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Snuff Powders from Pre-Hispanic San Pedro de Atacama: Chemical and Contextual Analysis[1]

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Humans since ancient times have utilized plants not only as sources of nutrition but also as part of their rituals and healing practices. While it is well known that the human race is basically sustained by a dozen or so species of food plants, we have much less appreciation for the many psychoactive plants that may have been responsible for the origin of the concept of the sacred. However, considerable documentation exists detailing the use of hallucinogenic plants by cultures both past and present all over the world (Furst 1972; LaBarre 1972; Schultes and Hofmann 1979; Wasson 1961, 1971; Wasson, Ruck, and Hofmann 1978).

 We thank Donna Torres for preparation of maps, Linda Repke for anthropological perspective, and Ken Straub for helpful discussions regarding the gas-chromatographic–tandem-mass-spectrometric technique.

In the Americas, there is a close relationship between the supernatural and the altered states produced by hallucinogenic plants; these plants are seen as intermediaries between humans and the supernatural. This function as intermediary seems to characterize all Amazonian use of hallucinogens, and it may have played the same role in the pre-Hispanic world (Bourne 1906:20; Reichel-Dolmatoff 1971:27–28). The botanical identity and the chemical makeup of many pre-Columbian hallucinogenic plants, particularly those used in the form of snuff powders, have been determined only in the 20th century. The evidence for their use has largely consisted of descriptions by early European chroniclers and comparisons between archaeological artifacts and those from the Amazon collected within the last 200 years (Aguado 1956[1560]; Bourne 1906; Wassén 1965, 1967).

Until recently, the oldest samples of South American hallucinogenic plants to have produced chemical evidence of psychoactive alkaloids were botanical specimens of *Banisteriopsis caapi* (Spruce ex Grisebach) Morton and *Anadenanthera peregrina* L. (Speg.) (Schultes, Holmstedt, and Lindgren 1969, Schultes et al. 1977) collected by Richard Spruce in 1852 and 1854, respectively, during his explorations of the Amazon Basin. Leaves of *Ilex guayusa* Loes. found at Niño Korin in Bolivia, radiocarbon-dated to A.D. 355, 375, and 1120, tested positive for the presence of caffeine (Wassén 1972:29), but the relationship between the bundles of leaves and the snuffing paraphernalia found in the same collective burial is not clear. No caffeine-containing plant is known to have been used as a snuff (Schultes 1972:115–17), although there is no known pharmacological reason caffeine could not be absorbed nasally. Eight samples of probable snuff powders from Niño Korin were analyzed and gave negative results for psychoactive alkaloids (Holmstedt and Lindgren 1972:140–41). It has been suggested that the failure to detect psychoactive compounds in archaeological specimens is directly related to the amount of material available for analysis (e.g., Núñez 1969). In this article we present the results of the first analysis identifying psychoactive components in snuff powders obtained through controlled archaeological excavations.

In pre-Hispanic times, the oases and river valleys of the Atacama desert of northern Chile (see figs. 1 and 2) were occupied by a succession of preceramic hunter-gatherers and ceramic-stage agriculturists and herders. San Pedro de Atacama, one of the largest of these oases, at an altitude of 2,450 m, is composed of small settlements located along the San Pedro River. The pre-Hispanic sites excavated are named for the settlements in which they are located. Among these Coyo Oriente, Quitor 5, Quitor 6, and Solcor 3 are notable because of their clear contextual associations and well-developed ceramic chronology (Berenguer et al. 1986, Llagostera, Torres, and Costa 1988, Tarragó 1968). This is a rich archaeological area in which the dryness of the environment allows for the excellent preservation of textiles, bone and wooden artifacts, and human remains.

