Coca Leaf Use in Southern Peru: Some Biosocial Aspects

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The use of coca leaves in the Andean region has usually been condemned as a simple addiction to cocaine. This paper summarizes a series of studies in the southern Andes which consider the biological and economic motivations of the users. It is suggested that consumption of leaves is limited to avoid the undesirable effects of large doses of cocaine, while the smaller doses received are beneficial in certain aspects of the arduous life at high altitude. The persistence of the practice is viewed in terms of economics. It is concluded that coca plays a role in Andean life which is not related to simple addictive properties.

THE PRACTICE of chewing coca leaves is widespread in the Andean regions of South America. Quechua, Aymara, and other highland peoples prize the leaves of Erythroxylum coca for the powers they are believed to possess. Indians and non-Indian visitors have claimed prodigious feats of labor are accomplished with the aid of coca (Mortimer 1901). In contemporary Indian society coca serves in shamanistic activities, in divination, and in sacrifice (LaBarre 1948; Martin 1970). It also plays an important role in folk medicine where it is prescribed for pain resulting from broken bones, sores, infections, and respiratory malfunctions. This prescription may be more than accidental because coca leaves contain cocaine which is a powerful local anesthetic. The use of the leaves and perhaps the associated mythology have existed for at least four millennia (Lanning 1967:77) and are prominently represented in pre-contact cultures (Martin 1970:424).

Coca chewing somewhat resembles tobacco chewing. A wad of leaves is placed into the mouth and chewed until a compact quid is formed. The quid is then placed in one cheek and periodically rechewed. Unlike tobacco, coca leaves are chewed with a bit of alkali (llipta) which users claim "sweetens" the quid. The juice and up to 70% of the leaves may be swallowed (Cuiffardi 1949). Coca leaves contain a number of alkaloids, among which cocaine is present in greatest quantities. Extraction of this narcotic is most efficient; Cuiffardi estimated that 80% of the cocaine in the leaves is removed by chewing. There is also experimental evidence which suggests that coca leaf chewing produces cocaine-like physiological and psychological changes. Coca users have been reported to show a general physiological stimulation after chewing for about an hour (Zapata Ortiz 1944:159; Risemberg 1944:327; Chambochumbi 1949:96). As a result, coca leaf chewing and cocaine addiction have been equated (Wolff 1952).

From an ecological viewpoint, coca leaf chewing, then, is of considerable interest. On the one hand, the almost universal use of cocaine—or a drug with cocaine-like effects—would seem incompatible with cultural stability because of the insatiable desire and paranoia that
cocaine produces in addicts (Traunt and Takman 1965). On the other hand, Andean cultures have been ecologically stable for several centuries (Baker 1966) and, superficially at least, the Indians do not seem to show symptoms of cocaine addiction outside the laboratory (Monge 1952). The purpose of this paper is to explore some biological and cultural consequences of coca use at high altitudes and to describe those aspects which may perpetuate its use in a high altitude environment.

PREVIOUS LABORATORY STUDIES

In 1944, Zapata Ortúz reported that responses to coca leaf chewing by habitual users were similar to those produced by cocaine. Coca leaves, in 50 to 90 gm doses, produced increases in oral temperature, heart rate, blood pressure, and respiration rate. There were also psychomotor and psychological changes. The most pronounced was hyperactivity which led to increased metabolism, reminiscent of the effects of cocaine ingestion (Herbst and Schellenberg 1931). Zapata Ortúz (1944:159) also found retardation in reaction time because “coca produces in the user a greater mental activity, principally fantasies which favor distraction.” Habitual users experienced severe withdrawal symptoms, including “general distress, sensations of cold, constipation and vomiting and diarrhea.” About the same time, Risemberg (1944) also administered 80 to 100 gm of coca leaves to eighteen habitual users and reported similar results. There were small increases in temperature, heart rate, blood pressure (chiefly systolic), as well as an increase in metabolic rate. Again, doses of cocaine were administered and the same results were observed. Chambochumbi (1949) studied the effects of alkali and acid on coca leaf responses and established that the llipta was required for a maximum effect. He administered 20 gm of leaves (with no alkali) in four hours and found a smaller change in temperature, pulse, and respiration. He also studied the effects of masticating unsweetened chewing gum and reported no measurable change in temperature, pulse, or respiration. The sum of these experiments suggests that coca use and cocaine use are similar in physiological effects, psychomotor performance, and psychological consequences.

