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by Tracy Torchetti

For the people inhabiting the high altitude areas of the Andes, the coca leaf plays an important role in both their cultural and physiological well-being. It has been attributed with the powers of a symbol of cultural identity (Allen 1981:157; Bolton 1976:633), as well as a means of alleviating the physiological demands placed on the peoples who work in a harsh environment (Fabrega and Manning 1972:243). Although the former serves as a cohesive mechanism naturally propagating the use of the coca leaf, it is the latter's credence that has been debated for many years. There is no doubt that the Altiplano region of the Andes does induce stresses on the people who dwell there. The question remains whether the coca leaf serves as the adaptive mechanism which has allowed them to remain there and thrive for thousands of years. In examining the nature of high altitude stress as well as the properties the coca leaf is believed to possess, the question of role in high-altitude adaptation will be illuminated.

Before any further discussion of the relevance of the coca leaf and high altitude adaptation, a brief introduction to the history and evidence for coca use and an explanation of how it is still used today is necessary.

A Brief History Of Coca

Information recorded from the time of European contact reveal that the custom of chewing coca leaves existed then. Since these observations occurred during the contact period, they predate any Spanish influence in the use and distribution of the plant or the custom (Bray and Dollery 1983:270). Columbus mentions the custom occurring in what is now modern-day Panama, while others witnessed it from Nicaragua and Colombia all the way to Chile (Bray and Dollery 1983:271). There is a considerable amount of archaeological evidence surrounding the use of coca. Actual coca leaves have been found in Peru and Chile along the coasts, no doubt due to the preservative qualities of the arid region (Bray and Dollery 1983:271). Other archaeological evidence includes heavy calculus accumulations on the teeth of skulls attributed to coca chewing suggest that early trade and use had begun in Ecuador by at least 1000 B.C. (Klepinger et al. 1977). Further archaeological associations include figurines which depict coca chewers with distinctive bulges of quid in their cheeks and lime pots which date the activity of coca chewing to 2000 B.C. (Bray and Dollery 1983:271). We, therefore, have evidence of coca being used for a t least 4000 years. During this century, the coca leaf, continuing to be used in the Andes and Amazonia, have spread out to other areas, namely North America and Europe. Cocaine was recognized and utilized for its medicinal qualities. Unfortunately, the means by which it was ingested produced side effects which led to addiction and abuse (Cusack 1986:66). Modern problems of abuse will not be treated here. It should merely be pointed out to the reader that the processing and ingestion of this substance is radically different than the activities surrounding its use in the Andes.

The Nature Of Coca Chewing And Its Use

Among the Quechua, Aymara and other peoples who live in high altitude areas, the practice of chewing coca plays an important role in their daily lives. The cultivated leaves of *Erythroxylin coca* are prized above other species which have varied amounts of alkaloids. This particular species has the highest percentage of cocaine (an alkaloid) in relation to total alkaloid content (Lee 1981:30). The ingestion of coca leaf however is not to be confused with the infestation of cocaine powder as mentioned above. These alkaloids are believed to be responsible for the physiological benefits cited by the peoples who use them (Fabrega and Manning 1972:243). There is no evidence supporting its use as a psychotropic drug not is there any indication of addictive properties (Hanna 1974:282-3).

Coca chewing, not unlike tobacco chewing, involves placing a wad of leaves into the mouth and chewing it until, what is called a 'quid', is formed. The quid remains in the mouth with the addition of alkali or lime taken from plant ashes (lee 1981:23). This supposedly sweetens the quid and activates the release of the alkaloids. The juice is ingested slowly in this manner, but not usually the quid itself (Allen 1981:160).

Coca is used by the Andean people for social, cultural and religious reasons. More relevant is its use as a medicinal agent and perhaps most

intriguingly as an aid in dealing with the nature of stresses associated with living at a high altitude.