The San Pedro archaeological remains are character-

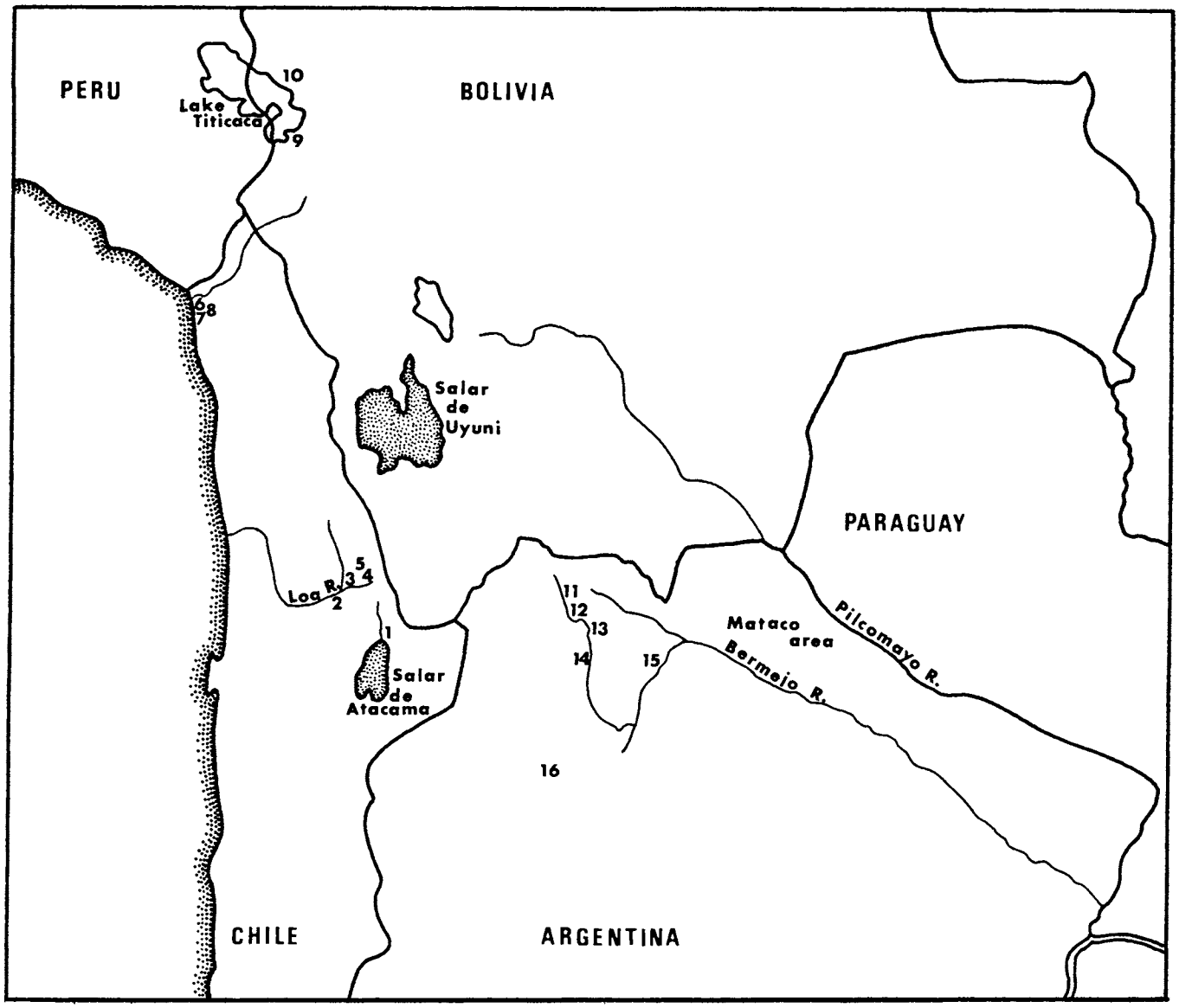

FIG. 1. *The south-central Andes, showing the locations of sites mentioned in the text.* 1, *San Pedro de Atacama;* 2, *Chunchurí;* 3, *Lasana;* 4, *Caspana;* 5, *Toconce;* 6, *Faldas del Morro;* 7, *Playa de los Gringos;* 8, *Quiani;* 9, *Tiwanaku (Tiahuanaco);* 10, *Niño Korin;* 11, *La Huerta;* 12, *Angosto Chico;* 13, *Pucará de Tilcara;* 14, *Antigal de Ciénaga Grande;* 15, *Calilegua;* 16, *La Paya.*