These conclusions were also supported by Cuiffardi (1948) who analyzed thirty-three quids from habitual users and found mastication effective in releasing the alkaloids contained in the leaves. About 86% of the total alkaloids were extracted from the leaves, of which about 80% was cocaine. The smallest quantity of cocaine removed was 64 mg, and the average of the 64 quids was 112 mg. The latter quantity exceeds the recommended maximum single dose for local anesthetic effects by some 12 mg (Traunt and Takman 1965). These values are for a single quid, but habitual users may chew four to six times per day. Although this represents a potentially large dose of cocaine, the amount producing activity may be smaller, for only that absorbed through the oral mucosa is thought to be effective, the rest being hydrolyzed in the gastrointestinal tract (Montesinos 1965:13). Llipta did not change the efficiency of extraction, but it may influence absorption. Because the responses observed in the laboratory are similar to those produced by cocaine (Herbst and Schellenberg 1931), and because potentially large quantities of cocaine are available, cocaine has been interpreted as the stimulatory factor in coca leaves.

OBSERVATIONS OF COCA USE AT HIGH ALTITUDES

Profound behavioral and physiological modifications resulting from coca use are not reported by those who have observed native coca chewers at high altitude (and outside of the laboratory). Monge (1952) noted that there are no overt symptoms among native coca users; there is no withdrawal and the habit is easily abandoned. He thought that coca use is
tied to the necessities of life at high altitudes. Mortimer (1901), Cárdenas (1952), and Slutes (1963) also reported that coca is harmless and produces no profound observable changes when used by Indians living at high altitudes. During two years' residence in the high altitude regions of Peru, the author did not observe any changes in behavior of native coca users in a variety of situations. I can also confirm Monge's claims that the practice is readily abandoned even by habitual users. During several instances when I chewed it, coca failed to produce any “fantasies or distractions.”

Despite the apparent absence of overt responses to coca use at high altitude, there is a striking relationship between coca use and altitude. At 15,000 feet coca use is nearly universal, at 8000 feet it is rare, and at sea level it is practically nonexistent (Monge 1952). Recent observations by Buck, Sasaki, and Anderson (1968:99) confirm this. In a survey of four Peruvian villages, the following percentages of the adult population were found to use coca: 72% at 11,500 feet, 28% at 5600 feet, 29% at 3500 feet, and 3% at sea level. There is not an absolute or universal relationship, for some high altitude groups do not chew coca while some coastal and Amazonian groups do (Cárdenas 1952:8). Still, considering Peru in terms of political subdivision, the relationship is strong. The two departments which are highest and coldest have the greatest coca consumption, while several warmer sea level departments have the lowest consumption (Gutiérrez-Noriega 1949a). In the absence of definitive evidence, the relation of coca use to altitude has been variously interpreted. Monge (1952) thinks that the hard life at high altitudes favors the use of coca, while Gutiérrez-Noriega (1949a) contends it is simply the proximity of coca plantations that promote its use. The claims of habitual users are that coca reduces hunger, enhances working ability, and promotes a feeling of warmth in the cold (Mortimer 1901; Little 1970:236). So strongly do the Indians believe this that they chew more coca during the cold season (Little op. cit.) and may refuse to perform manual work without it (Stein 1961:169). Since coca use is typically confined to lower classes who do most of the physical labor, experience the greatest cold exposure, and live under the most marginal nutritional conditions, the attribution of such powers may not be purely coincidental. To further confuse the situation, Indian users at higher altitudes are living within an aboriginal culture, while those living in cities have become at least partially acculturated and use coca only infrequently if at all. Therefore, it might be argued that culture, not altitude, is the driving force behind the continuation of coca chewing in the Andes. Thus, there are two views of coca leaf chewing. In the laboratory, coca leaf chewing may produce modification in resting physiological functions and may lead to behavioral modification, but these responses are not apparent during normal consumption at high altitude. In short, coca leaf chewing is generally restricted to a high altitude environment where the rigors of life under biological stress or life within an aboriginal Indian culture—or perhaps both—may favor its continuation.

COCA USE IN NUÑOA

The studies and observations to be dealt with here were undertaken in the town of Nuñoa in southern Peru. Numerous studies have described the town and its environment and have examined some biological and cultural aspects of life in the area (Baker 1969, 1966; Baker et al. 1967).

The quantity of coca leaves normally used by habitual users at altitude has been estimated frequently but seldom measured. The daily consumption of habitual users was estimated by Gutiérrez-Noriega (1949b:146) at 20 to 50 gm and Buck, Sasaki, and Andersen (1968:99) reported 35 to 50 gm per day. Cuiffardi found a single quid to contain 15 to 62 gm, with a mean of 35 gm. He also noted that chewing occurred four to six times per day. This yields a daily consumption of 140 to 210 gm, far in excess of other estimates. Since
Cuiffardi was using quids collected in the field, these values may include water. The author does not make this clear. Baker and Mazess surveyed thirty-nine households in the Nuñoa region and found daily consumption to be 25 to 75 gm. They also observed *llipta* consumption to be 2 to 4 gm per day (Baker and Mazess 1963:1466). The average estimate then, is somewhat less than 50 gm per day.

