed, the coca leaves are swept into large piles and left for about three days before being taken to market and/or processing facilities. The weight of packaged leaves varies from the 100 pound "carga" in the Bolivian Chapare, to the 25 pound "arroba" in Peru's Upper Huallaga Valley. In Colombia, coca leaves are not usually sold; however, when dried coca leaves are sold, it is usually in packages of 25 pounds.

Typical coca leaf drying area.

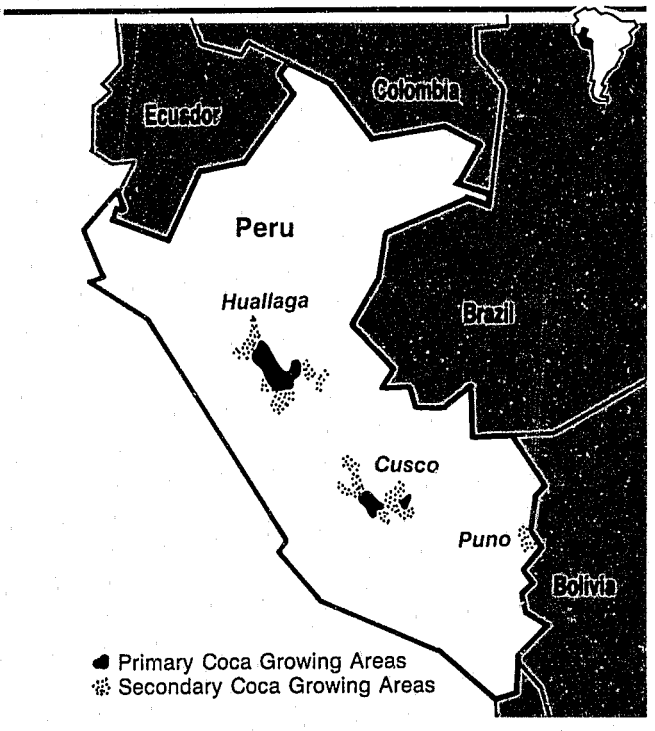
Peru

Peru, the world's largest source of coca, has both licit and illicit cultivation. Licit coca is cultivated by farmers registered with the National Coca Monopoly (ENACO). ENACO buys and sells it to retailers either for resale domestically, for chewing or for herbal tea, or for export to produce soft drink flavoring or pharmaceuticals. The 18,000 hectares that have been registered for licit coca cultivation are centered in the department of Cuzco.

Illicit coca cultivation occurs primarily in the Upper Huallaga Valley region of northern Peru including the departments of San Martin, Huanuco, and Ucayali. Other areas under cultivation include the valleys of La Convencion and Lares in the department of Cuzco, and the provinces of Huanta and La Mar along the Rio Apurimac in the department of Ayachucho. There are also smaller growing areas located in the departments of Puno and Pasco.

The Upper Huallaga Valley is a tropical area with a mild climate that receives an average of 12.44 feet of rain during the year. June through September is the dry season when the region gets very little rainfall. The mean annual temperature is 55 degrees Fahrenheit. Coca is usually grown here between 1,980 to 2,640 feet above sea level but is sometimes planted up to 6,270 feet in altitude. The soil in the Upper Huallaga Valley is well drained and rich in iron, an important element for all plant life.

The area surrounding Cuzco has an average rainfall of between 1.32 and 5.94 feet annually which usually falls between the months of October and April. The average temperatures in this region are greater than 53 degrees Fahrenheit. Coca is generally grown between 2,409 and 4,257 feet above sea level. The soil is especially poor in iron content.



A semi-tropical climate with warm days and abundant rain fall, between 6.6 and 7.26 feet per annum, characterizes the Ayacucho area. Coca is usually grown on steep slopes which require terracing at an elevation of between 1,650 and 4,290 feet. Soils in this area are red and high in iron.

Bolivia

Bolivia is the world's second largest source of coca leaf. There is both licit and illicit coca cultivation occurring in this country as well. In mid-1988, a law became effective that made coca cultivation illegal in most of the country. The law also established legal, transitional, and illegal zones of cultivation and declared that 12,000 hectares of coca would be the amount grown to meet the traditional demand for coca.