ized by the highest concentration of snuffing implements known from pre-Columbian America. The most common of the snuffing kits consists of a woolen bag containing a rectangular wooden snuff tray, a snuffing tube, usually of wood or bone, a spoon or spatula, a small mortar and pestle, and one or more leather pouches containing snuff powder. All of these objects may be present in any particular set, although frequently only tubes, spoons, and snuff powder containers are found. A total of 612 snuffing kits have been found in the approximately 5,000 burials excavated since the mid-1950s. Forty-two of the approximately 50 sites excavated in the area have yielded these kits. The sites with the largest numbers are Quitor 6, with 127, Coyo Oriente, with 73, and Quitor 5, with 67. In Solcor 3, 39 snuffing kits have been found; 34 of these are complete sets, while the rest consist only of a tube, a small spoon, and a leather pouch containing snuff powder. The excavated sector of the cemetery of Solcor 3 consists of 118 graves with a total of 205 bodies; thus 19% of the individuals buried in this cemetery carried snuffing implements. Thirty-seven snuffing kits were associated with males, one with an infant, and the remaining one with a mature female. All of the San Pedro snuffing kits have been found in funerary contexts, although it should be noted that very few habitation sites have been excavated (Berenguer et al.

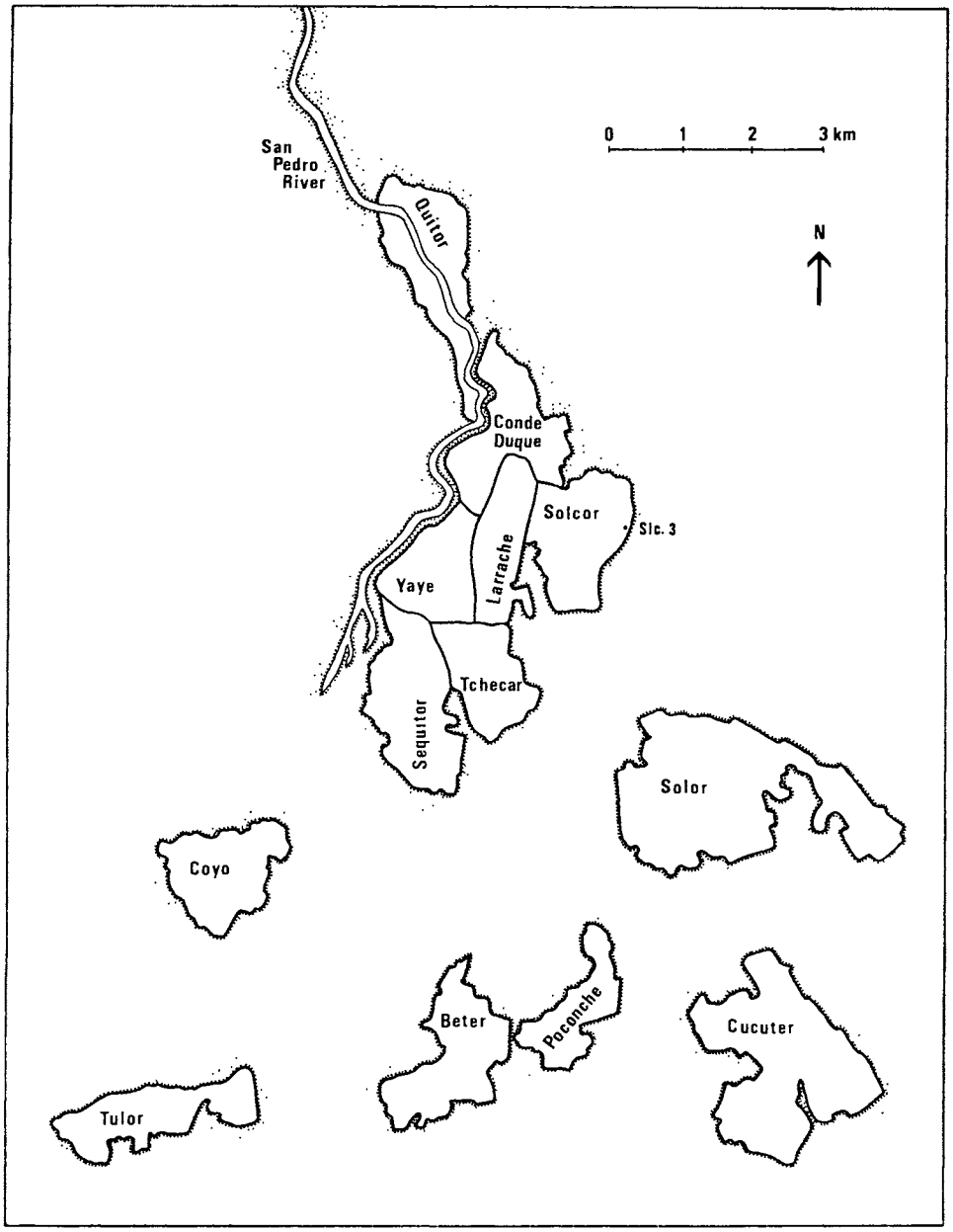

FIG. 2. *The San Pedro de Atacama area.* Slc. 3, *Solcor 3.*

1986; Le Paige 1964, 1965; Llagostera and Costa 1984; Núñez 1963).