The initial study in Nuñoa was undertaken to estimate the daily consumption by habitual users. It was determined that the quantity used per day was similar to that reported by others, but considerably less than had been typically given in the sea level laboratory studies. During a dietary study, families with members who habitually used coca leaves were given one plastic bag containing 50 gm of leaves for each member who was an habitual user. In addition, each was given a bit of *llipta* that had been weighed. They were instructed to chew only as much as they normally used and extra bags were available upon request. The next day the bags were collected and the remaining coca leaves and *llipta* weighed. The average daily coca consumption of the twenty-two participants is noted in Table I.

| TABLE I. DAILY COCA LEAF LLIPTA CONSUMPTION IN TEN FAMILIES RESIDENT IN NUNOHA |
|---------------------------------|---------------------------------|
| Male Mean                       | Female Mean                     |
| N                               | 10                              | 12 |
| Age (yr)                        | 39                              | 40 |
| Ht (cm)                         | 151                             | 115 |
| Wt (kg)                         | 51                              | 45 |
| Coca (g/day)                    | 62.5                            | 54.1 |
| Llipta (g/day)                  | 5.9                             | 6.4 |
| S.D.                            | 19                              | 18 |
|                                 | 10                              | 4  |
|                                 | 10                              | 8  |
|                                 | 23.2                            | 23.3 |
|                                 | 4.2                             | 4.6 |

The mean daily coca consumption was 58 gm per adult with men chewing slightly more than women. There is some danger that this is an overestimate (the subjects taking advantage of free coca) but the quantity is within the range reported by Baker and Mazess (1963) for the same area. The weight of the *llipta* consumed was slightly higher than that observed by Baker and Mazess.

Because this is considered average coca consumption in the Nuñoa area, it is informative to estimate the amount of cocaine potentially involved. Cuiffardi (1948) found that 30 gm of coca leaves contained an average of 181.5 mg alkaloids, of which 86% was extracted through chewing. Of this, 80% was cocaine. Hence, in the present study, the total cocaine available should have been about 250 mg. This is more than double the recommended dosage for local anesthetic effects and borders on lethality (Traunt and Takman 1965). The total cocaine available thus should be adequate to produce some physiological responses. Because the potential dose level is adequate to produce some response, the following experiment was undertaken.

From a group of twenty applicants exhibiting varying degrees of coca addiction, six habitually heavy users and five nonusers (less than once per week) were selected. Each group chewed coca for a full day and abstained on another. Order of presentation was alternated—half of the subjects abstained from use on the first day, and the other half chewed coca on the first day. On their coca chewing days, habitual users were given any quantity of coca that they requested while nonhabitual users were given 50 gm and were...
Hanna]

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requested to chew all of it. Llipta was given to be used with coca. During a noncoca day, three of the habitual users remained in the laboratory overnight to assure that they did not chew. Three nonhabitual and four habitual users were retested both with and without coca. Thus, there was a total of eighteen trials equally divided between habitual and nonhabitual users.

One day after coca was given (or after abstaining from its use) the subjects reported to the laboratory. They were asked to sit quietly for an hour during which they continued to chew coca if it was their day to do so. At the end of the hour they were conducted to an experimental room and sat quietly upon a bicycle ergometer for ten minutes after which oxygen intake, heart rate, and blood pressure were measured. Table II presents the results of these measurements.

None of the differences between coca and noncoca trials is statistically significant in either the user or nonuser category. The limited response to coca use is thus in contrast with that described in the sea level laboratory work. Furthermore, none of the subjects reported fantasies or other psychological disturbances. Disequilibrium, which characterizes cocaine use and which has been reported for coca use (Zapata Ortíz 1944:159), was not observed although simply sitting on a bicycle ergometer requires some balance. None of the habitual users manifested or reported any withdrawal symptoms such as have previously been described. Thus in this study there were no overt responses to coca use when chewed in these quantities.

The frequent intake of small quantities instead of a single large dose may reduce overt responses. The earlier laboratory studies typically employed larger quantities at one sitting.

Table II. Responses of Habitual and Nonhabitual Coca Users After 24 Hours of Chewing or Abstaining From Coca

<table>
<thead>
<tr>
<th></th>
<th>Habitual</th>
<th>Nonhabitual</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Retests</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>30</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>With</td>
<td>Without</td>
</tr>
<tr>
<td>$\dot{V}_O_2$ (1/min)$^{1,2}$</td>
<td>.31 (0.1)*</td>
<td>.32 (.01)</td>
</tr>
<tr>
<td>HR (f/min)</td>
<td>81 (12)</td>
<td>80 (10)</td>
</tr>
<tr>
<td>Systolic (mm)</td>
<td>119 (9)</td>
<td>122 (14)</td>
</tr>
<tr>
<td>Diastolic (mm)</td>
<td>83 (6)</td>
<td>83 (10)</td>
</tr>
</tbody>
</table>