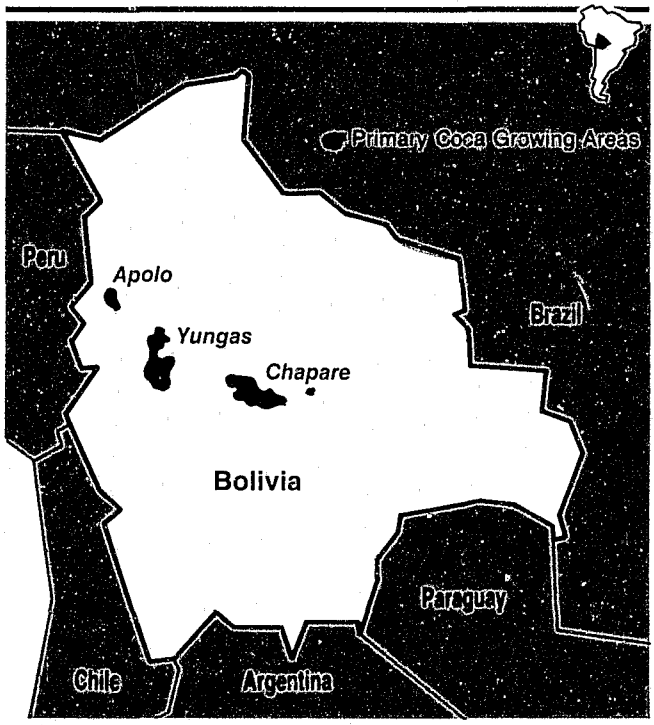
There are roughly three main growing areas in Bolivia. The three areas are the Yungas de La Paz, the Chapare, and the Apolo. Coca cultivation in the Yungas de La Paz is located between the cities of Guanay and Inquisivi, northeast of La Paz on the eastern slope of the Andes. Cultivation in the Chapare occurs in the provinces of Carrasco, Chapare, and Arani in the department of Cochabamba, east of La Paz. The small area of Apolo is in the La Paz department north of the city of La Paz.

Nearly all the licit coca is grown in the traditional growing areas of the Yungas. The overwhelming amount of illicit coca is grown in the Chapare where it is estimated that about 75 percent of the country's coca crop is cultivated. The amount of coca grown in the Apolo is much less than in either of the two other areas.

Parts of the Yungas have been cultivated for hundreds of years. Coca is planted at between 4,800 and 6,000 feet in altitude on terraced fields, generally on steep slopes. Some of these fields have a slope of more than 45 degrees. The Yungas is characterized by a five-month rainy season that runs from December to April receiving about 4 feet of rainfall per year, followed by seven dry months. The soil content is poor, and this area has suffered severe erosion problems.

In the Chapare, the weather is continually wet and warm, with an annual rainfall averaging around 13 feet. The growing areas in this region are broad, low plains containing some hills. Coca is cultivated at between 660 and 1,650 feet above sea level where the temperature averages around 57 degrees Fahrenheit. The soil is clay based, rich alluvial (sediment deposited by flowing water).

Bolivia

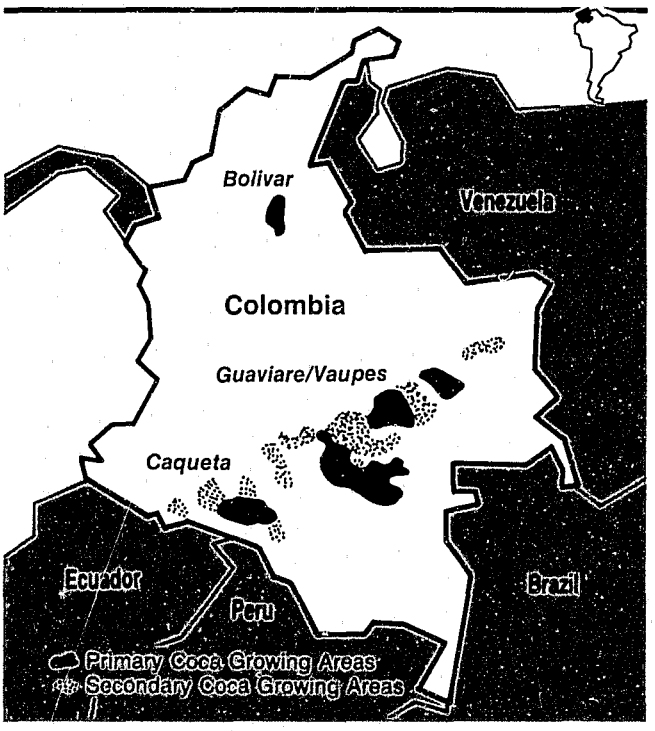


The Apolo, located in La Paz department, is also a noteworthy coca-growing region of Bolivia. Coca in the Apolo region is often interplanted with coffee, a major crop in the area. Soil in the Apolo is not suited very well to coca; the longevity of a coca bush there is only from five to eight years. Coca plants in the Apolo are therefore constantly replaced.