The snuff samples submitted for analysis were found in tomb 112 (figs. 3–5) of the Solcor 3 cemetery. The site has been dated by a series of seven radiocarbon determinations and thermoluminescence dates on six ceramic samples ranging from A.D. 320 to 910. The approximate date of tomb 112 is A.D. 780,[2] as determined by radiocarbon and comparisons with artifacts found in other dated tombs.

2. Beta-32447, 1,170 ± 60 B.P.; carbon-14 dating by Beta Analytic, Inc., Coral Gables, Fla.

Tomb 112 is the very well-preserved burial of an adult male approximately 45 years of age. The body was buried in a cylindrical grave in fetal position facing east, the direction of Licancabur volcano (6,920 m), the most prominent peak in the area. The mummified body was wrapped in several layers of woolen textiles and topped by a cylindrical red feather cap (see fig. 3); this is the most common burial type in the San Pedro de Atacama area. The artifacts found in the grave include three polychrome baskets, two large bows with their respective bundles of arrows, an axe with a bone blade, and a silver pectoral. The burial also included two ceramic vessels of the type known as San Pedro Black Semi-Polished.

FIG. 3. *Tomb 112, Solcor 3, San Pedro de Atacama* (in situ).

Most of the snuffing utensils in San Pedro de Atacama are associated with San Pedro Black Polished and San Pedro Black Semi-Polished ceramics, which are diagnostic of the Middle Period (ca. A.D. 300–900) of cultural development in the area (Llagostera and Costa 1984:28–35; Tarragó 1968:122–24).

Attached to the mummy bundle at shoulder height on the left and the right were two snuffing kits in multicolored textile bags (fig. 3). The bags were roughly square and woven with a transposed-warp technique. Each bag held a rectangular snuff tray, a simple snuffing tube, two leather pouches, and a small spoon (figs. 4, 5). Each snuff tray had a flat panel extending from one of the narrow sides of a shallow rectangular cavity. This is the most commonly found type of snuffing receptacle in this area; at least 114 snuff trays in the collection of the San Pedro de Atacama Archaeological Museum belong to this type (Torres 1987:53). The snuff samples analyzed were found in two of the leather pouches. In addition to the snuffing implements, each bag also held a small leather pouch containing crushed malachite. This mineral is frequently associated with snuff powders in Solcor 3 and other sites in the San Pedro de Atacama area. Within one of the lumps of snuff found in tomb 112 was found an almost perfectly hexagonal piece of malachite approximately 3 mm across.

The two snuff samples submitted to chemical analysis consisted of dark amorphous lumps. Extraction of these materials followed the methods of Fish, Johnson, and Horning (1955) and Repke, Mandell, and Thomas (1973). Mass-spectrometric analysis of the alkaloidal fraction was performed using the methodology described by Johnson, Yost, and Faull (1984; Johnson and Yost 1985) and by Lee and Yost (1988).[3] The analysis demonstrated the presence of the psychoactive alkaloids dimethyltryptamine, 5-methoxydimethyltryptamine, and 5-hydroxy-N, N-dimethyltryptamine (bufotenine) in both snuff samples (fig. 6).

While the botanical sources of American hallucinogens now number over 100 genera from 20 families (Emboden 1972, Schultes 1970, Schultes and Hofmann 1980), their active chemical constituents center around simple indoles of the tryptamine and β-carboline classes, tropanes such as atropine, and phenethylamines such as mescaline (Agurell et al. 1969, Hoffer and Osmond 1967, Schultes 1976, Schultes and Hofmann 1980; see fig. 6). The most important plant families are the Myristicaceae (Holmstedt et al. 1980), the Malpighiaceae (Rivier and Lindgren 1971, Schultes 1957), the Leguminosae (Rendon and Willy 1985), the Solanaceae (Wilbert 1987), and the Cactaceae (Schultes and Hofmann 1980). The most widely used genera are *Anadenanthera* Speg., *Banisteriopsis* Morton, *Nicotiana* Linnaeus, and *Virola* Aublet (von Reis Altschul 1972, Schultes 1970, Wilbert 1987).