1 $\dot{V}_O_2$ is oxygen intake per minute; HR is heart rate; systolic and diastolic are blood pressure measurements.
2 None of the group differences is statistically significant.
* Means and Standard Deviations are Indicated.
(up to 100 gm), perhaps accounting for the more pronounced responses. By chewing coca in small quantities, Nuñoa residents may avoid its undesirable side effects. It is easily imagined that elevated metabolism and hyperactivity from a large dose would increase dietary food requirements while fantasies or other cocaine-like psychological and physiological phenomena would be undesirable to the community at large. The ingestion of small, readily metabolized quantities of cocaine may also avoid habituation.

**Coca Use as a Response to Environmental Stress**

Because coca had little measurable effect on resting subjects, the benefits claimed by habitual users were considered. In the Andes two of the most pervasive environmental stresses are low oxygen tension and low temperatures. Coca is reputed to be helpful in both areas.

Limited oxygen availability could become serious during work and could impose considerable stress. It is during this period that coca users claim benefits from chewing coca leaves. To determine if there may be a physiological basis for these claims, the following experiments were undertaken. They have been discussed in detail elsewhere (Hanna 1971a), and thus will only be summarized here.

Seven nonusers and five habitual users were asked to perform an exercise test. Of these, one nonuser and three users were tested twice, thus, when added to the original twelve subjects, there was a new total of sixteen "subjects." The sixteen were evenly divided between habitual and nonusers. They were tested after one hour’s rest on two days; one day not using coca, the other day using it (any desired quantity for users, about 50 gm for nonusers).

Exercise was performed on a Monark bicycle ergometer. The test was progressive, consisting of three minutes of effort at each of four increasing work loads. The final load was about 80% of maximal effort. Three subjects did not complete all four levels so that the basic statistical analysis was computed only over levels one to three. Variables considered were oxygen intake, ventilation, heart rate, and blood pressure.

Blood pressure and ventilation did not differ statistically between trials when tested with an analysis of variance. Oxygen consumption and heart rates are presented in Figure 1.

Oxygen intake was not greatly influenced, analysis of variance over the first three levels showing no statistical difference between the trials. This is of interest because it suggests that coca use did not modify working efficiency nor did it change the energy requirement for a given task. Heart rates also illustrated in Figure 1 are statistically different between trials (.01 < p < .05). While this should have little influence upon actual work performance, it is possibly indicative of some underlying stimulatory effect such as is generally attributed to cocaine (Traunt and Takman 1965).

The data from coca use trials were broken into two groups based upon five subjects who were habitual chewers (four individual subjects and one retest) and the five nonusers who most closely matched them in height and weight. A multiway analysis of variance was performed on these ten subjects and a portion of the resulting table is presented in Table III. None of the group differences were statistically significant, hence there were no differences between habitual and nonusers in these parameters. This suggests that the accelerated heart rate during work is not found only in habitual users, but characterizes habitual users and nonusers alike.

The final exercise test was an examination of maximal working ability. This test compared four habitual users with four nonusers after the same pretrial regimen. The test was again conducted on a bicycle ergometer, however, the work load was set at a high level
Figure 1. The results of coca use on oxygen intake ($V_{O_2}$) and heart rate. Work level 1 is 350 kg-M/min, 2 is 525, 3 is 875 and 4 is 1150. Level 5 is heart rate 4 minutes and 6 is 30 minutes after the cessation of work.

TABLE III. PERFORMANCE OF MATCHED HABITUAL AND NONHABITUAL COCA USERS DURING WORK. MEANS FOR COCA USING TRIALS

<table>
<thead>
<tr>
<th></th>
<th>Habitual Nonusers</th>
<th>Habitual Users</th>
<th>$F^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Age (yr)</td>
<td>24.8</td>
<td>26.2</td>
<td>ns**</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>155.4</td>
<td>152.2</td>
<td>ns**</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>53.8</td>
<td>52.4</td>
<td>ns**</td>
</tr>
<tr>
<td>$V_{O_2}$ (l/min)$^1$</td>
<td>1.64</td>
<td>1.61</td>
<td>ns</td>
</tr>
<tr>
<td>HR (f/m)</td>
<td>139.9</td>
<td>141.5</td>
<td>ns</td>
</tr>
</tbody>
</table>

$^*F = ns$ is nonsignificant.
$^{**}$ Paired “t” used for first three characteristics.
$^1$ Mean $V_{O_2}$ and HR for the first three levels of work while using coca.
and was increased each minute until the subject was completely exhausted. Maximal oxygen intake and maximal heart rate during the trial were recorded as were pre- and post-trial blood pressures. Table IV summarizes the results. None of the differences are statistically significant; however, during the coca use trials there was a propensity toward a longer riding time, about twenty seconds (1. \( t > .05 \)). This is in agreement with observations of Gutiérrez-Noriega (1944) who found that dogs, run to exhaustion, were able to continue longer if first given cocaine.