Colombia

Colombia ranks third in worldwide coca leaf production with all cultivation being illicit. There is widespread cultivation in the eastern plains region of the Llanos which encompasses about one-half of Colombia. The heaviest areas of cultivation are located in the departments of Putumayo, Caqueta, Guaviare, and Vaupes. There is substantial expansion of the coca crop in the Bolivar department in the north-central area of Colombia as well as areas of cultivation in the south and southwest part of the country.

In the southern coca-growing region, the temperature averages between 49.5 and 52 degrees Fahrenheit and there is light rainfall. Coca is normally grown between 3,300 and 6,600 feet above sea level. The soil in this region is iron rich; however, there is some erosion.



Cocaine Processing

The conversion of coca leaves to coca paste, cocaine base, and cocaine hydrochloride occurs primarily in Bolivia, Colombia, and Peru. Peru and Bolivia are the primary locations for the conversion of leaf to coca paste and cocaine base, while Colombia is the primary location for the final conversion to cocaine hydrochloride. It is believed that both Peruvian and Bolivian traffickers have begun increasing their production of HCl in the last few years.

There are a number of chemicals and solvents which play vital roles in the processing of coca leaves to paste, base and HCl. Many of these chemicals are quite common; all are theoretically substitutable and all have legitimate uses making them difficult to control. These chemicals and solvents, along with their substitutes, are identified in Table 2. Also identified are the processing steps in which they are utilized.

Table 2

Step	Chemical	Substitute
Coca Leaves To Coca Paste	Kerosene, Sulfuric Acid, Sodium Bicarbonate	Gasoline, Benzene, Hydrochloric Acid, Sodium Hydroxide
Coca Paste to Cocaine Base	Sulfuric Acid, Potassium Permanganate, Ammonia Hydroxide	Hydrochloric Acid, Potassium Dichromate, Sodium Hydroxide
Cocaine Base to Cocaine Hydrochloride	Ethyl Ether, Acetone, Hydrochloride Acid	Chloroform, Methyl Ethyl Ketone, Hydrogen Chloride Gas

Coca processing can be broken down into three stages. The first is the conversion of the coca leaf into coca paste; this is almost always done very close to the coca fields to cut down on the transport of the coca leaves. The second phase is the conversion of coca paste into cocaine base. This step is usually omitted in Colombia and the process is taken straight through from paste to cocaine HCl. The final stage is conversion of base to HCl.

Coca paste pit.

Coca Leaves to Coca Paste

The conversion of coca leaf into coca paste is accomplished in a coca paste pit, or "pozo." A typical coca paste pit is a very crude structure located near the harvesting site and consists of only a very few items. Some paste pits have even been reported in peasants' houses. The paste pit is usually a hole in the ground, lined with thick, heavy plastic, or may even be a 55-gallon drum with the top cut out. Paste pits are often located near streams so that the processors will have a constant supply of fresh water, which is used in the first stage of processing. The process of converting leaves to paste usually takes a few days. Often, however, the leaves will be "worked" or "stomped" for only a few hours rendering less paste than if "worked" for several days. It is apparently sometimes more desirable to move the paste out than to get more paste per kilogram of coca leaf. Depending on the size of the pit and the amount of leaf, the whole process will require the energy of two to five workers.

The following recipe for coca paste is but one of many. Recipes will differ depending on where the laboratory is located. Some will opt not to use water in the first step and amounts and mixing times vary widely. However, this remains a good benchmark formula.

Step 1

The coca leaves are put in an above-ground container or in a plastic lined pit. An alkaline material (sodium carbonate) and water are added to the leaves. Here the alkaline material enables the cocaine alkaloid present in the leaf to be extracted into kerosene.

Step 2

A water immiscible solvent (kerosene) is added to water, solution, and leaves. The mixture is then agitated. Usually this is accomplished by having several people stomp on the leaves. The solvent acts to extract water-insoluble cocaine alkaloids from the alkaline solution.