Our finding of bufotenine in the Atacama snuff suggests that the plant source of this material was a species of the genus *Anadenanthera* (formerly *Piptadenia* Benth.). This is the only genus implicated in the hal-

3. The smaller sample weighed 2.4 g and the larger 10.1 g. Each sample was reduced to a powder in a mortar and then stirred in a mixture of chloroform, methanol, and ammonium hydroxide for 16 hours. The mixture was then filtered and the filtrate concentrated under reduced pressure. The residue was partitioned between dilute hydrochloric acid and ethyl acetate. The aqueous acidic phase was separated and basefied with 10 N sodium hydroxide. The alkaloids were extracted with chloroform. Separation of the chloroform phase and concentration under reduced pressure produced an alkaloid residue which was then subjected to gas chromatographic–mass spectrometric analysis.

Analyses of the hallucinogenic substances in the snuff extracts were carried out with a short-column gas-chromatographic–tandem-mass-spectrometric technique. All data were obtained on a Finnigan-Mat TSQ-70 mass spectrometer coupled with a Hewlett-Packard 5890 gas chromatograph. A 5-m × 0.25-mm DB-5 column was used for separation, and electron impact was used to ionize the analytes. Compounds present were identified by chromatographic retention times and two tandem-mass-spectrometric transitions for each compound known to be characteristic of them as well as identity with reference standards. Detection limits for these alkaloids were on the order of 0.5 to 1.0 ng. The validity of the instrumental technique was verified by their absence from a suitable "blank" consisting of the concentrated organic extract of the aqueous acidic fraction.

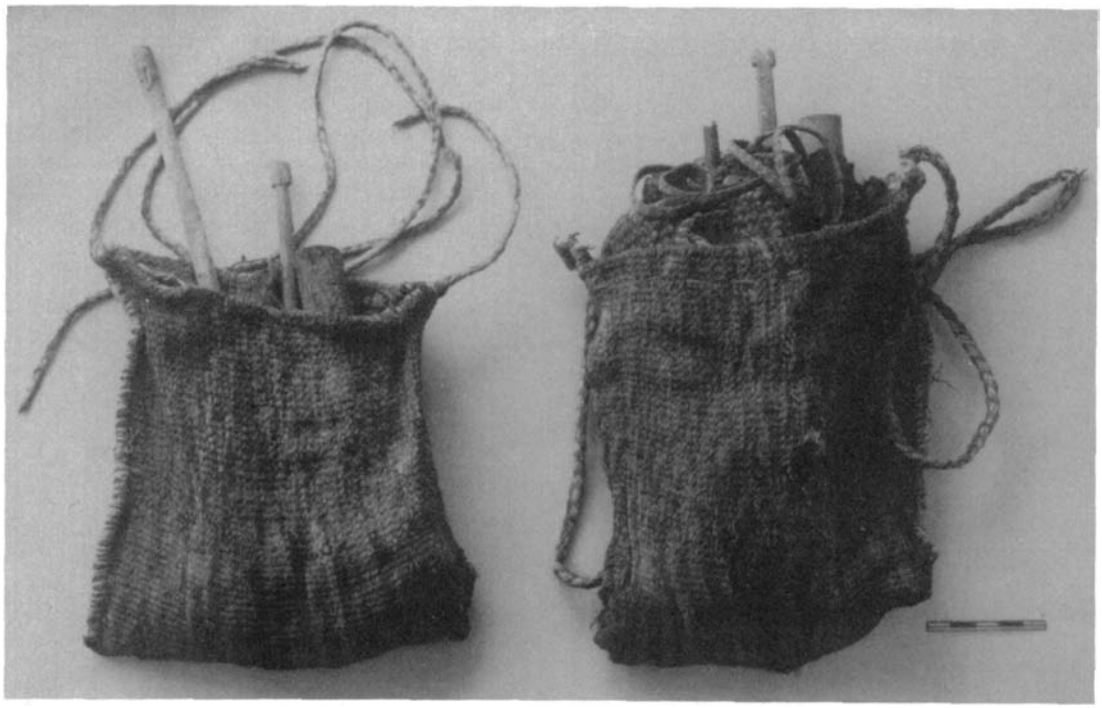

FIG. 4. *Woolen bags containing snuffing kits, tomb 112, Solcor 3. Collection nos. 3901* (left), *3902* (right), *Museo Arqueológico R. P. Le Paige, San Pedro de Atacama.*