Coca use during work performance, thus, may operate in two areas. First, coca produces an accelerated heart rate during submaximal effort, and second, coca use may promote increased endurance time. The factor most likely involved would seem to be cocaine, for both responses have been reported after administration of cocaine hydrochloride (Gutiérrez-Noriega 1949b:147). If it actually is cocaine, consideration of other psychostimulants—amphetamines and caffeine—offers some suggestion as to actual advantage gained. Amphetamine use produces central stimulation, as does cocaine, and leads to enhanced athletic performances (Weiss and Laties 1962). Amphetamines also reduce fatigue and lead to longer endurance at maximal effort on the bicycle ergometer (Wyndham et al. 1971). The actual mechanisms involved are not known, but under the influence of such drugs the worker feels "pep" and is less sensitive to fatigue. Both of these effects should be most welcome to the worker in a high altitude environment.

A second stressful situation frequently encountered in Nuñoa and throughout the Andes is low environmental temperature. When asked about the effect of coca use on response to cold, 75\% of the Indians questioned by Little (1970:236) reported using more coca during the cold season than during the warm one. Another study was undertaken to determine if coca use does modify response to cold stress and has been described in detail elsewhere (Hanna 1971b, 1973).

Fourteen Quechua men, of whom nine were habitual coca users, served as subjects. As in the exercise study, they chewed coca in accustomed amounts on one day and abstained from its use on the other. Each was tested on two days, one day with coca and the other without

**Table IV. Resting and Maximum Values for Maximal Working Test**

<table>
<thead>
<tr>
<th></th>
<th>Rest</th>
<th>t&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Maximal</th>
<th>t&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Coca</td>
<td>Coca</td>
<td>ns</td>
<td>No Coca</td>
</tr>
<tr>
<td>( V_{02} ) (l/min)</td>
<td>0.31</td>
<td>0.33</td>
<td>ns</td>
<td>2.56</td>
</tr>
<tr>
<td>Aerobic Capacity (cc/kg/min)</td>
<td>—</td>
<td>—</td>
<td>ns</td>
<td>46.8</td>
</tr>
<tr>
<td>HR (l/min)</td>
<td>82.7</td>
<td>80.8</td>
<td>ns</td>
<td>183.6</td>
</tr>
<tr>
<td>SP (mm)</td>
<td>118.2</td>
<td>119.4</td>
<td>ns</td>
<td>152.9</td>
</tr>
<tr>
<td>DP (mm)</td>
<td>80.7</td>
<td>83.1</td>
<td>ns</td>
<td>88.9</td>
</tr>
<tr>
<td>Duration (min)</td>
<td>—</td>
<td>—</td>
<td>5;2</td>
<td>5;6</td>
</tr>
</tbody>
</table>

1 None of the differences are statistically significant at 5\% or better. A paired samples t-test with 6 df was used.

2 1 \(< t < .05\).
it. Prior to cold exposure, the men, who were dressed only in athletic shorts, reclined on metal cots and were covered with blankets. After one hour they were uncovered and exposed to 15.5°C (60°F) for two hours. Six surface temperatures, rectal temperature, and oxygen intake were measured during the cold exposure. They continued to chew coca during both the rest and exposure periods if it was their day to do so.

Finger, toe, and rectal temperatures during the two-hour exposure are presented in Figure 2. Analysis of variance shows that coca use resulted in significantly lower finger and toe temperatures. During the second hour of exposure, use yielded a lesser decline in rectal temperature—also statistically significant. There were no differences in oxygen consumption.

It appears that coca use during cold exposure produces a mild vasoconstriction which is observed as lower finger and toe temperatures. This was also evident in studies by Little (1970:237). The result is reduced heat loss from these areas and, subsequently, a higher central temperature.

![Figure 2: The result of coca use on body temperature. Finger and toe temperatures are significantly lower after coca use. The resulting economy of body heat content is seen in rectal temperature.](image)

The advantage of increasing heat retention is obvious when observations of day-long routines in Nuñoa are considered. Thomas (1972:9-32) has determined that most of the day may be spent in sedentary activities. Even the task of herding alpacas was 75% sedentary. This may be a most beneficial adjustment to hypoxia or to a low calorie diet (Thomas 1972:9-32), but does not allow production of much heat for maintenance of body thermal balance. Continual use of coca should promote lesser heat loss throughout the day and
provide partial compensation. It is also noteworthy that in the absence of external sources of heat, such mechanisms of heat conservation would be most desirable.