Step 3

Cocaine alkaloids and kerosene separate from water and leaves. The water and leaves are then drained off.

Step 4

Cocaine alkaloids are extracted from the kerosene into a dilute acid solution. Alkaline material (sodium carbonate) is added to the remaining solution which causes a precipitate to form. The acid and the water are drained off and the precipitate is filtered and dried to produce coca paste, a chunky, off-white to light brown, putty-like substance.

Coca Paste to Cocaine Base

The processing of coca paste into cocaine base is more complicated than paste production, requiring more sophisticated equipment and added skills. Cocaine base can be processed at the paste facility, but base laboratories may be located away from the cultivation zones. Usually the base laboratories are located near rivers or have a clandestine airstrip located in the vicinity to facilitate both the movement of coca paste into the base laboratory, but also the movement of cocaine base to cocaine HCl laboratories.

As with the paste recipes, the base recipes have many versions. This one is one of the more common and a continuation of the paste recipe.

Step 1

The coca paste is added to sulfuric acid or hydrochloric acid and water. The paste is dissolved into the acid solution.

Step 2

Potassium permanganate is combined with water. This mixture is added to the coca paste and acid solution. Potassium permanganate is used in this step to extract other alkaloids and material that is undesired in the final product. In particular, potassium permanganate is used to break down the alkaloid ciscinnamoylcocaine found in large concentrations in E. novogranatense varieties. If the coca paste has a high concentration of this alkaloid and potassium permanganate is not used, then crystallization of cocaine HCl will be very difficult.

Step 3

This mixture is allowed to stand for about six hours.

Step 4

The solution is filtered and the precipitate is discarded. Ammonia water is added to the filtered solution and another precipitate is formed.

Step 5

The liquid is drained from the solution and the remaining precipitate is usually dried with heating lamps. The resulting powder is cocaine base.

It is common in Colombia to skip the base stage of cocaine processing and go right from coca paste to cocaine HCl. This can be accomplished by eliminating the last part of step number four in coca paste processing and skipping to step number two of the cocaine base phase where the coca paste is added to the potassium permanganate solution.

Cocaine Base to Cocaine Hydrochloride (HCl)

The final stage of cocaine processing requires even more skill and equipment, and is much more dangerous than the previously mentioned steps. Unlike paste and base processing, cocaine HCl processing calls for expensive chemicals that are harder to find and often not manufactured in the processing country.

The HCl laboratory usually consists of several buildings including dormitories, eating facilities, an office, storage facilities, and the laboratory itself. Also usually found at HCl laboratories are communications operations, generators, filtering and drying equipment, and, more recently, chemical recycling facilities. The HCl laboratory will sometimes have direct access to an airstrip.

The following recipe is a continuation of the above two. At this point the methods of processing vary only slightly.

Step 1

Acetone or ether is added to dissolve the cocaine base and the solution is filtered to remove undesired material.

Step 2

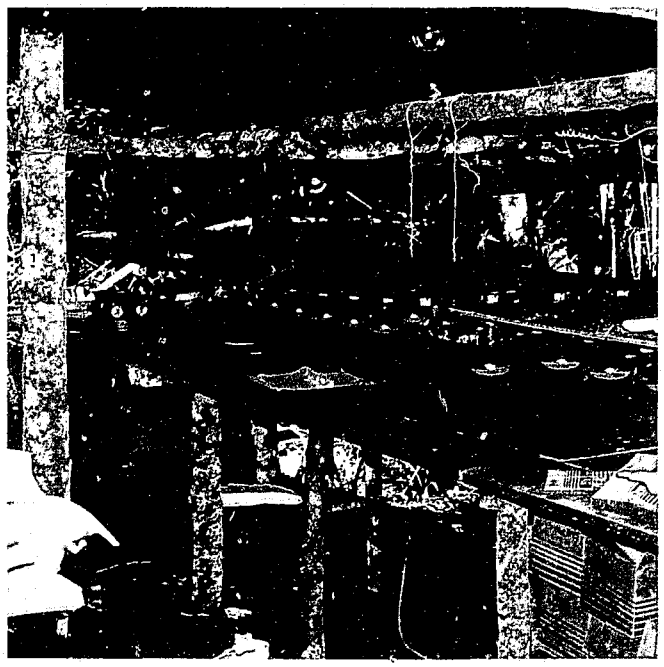
Hydrochloric acid diluted in acetone or ether is added to the cocaine solution. The addition of the hydrochloric acid causes the cocaine to precipitate (crystallize) out of the solution as cocaine hydrochloride.