lucinogenic snuffing complex that contains bufotenine.[4] This compound, along with its methyl ether (5-methoxy-dimethyltryptamine), dimethyl-tryptamine, monomethyltryptamine, 5-methoxymonomethyl-tryptamine, 6-methoxy-1,2,3,4-tetrahydro-β-carboline and its 1-demethyl analog, and several tryptamine N-oxides, has been reported to occur in *Anadenanthera* and in fresh snuff samples prepared from it (Agurell et al. 1968, de Smet and Rivier 1985, Holmstedt and Lindgren 1967). In addition, small pouches containing seeds have been found in burials in Solcor 3 corresponding to the same period as the snuff samples analyzed, and these seeds have been identified by Schultes as belonging to the genus *Anadenanthera*.[5] Today, several specimens of *A. colubrina* considered only as ornamentals, are to be found growing in the environs of San Pedro de Atacama. Use of *A. colubrina* snuff has been documented as recently as in the mid-1970s among the Mataco of the Bermejo and Pilcomayo Rivers (see fig. 1). Extensive trade in *cebil* seeds also existed between the Pilcomayo area and the Chaco in western Paraguay (Califano 1975:46; see also von Reis Altschul 1972:64).

Because in most cases finds of snuffing utensils throughout South America have not been the result of controlled and well-documented archaeological excavations, current theories concerned with the pre-Columbian hallucinogenic complex have relied almost exclusively on ethnographic data. The most scholarly attempt to deal with this subject has been that of the Swedish ethnographer S. Henry Wassén. Relying on the written accounts of the last four centuries and the iconography represented on the snuffing equipment, Wassén (1965:77–78; 1967:275–76; 1985:32) has tentatively placed the origin of South American snuffing in the northern Amazon. Previously Naville (1959:3) had concluded that the use of snuff trays and tubes as part of snuffing paraphernalia was Amazonian, probably Arawak, in origin. Indeed, this area has, at least in the 19th

4. The presence of bufotenine is used to distinguish *Anadenanthera* from *Virola*, a common source of snuffs in the northwestern Amazon. Although the various species of *Virola* used in the preparation of snuffs contain relatively large concentrations of dimethyltryptamine, 5-methoxy-dimethyltryptamine, and related tryptamine derivatives, bufotenine has not been reported from this genus. While bufotenine has often been referred to as a hallucinogen, current thinking among neurophysiologists is that it is probably not one. In contrast to dimethyltryptamine, 5-methoxy-dimethyltryptamine, and psilocin, to which it is chemically very similar, bufotenine does not readily cross the blood-brain barrier. It can have profound effects on peripheral physiological processes such as heart rate and blood pressure, and these may well provide a significant contribution to the total overall activity of hallucinogenic snuffs prepared from species that contain it. While our identification of bufotenine in the snuffs excavated in San Pedro de Atacama is strong chemical evidence of their derivation from the genus *Anadenanthera*, it is possible, although unlikely, that the bufotenine in these ancient snuff samples arose at least in part from 5-methoxy-dimethyltryptamine by a millennia-long process of hydrolysis.

5. From three to fifteen seeds or beans are borne in coriaceous or subligneous brownish, flat, falcate or sickle-shaped, rather scurfy legumes or pods, usually constricted between the seeds, 6–30 cm long and 2–3 cm wide. The beans are glossy brown or black, very thin, rather flat, and orbicular and are 10–20 mm in diameter.