Thus, coca use at altitude seems to have four biological consequences. First, when it is used in habitual quantities by habitual users, there appears to be none of the profound physiological or psychological disturbances that have been reported in laboratory studies. This seems to result from using small quantities of leaves throughout the day rather than large quantities at only a few times. Second, a comparison of resting and working physiological responses of a limited number of habitual users with a number of nonusers reveals no appreciable difference which can be related to coca habituation. None of the habitual users reported withdrawal symptoms when they abstained from coca use. Third, during work performance, coca leaf chewing elevates heart rate, which suggests some stimulatory effect. This may be similar to that received from caffeine or other psychostimulants and may give the user a feeling of greater well-being. Similarly, during maximal effort, coca leaves—like cocaine—may prolong performance through reducing fatigue perception. Both of these functions should make arduous tasks more bearable for the coca user. Fourth, coca leaf chewing aids in conservation of body heat, a most desirable consequence in an area where caloric availability may be limited.

A biological aspect of coca use which has yet to be studied is its relation to nutrition. Proponents of abolition have claimed coca use dulls hunger pains in a chronically hungry population (Gutiérrez-Noriega 1949b:151; Wolff 1952:4). These arguments are based upon the recognized capacity of cocaine to reduce hunger, but adequate information for evaluating this argument is not available. Gutiérrez-Noriega quotes a broad correlation between annual per capita coca consumption and daily food intake. Using average daily food consumption in Lima as a base (100%) he reports a 44% deficit in grams of food/day/individual in “the southern Peruvian Andes,” where annual per capita coca use is highest; a 27% deficit in the northern Andes where consumption is intermediate; and a 13% deficit where coca is not used. These imprecise correlations may be questioned on two points. First, the Lima population is a mestizo population that probably tends toward a greater body size, hence toward a greater food requirement than that of the smaller Andean Indian population. Second, subsequent dietary studies in the northern (Callazos et al. 1954) and southern Andes (Mazess and Baker 1964; Picón-Reátegui 1968) have indicated that the Indian population is probably not greatly hypocaloric. Thus, chronic hunger is probably not the “main cause of the coca habit” as Gutiérrez-Noriega (1949b:143) has claimed.

On the other hand, given a hunger-suppressing property in coca leaves, it would be surprising if the user did not use it to his advantage during periods of acute hunger. Martin (1970:432) quotes Weddel’s observations which seem to support this view: “the Indians who accompanied me in my voyages chewed, in effect, the coca during the entire day; but when evening arrived they replenished their stomachs like starved men and I can assure that I have seen them often ingest in one meal as much food as I would consume in two days.”

The actual food value of coca leaves is probably small, however they may aid in vitamin and mineral supplementation. Martin (1970:432) claims coca leaves contain vitamin B₁, riboflavin, and vitamin C. He states that “chewing approximately two ounces of coca leaves daily (an average dose) will supply almost a daily vitamin requirement.” Similarly Baker and Mazess (1963:1466) have noted that the alkali, llipta, normally used with coca leaves is an important source of calcium for the calcium deficient Andean populations.

In summary, the exact relationship between coca chewing and nutrition has not been established, but caloric deficiency does not seem to be the driving force in its use—except possibly during periods of acute hunger. Some vitamin and mineral value may also accrue from daily coca use.
ECONOMIC ASPECTS OF COCA USE

Because coca use is so extensive, and because it plays an important role in life at high altitude, some consideration of its economic consequences is in order. The coca-producing areas are located in the foothills on the eastern slopes of the Andes. Their physical distance is only a few score miles from the altiplano where coca consumption is highest (Gutiérrez-Noriega 1949a), however the extreme ruggedness of the terrain makes communication between the two regions very difficult. The problem is compounded by the character of valleys that descend from the Andes to the Amazon. These are deep canyons with boiling rivers that make lateral communication along the foothills most difficult. In ancient times, as now, communication was mostly vertical by means of foot trails from the altiplano to the jungle with little contact between valleys. More recently, roads have penetrated some valleys, but frequent landslides make their passage problematic (Drewes and Drewes 1957). Communication from the roads to neighboring valleys is still difficult.

In the coca-producing region, there are two major producing plantation types—large commercial operations and small individual holdings. The larger, more extensive plantations are generally owned by upper-class families who live in cities but are supervised by a hired administrator. These plantations represent a large investment, but because of the constant demand a certain return is assured. By and large the majority of the coca plantations are small and their owners seem to derive all of their income from the sale of coca. (J. Murra, personal communication.) Their operation will be described presently.

There is also a formal distribution network that has been carefully controlled by the national government at various levels, with the local dealer being licensed at one time or another. Taxes and distribution costs are passed on to the ultimate consumer. The cost of coca leaves in Nuñoa, after they have passed through the formal network, is not excessive. During my stay, the cost of 225 gm (one half pound) varied between 10 and 12 Sols (S/.). There was not much difference between the prices in several stores which sold coca, but users had preferences usually based upon the quality of the leaves. The more green leaves and the fewer yellow, the higher the quality.