Step 3

The remaining acetone/ether solvent can be discarded or reused.

Step 4

Cocaine HCl is dried under heat lamps, laid out to dry with the aid of fans, or dried in microwave ovens.

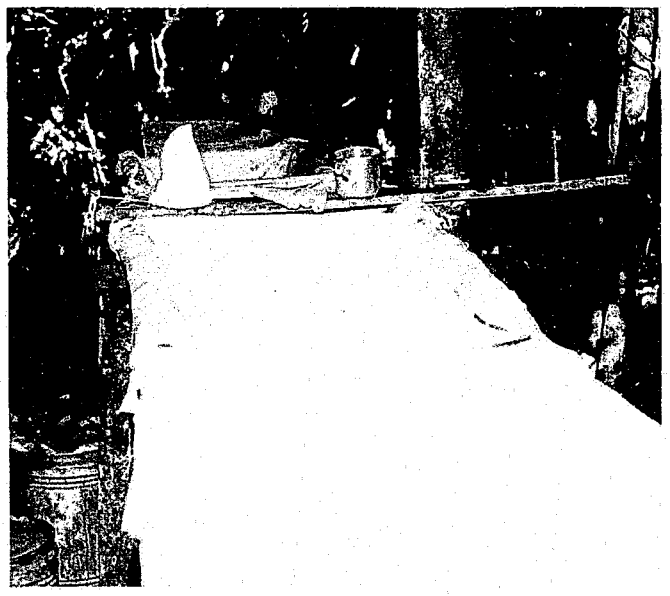


Interior view of HCl lab showing drying tables and heat lamps.

Chemical containers discarded near an HCl lab.

Ether and acetone containers seized in a raid on an HCl lab.

View of an HCl lab showing filtering tables.

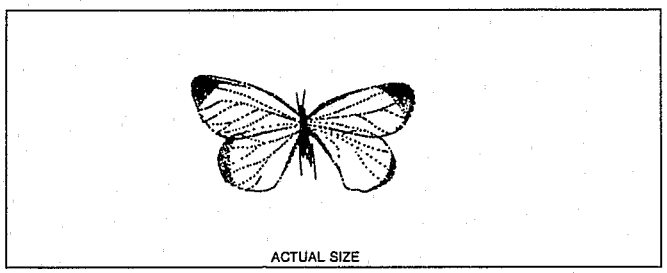


Natural Enemies and Eradication Efforts

Although the coca bush is a very strong plant and will live for many years and produce many harvests of leaf, it will do better if taken care of, fertilized, and treated with herbicides and insecticides.

Occasionally, a coca field will become infested with one of the plant's natural enemies. The main pests and the effect that they are known to have on the plant are discussed below.

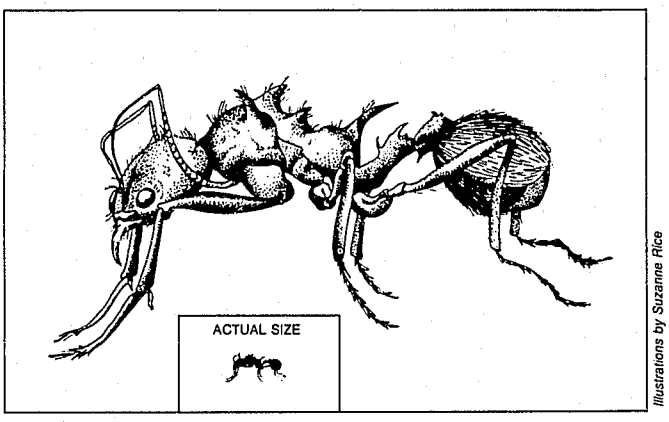
The larvae of the moth Eloria Noyesi presents the most serious threat to the coca plant. This moth lives through out the coca-growing region of South America and seems to feed almost exclusively on E. coca. It has also been recorded feeding on E. novogranatense in Colombia and northern Peru. The larva will develop in about a month and will eat up to 50 leaves in its lifetime. The larva will also eat the shoots of the bush that grow out after harvest. If Eloria attacks a plant repeatedly, even a strong plant will die. The moth is usually only abundant from December to April. Coca growers are using insecticides to eradicate Eloria.