The Nature Of High Altitude Stress And Adaptation

Although human beings inhabit various marginal regions all over the world, places of high altitude seem to be the most difficult to adapt to, especially those over 3000 meters above sea level. The high plateau or Altiplano, that millions of Andean people occupy today, is such an area. A number of stresses are related to a high altitude environment. They include hypoxia, intense ultraviolet radiation, cold and a marginal nutritional base (Molnar 1992:216). The farther the distance from sea level one travels, the thinner the air becomes, that is, both the oxygen and barometric pressures decrease. Consequently, more solar radiation penetrates the atmosphere, and more heat energy is lost, leading to cold conditions. These factors are detrimental to both plant and animal life resulting in a poor food base. Human beings are also directly affected. Hypoxia is a condition that involves an inadequate amount of oxygen reaching the tissues, which can result from a number of environmental conditions, in this case, low pressure of oxygen in the atmosphere. In the attempt to adapt to these stresses, many natives possess physiological modifications in response, not necessarily good enough or beneficial. Studies on the growth and development patterns as a result (Demeer et al. 1933). A cultural adaptive mechanism is believed to alleviate some of the physiological stresses that are experienced. The coca leaf is believed to possess such maladies but most important is its use for the alleviation of symptoms relating to hypoxia, cold, and hunger which is useful for adaptive and productive reasons. These three stresses and their relation with coca ingestion will be discussed.

Coca and Oxygen Related Stresses

Coca use is thought to be a response to stresses dealing with low oxygen pressure or simply any mechanism that prevents a sufficient amount of oxygen to be supplied to the tissues. This is probably due to the fact that the symptoms that characterise hypoxia are those that are treated with coca by the Andean people, which include fatigue, pain and hunger (Fuchs 1978:278). This fact is complimented by the realization that the majority of coca users dwell in high altitude areas (Hannah 1974:283). The human body, however, attempts to respond to hypoxia by increasing the number of red blood cells so that more hemoglobin is available for oxygen transfer (Fuchs 1978:280), detrimentally affecting the heart's ability to pump an adequate volume of blood (Molnar 1992:219). Not surprisingly, coca is used to relieve the symptoms of Polycythemia as well.

This relationship is questioned by Fuchs who does not believe that the pattern of coca chewing is directly associated with a high altitude environment. He cites the exception of miners who work at any altitude and use coca for their problems with silicosis, which also affects oxygen intake. They do not deal with cold or high altitude like the Andeans do and therefore any important property attributed to the coca leaf is not as significant as whatever is responsible for lowering red blood cell levels (1978:280). He credits the antimuscarinic properties of the cocaine and ecgonine alkaloids found in the coca leaf in treating hypoxia and other related conditions (Fuchs 1978:282-3) . Fuchs concludes that the explanations of coca use associated primarily with polycythemia, rather that other properties , are acceptable while exceptions such as the miner's case exists (1978:283). This arguments seems somewhat irrelevant when the benefits of coca are being explored. If a certain quality in coca leaves is found to be beneficial, then they can supposedly be adaptive for a particular population without having to be exclusively utilized by them. It can be beneficial to different peoples in different ways.

Coca And Body Heat

In discussing the correlation between coca chewing and the feeling of warmth believed to be associated with it, the hypothesis can be supported by a number of controlled experiments as performed by Hannah (1971; 1974) and Little (1970). Although the chewing of coca had already been found to increase the metabolic rate and temperature in users (Chamochumbi 1949), as cited in Hannah (1971:273), it was not directly tested against cold exposure. In a number of controlled experiments it was found that the temperature of the hand and foot extremities were lowered in those subjects who used coca. Although the thermal difference is not great, both Hannah (1971) and Little (1970) feel that even this small difference could be advantageous under certain conditions. For example, many of the Andean peoples live and work with exposed hand and feet. Therefore, the slight vasoconstriction which causes the decrease in temperature serves to prevent, or at least slow down, heat loss in order to maintain the core temperature of the individual (Hannah 1974: 289). According to these experiments, it is not the production of warmth that can be attributed to coca chewing but rather body heat retention, which is most important when outside sources of heat are not available such as food energy or heat. This mechanism would most certainly be advantageous for the Andean people who work mainly outdoors in the cold, often not eating until to the end of the

day.