An Indian laborer working at the most menial task could earn about 35 S/. each day; hence one day’s work would suffice for over a week’s supply of leaves. Three to four days work per month would keep the user in constant supply. With an average daily consumption of 58 gm, the annual consumption is about 21,170 gm at a cost of S/.1125. This represents the yearly wool production of nine alpacas or of fifty-three sheep (Thomas 1972:158), a considerable cost for most families. Fortunately, all of the coca used in Nuñoa does not come from the store. The typical farmer receives quantities of coca along with his wages when he is working in town (or for a hacienda). Unfortunately, there is no available estimate of the quantity received from these sources. Coca may also be obtained from fellow farmers, given in return for agricultural assistance and derived through an unofficial network.

Perhaps the most economical manner for coca acquisition is to circumvent the formal network by making direct contact with one of the smaller coca producers in the foothills. Each year some men (sometimes with their families) travel to the foothills, taking with them animals, meat, potatoes, and cereals from the altiplano. These they can trade for coca as well as for other tropical products to be used and sold when they return to Nuñoa. In some cases, the traveler may remain and aid in cultivation of fields in the coca-producing regions. The system is viable because it avoids the more costly distribution network and its taxes, but, more importantly, the individual farmer can realize a multiplier effect on the materials that he transports. The meat and potatoes could be sold to a local Nuñoa store, but they are worth far more when transported to lower altitudes. Similarly, coca and other products of
he foothills are more valuable when taken to Nuñoa. The traveler thus receives a double advantage: a multiplier operates upon the goods he takes to the jungle and upon the products he brings home to the altiplano.

Burchard (1971) has recently described the functioning of such a system in northern Peru. He reports that strong economic and social alliances are built between individuals in the altiplano and in the coca-producing regions. The high-altitude resident annually descends to the foothills to help his counterpart with cultivation of his fields. Even *compadrazgo* relationships may be established. During years of crop failure in the Andes, the farmer can take his small potato crop to his counterpart and trade it for a disproportionately large quantity of coca, which he then takes home and trades for food. Under ideal conditions, the farmer may realize as much as an eight-fold increase in food.

This reciprocal exchange network is a form of an ancient one that has been in operation since the Incaic period. During the precontact and Colonial periods, some political divisions owned lands in both the altiplano and foothills. Residents of Andean villages then cultivated both areas on a regular basis because there was little overlap in the agricultural cycles (J. Murra, personal communication). South of Nuñoa there are still some districts which maintain their own coca plantations (Schaedel 1959:47).

Another important consequence of the flow of coca up the eastern slopes is regional economic integration. Because travel between the highlands and foothills is so difficult in the absence of some incentive such as coca exchange, it seems likely that, in the absence of this trade, the foothills region would play a less important role in the regional and national economy than it now does.

In the altiplano, coca leaf chewing has another salient economic consequence. The Nuñoa region is predominately Indian in cultural and economic makeup. The Indian community tends to be self-sufficient, making or growing almost all of its needs. The Indians are, then, potentially outside of the greater regional and national economic system. If the Indian community did not participate in the regular exchange of goods, a large number of actual and potential consumers would be lost to the economy. The continual use of coca brings large numbers of potential consumers into the town where they are introduced to the products of other regions and other parts of the world. The potential consumer is thus introduced into the workings of the cash economy and is familiarized with products of which he is not aware. Stores will normally exchange raw materials, meat, potatoes, and wool for coca at fixed rates; thus lack of cash does not constitute a barrier. It would be difficult to overestimate the importance of this economic function in enlargement of the consumer pool and in stimulating the farmers to produce an agricultural surplus to be exchanged for coca or consumer goods.

The isolated Indian family also derives considerable noneconomic benefit from the regular need to procure coca. Since each family group is potentially self-sufficient, it is possible for far-flung and isolated families to spend several months without seeing other people. The coca requirement brings them into contact with other Indians or larger communities on a regular basis.

Finally, as noted above, coca leaves are in some cases a substitute currency. In stores and other situations, a fixed rate of exchange may be established. Part or all of the wages for various tasks may be given in coca; indeed, coca seems to perform the same economic function as tobacco and salt in other situations.

**DISCUSSION AND CONCLUSIONS**

The approach of this paper has been to view coca leaf chewing in a biological and cultural context, rather than as a simple addiction. It has been argued that the practice may fill
certain biological needs, some of which are unique to the high altitude Andean environment. Only one aspect of culture, economics, has been emphasized, but these observations could easily be extended into other aspects of Quechua and Aymara life. Other investigators have considered the ceremonial, religious, and medical functions of coca chewing (LaBarre 1948; Mortimer 1901; Martin 1970) and may be consulted for data on those topics.