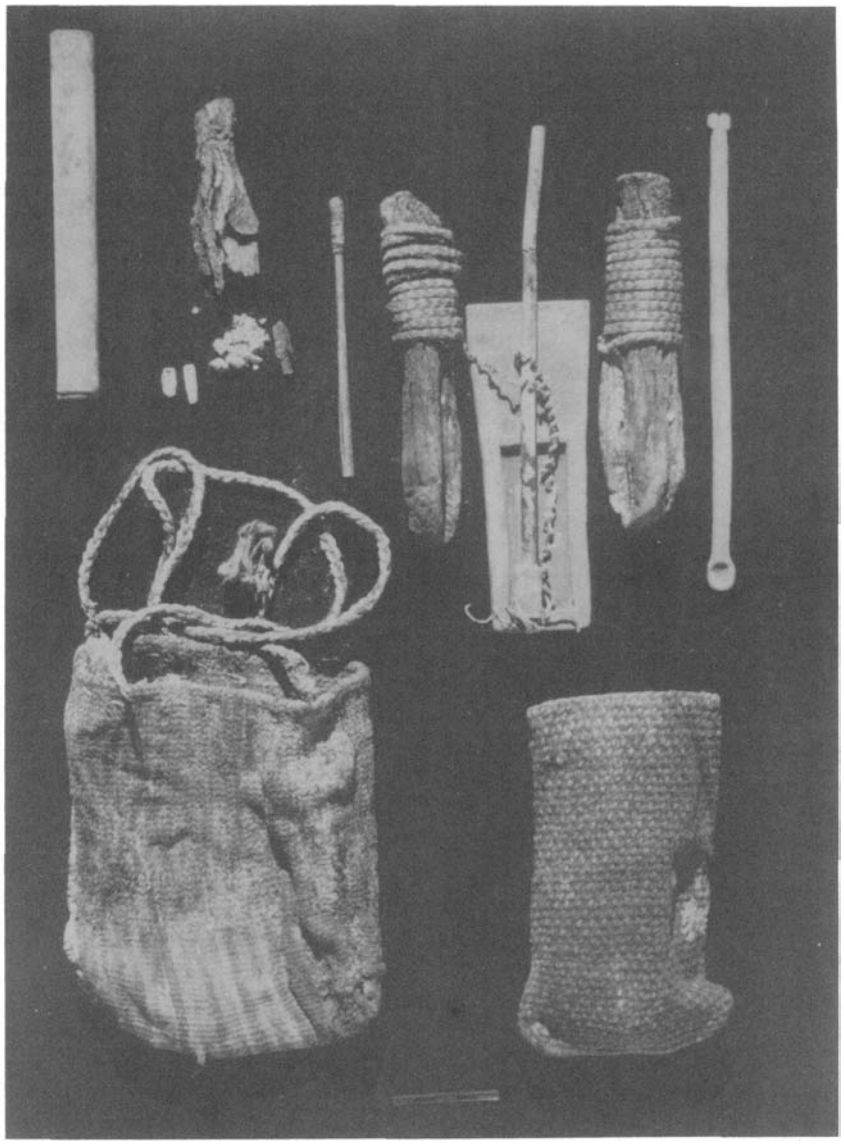

FIG. 5. *Contents of woolen bag 3902. Snuff tray (collection no. 8445) and snuffing tube (collection no. 8446) flanked by leather pouches (collection nos. 8449, 8450) containing the snuff powder samples analyzed, Museo Arqueológico R. P. Le Paige, San Pedro de Atacama.*

and 20th centuries, the highest concentration of hallucinogenic snuff use.

The prevailing climatic conditions in the Amazon Basin are not conducive to the preservation of wooden and bone artifacts, a situation that probably accounts for the absence of snuff trays and tubes from the archaeological record. The earliest snuff trays date from the second half of the 18th century (Wassén 1970:47; Hartmann 1982:191). Mention of snuffing in the Amazon was made as early as 1560 by the Spanish chronicler Fray Pedro de Aguado (1956 [1560], vol. 2:599). Previous to the period of European contact, there is no clear chronology for snuffing in the Amazon.

In the southern Brazilian highlands and in the Andes of Peru and northern Chile, however, snuffing paraphernalia has been found in several preceramic sites. Stone receptacles in the form of birds and sometimes fish found in southern Brazil and eastern Paraguay represent the earliest probable evidence for snuffing implements in the Americas (Wassén 1967:251–53, fig. 12). These objects have been tentatively dated to ca. 3000 B.C. (Muñoa 1965:53). The oldest known snuff trays from the Andean region, dated ca. 1200 B.C., are those excavated by Bird (1948:27; see also Wassén 1967:256) at Huaca Prieta on the north-central coast and by Engel (1963:12, figs. 147, 148) at Asia on the south-central coast of Peru.