Coca And Nutritional Stress

The third important stress that coca is believed to alleviate is hunger. This point is debatable considering that there is ethnographic evidence both for and against this hypothesis. In Buchard's treatment of the subject, he admits to seeing individuals eat incredible amounts of food following an entire day of coca chewing, sometimes renewing the habit immediately following the meal (Buchard 1992:13). On the other hand,Andean people have been telling ethnographers that,

> With coca we get along fine even though it be all day long. Our cattle are down in the bush. Sometimes our food runs out when we are down there; then we must resort to coca, and when we chew, with that we keep going, and in the afternoon, when we reach someone's house, they invite us to a little food. With that we can keep on for days and days, looking for our cattle. Only when we return home do we eat well (Carter 1980, as cited in Burchard 1992:13).

In a study using matched-pair individuals, Burchard found that coca chewers ate just as much as and sometimes more than their non-chewing counterparts (1992:4-5). He concludes from this that coca chewing and eating are complimentary activities. This may be true to some degree but not to the extent that Burchard takes it. Burchard presents his argument in such a ways as to imply that coca use increases an individual's food intake rather than simply disprove the idea that coca suppresses hunger. As Heath points out, coca chewing appears to assuage hunger but does not prevent or quell one's wish to eat when food is readily available (1992:17). It must also be recognised that coca chewing has other nutrition related effects; metabolic effects in particular. It has been suggested that coca chewing may be a response to hypoglycemia, a condition that concerns blood glucose concentrations (Bolton 1976:631). Blood glucose levels are obviously affected by diet. It has been found that those people who have low levels of glucose because of diet or simply because of metabolic difficulties tend to chew more coca leaves, more frequently than others whose glucose levels fall slowly as is normally expected (Bolton 1976:631-2). Support for this hypothesis is illustrated in the example mentioned above, where coca chewing immediately followed the meal. Ingesting coca at this time would prevent glucose levels from declining too rapidly, which is usually the case following a high carbohydrate-low protein meal (Bolton 1976:632; 1992:15). This explanation would conveniently explain coca chewing immediately following a meal as well the chewing and ingestion that is done many time a day—similar to the North American coffee break—for renewed energy. Therefore if coca contributes to glucose homeostasis in an environment of limited nutritional resources than it can be said to be crucial for adaptation in this high altitude region.

Before reaching any final conclusions, a number of points used to discredit any high altitude physiological benefits derived from coca, must be addressed. First, it is argued that coca was widely used in the lowlands as well as the highlands (Bray and Dollery 1983:271). Archaeological, as well as ethnohistorical, evidence as discusses above supports this statement. However, coca's widespread use does not discredit the benefits of the coca leaf as is utilized in the high altitude environments. Further, it should be noted that although it persists in the lowlands, its use is varied. In the urban centres near sea level, the plant is largely exploited for its curative and ritualistic powers rather than consumed daily (Carter et al. 1981), whereas in the highest elevations, the coca is almost universally used (Hanna 1974:283). In Amazonia—another marginal environment—coca is used frequently. It has been shown that the highest proportion of coca chewing occurs in those villages where traditions are upheld and somewhat isolated, which in turn correlates with altitude (Bray and Dollery 1983:273). It is seen, then, to be merely a product of culture and not adaptive necessity. However, it is also known that the Indian populations who use coca on a daily basis occupy the harshest land, and work under the stress of poverty, ill health, and poor diet (Bolton 1983:276). They also belong to the lowest classes, perform most of the physical labour and experience the greatest amount of stress owing to climate (Hanna 1974:283). There is no doubt that if there are any physiological benefits to be derived from the plant, they would be utilized as they are today.

Although the role of the coca leaf in Andean cultures is deeply entrenched into the social, cultural, religious, medical, and economic aspects of the people's lives, the adaptive potential of the leaf was the focus of this discussion. So special is its place in this culture that programs directed at banning or destroying the coca plant is seen as some to be, in the words of Ralph Bolton, "in effect, though perhaps not in intent, a sophisticated form of ethnocide" (1979:418). Its persistence has been shown here to have some basis in scientific fact; however, scientific experiments, for the most part, confirm what the Andean people have always credited to the coca leaf. These qualities of providing relief for a number of maladies and especially those stresses associated with a high altitude environment, namely oxygen deficiency, cold, hunger, can only be beneficial and, therefore, adaptive. Coca is a clear example of a cultural

response to physiological stress, which successfully produces physiological adjustments in those who chew the leaves, and therefore ensure continued survival.

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