It is now possible to propose answers to some questions about the use of coca; specifically, why is its use most intensive at high altitude, and, if it is not addictive, why has it resisted attempts at abolition?

The first question can be answered tentatively through consideration of the biological data presented above. The work performance studies suggest that coca increases maximum working time. This seems to result from coca diminishing sensations of fatigue in much the same way as do cocaine and amphetamines (Hanna 1971:208; Wyndham et al. 1971). One of the major difficulties of living at high altitude is the reduced availability of oxygen to the working tissues. This results in an accumulation of lactic acid and other waste products that contribute to the sensation of fatigue (Karpovich 1966:201). Since coca use seems to alleviate fatigue to some degree, its use may be beneficial at altitude. Another biological consequence of coca use is promotion of body heat retention. As noted, low activity levels and a lack of an external heat source favor the specific thermal regulatory properties that have been found in coca. These conditions are not found in the lower altitude, coca-producing areas; indeed, thermal problems there revolve about heat loss during work rather than heat retention. Given the vasoconstrictive properties of coca chewing, it can now be appreciated why it is not regularly utilized for fatigue elimination at low altitude. Working in a warmer environment requires heat loss, and maximal peripheral vasoconstriction may be anticipated with heavy work. The use of a substance that promoted heat retention and at the same time prolonged working ability could be fatal.

As to the question of why coca use resists abolition in the absence of addiction, some part of the answer seems to lie in the cultural sphere. In the southern Andes where coca use is heaviest (Gutiérrez-Noriega 1949a, 1949b), the coca trade stimulates regional economic integration. The continual flow of coca facilitates the flow of other goods between potentially isolated areas. For the mestizo merchant in the Andean town, coca means more than a profit. It brings more potential consumers to his store and it provides a medium of exchange for buying farm products that can easily be turned into cash. The Indian family, too, receives some social and economic benefit from the coca trade. There are periodic visits to town and regular contact with other families. If so disposed, the family can deal directly with a small producer and realize economic benefit through labor and trade. Finally, the region and the nation benefit from the trade. There is at least peripheral integration of a large number of consumers into the cash economy. They bring agricultural products that might not otherwise be produced; and they pay taxes, that would not otherwise be paid. They might even buy other consumer goods. If coca use were to be abolished, these functions would have to be met by some alternative. And as yet there seems to be none. Thus, each attempt at abolition unites the upper-class plantation owner, the small plantation owner, the mestizo merchant and the Indian consumer. Few governments can resist such a union.

It should not be concluded that coca use cannot be eliminated, because some countries have succeeded in doing so. Colombia and Ecuador have had some success; however, the pattern of extreme high altitude communities and a long and intact cultural tradition is not found in those countries.

These observations are not the final answers as to why coca is used; rather they show that consideration of the habit from a biological and cultural viewpoint yields some insight into
the reasons for its persistence. Clearly, more work is needed, but it seems safe to conclude that coca use is an integral part of life in the Andes, not simply an addiction of the lower classes.

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NOTES

1 In this communication, cocaine is assumed to be the principal active factor in coca leaves. This seems a reasonable assumption based upon the high percentage of the plant alkaloids contributed by cocaine—80% by Cuiffardi's (1949) analysis. There is also the parallel between the physiological action of cocaine and coca leaf use (Zapata Ortíz 1944). Still, the possibility of another active factor cannot be excluded. R. Burchard (personal communication) believes arecoline rather than cocaine is involved. A cholinomemetic such as arecoline would also produce a general stimulation and hyperactivity found in some coca studies. Picón-Reátegui's (1968) observation of an increased cutaneous water loss with coca use also supports this hypothesis because arecoline, unlike cocaine, is a powerful diaphoretic agent. Only a few milligrams are required to produce a measurable response in man, so large quantities need not be extracted from the leaves.

2 Exercise studies were accomplished on a bicycle ergometer. This is a stationary bicycle on which pedaling effort can be adjusted so that a precise amount of work can be accomplished per unit of time. Thus, it is possible to repeat exactly the same work load for a given individual on two different occasions or it is possible to work several individuals at the same rate. Work can be correlated with the amount of oxygen consumed to estimate an individual's efficiency or it can be correlated with heart rate to estimate cardiovascular performance. Finally, a bicycle ergometer can be used to estimate the maximum work an individual can accomplish during a minute.

3 Little (1970) reported no statistical difference in lower extremity temperature with coca chewing, however, examination of his Figure 1 shows a definite pattern of lower temperature with coca. His statistical analysis involved a serial 't' test which is less appropriate than an analysis of variance under the conditions of his test. Had the latter test been used, his trials may have been significantly different.

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