Adult moth, *Eloria Noyesi.*

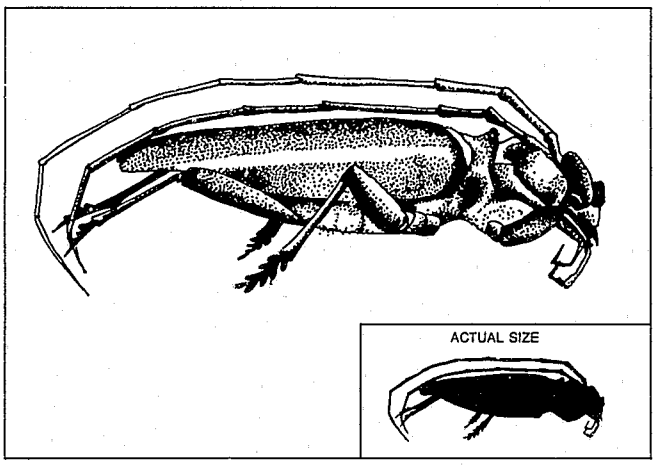
The larvae of Eucleodora Coca, a fly, seems to cause harm only to Trujillo coca. (There have been major infestations of this insect in the past usually occuring from April to August.) The larvae spend their entire lives on the plant, feeding on the leaves and shoots. As with the Eloria, Eucleodora is being controlled with insecticides.

Very little is known about the effect of the leaf-cutting ant, Acromyrmex, on coca. Growers in the Upper Huallaga Valley report that serious damage in the past has been done to their coca cultivation. The damage is often controlled with the use of insecticides and flooding.



Ant, *Acromyrmex.*

The beetle, Aegoidus Pacificus, also poses a threat to Trujillo coca. The adult beetle lays her eggs in the bark of the coca plant, and the larva later burrows into the stem of the plant. This usually results in an infestation of pathogenic fungi which is ultimately responsible for the death of the coca plant. As with the other pests, the beetle can also be controlled with insecticides.



Adult beetle, *Aegoidus Pacificus.*

Most of the other insects which attack coca only do so when there are shortages of their normal food supply. Some scientists believe that cocaine and other alkaloids may present some natural defense against most pests. Nevertheless, sometimes insects such as spider mites, grasshoppers, leafhoppers, and beetles find it necessary to eat coca.

The coca plant is also susceptible to numerous species of pathogenic fungi. Fungi seem to present the greatest threat to a plant during the wet season. The most serious threat seems to come from a fungus called "witches broom." The exact effect of this fungus on the coca plant is not clear because of the limited amount of study which has been done on this fungus infesting coca plantations.

Natural enemies hold hope for control of the coca plant in the future. At present, however, the most successful methods in controlling the growth of coca are herbicides and manual eradication.

As of early 1990, all eradication of the coca plant in Bolivia and Colombia was being done manually. The usual method has been for a team of eradication workers to go into a field and pull up the bushes plant by plant. In Peru, manual eradication of coca is often suspended because of security reasons. Prior to that time, a number of gasoline-powered cutters had been supplied to the workers making it easier and much quicker to cut the coca. The problem with this method is that sometimes the coca bush will sprout from the stump within 12 to 18 months. As such, the cutting must be made very close to the ground to insure that the plant does not sprout again.

A number of herbicides have been tested for use in eradicating the coca plant including hexazinone and tebuthiuron (spike). Application of both has been deemed successful in killing the plant as long as they are applied in the correct manner and amount. Within ten to twenty days after application of hexazinone or tebuthiuron the coca bush sheds all its leaves and usually within 60 to 90 days the coca plant will be completely dead.

The United States is working with some South American governments to develop an herbicidal eradication program; Bolivia, however, has prohibited the use of herbicides for this purpose.

Notes

Distribution

DEA Headquarters
DEA Field Offices
DEA Laboratories
EPIC

The White House
National Security Council
Office of National Drug Control Policy

Department of Justice
Federal Bureau of Investigation / DIU
Federal Bureau of Prisons
Immigration and Naturalization Service
Organized Crime Drug Enforcement Task Forces
U.S. Marshals Service

Department of Treasury
Bureau of Alcohol, Tobacco and Firearms
Internal Revenue Service
U.S. Customs
U.S. Secret Service
Financial Crimes Enforcement Network

Department of Defense
Defense Intelligence Agency

Central Intelligence Agency / CNC
National Security Agency

Department of State

U.S. Coast Guard

State and Local Law Enforcement