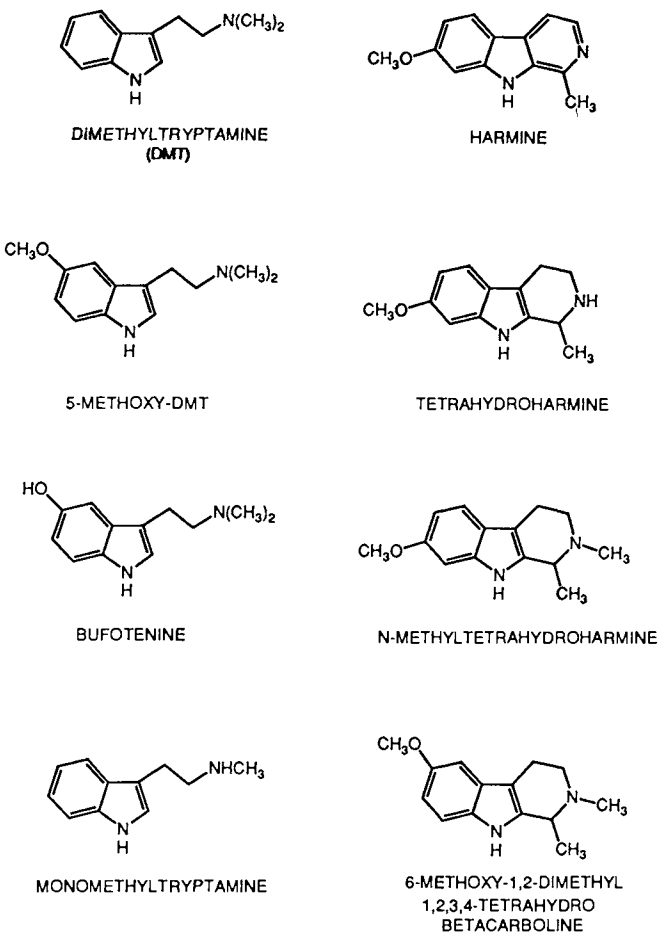

FIG. 6. *Representative constituents of South American hallucinogenic plants.*

In the area of Arica, on the northern coast of Chile, the sites of Faldas del Morro, Playa de los Gringos, and Quiani, among others, have yielded snuffing implements dated ca. 800 B.C. (Bird 1943:225–26, 248, figs. 13, 20; Dauelsberg 1985:17–18, 43, figs. 4, 5).

In later times the evidence for the use of hallucinogens continues and seems to have been integrated into the ritual practices of more complex civilizations. Several *Anadenanthera* representations are seen in ritual deer-hunting scenes on the pottery of the Moche (ca. A.D. 100–800) (Donnan 1976:104, fig. 88; Furst 1974:84, fig. 18). The Tiwanaku (Tiahuanaco) culture (ca. A.D. 100–1000) of the Lake Titicaca region, whose style and iconography are diagnostic of the Middle Horizon of Andean culture history (Menzel 1964), shows significant evidence of hallucinogenic snuff use. Snuff trays and tubes bearing Tiwanaku iconography are common in San Pedro de Atacama and at Niño Korin (Wassén 1972). In addition, at least eight stone snuff trays have been found at Tiwanaku (Uhle 1912:530–31). It has also been suggested (Berenguer 1987) that some of the objects depicted in Tiwanaku monolithic sculpture represent snuffing implements. Snuff trays have been found as far north as northern Colombia (Reichel-Dolmatoff 1972:67) and as far south as Calingasta, San Juan Province, Argentina (Ambrosetti 1902:figs. 17*a*, *b*), and Coquimbo, Chile (Castillo 1984:269).

To the north of San Pedro de Atacama, in the middle Loa River valley, several other sites also have a high incidence of snuffing paraphernalia. Approximately 188 snuff trays have been unearthed in the settlements of Caspana, Chiu-Chiu, Toconce, Chunchurí, and Lasana, among others (fig. 1; Torres 1987:32–40). In northwestern Argentina, numerous snuff trays have been found in sites located in the Quebrada de Humahuaca and most notably in the ancient city of La Paya in the Calchaquí Valley (fig. 1; Ambrosetti 1907–8, vol. 2:493; Torres 1987:56–66). This concentration of the use of hallucinogenic inhalants suggests an early acceptance of snuffing in the south-central Andes and the southern Amazon Basin periphery.

If in fact the Atacama snuff was prepared from *A. colubrina*, then the work of von Reis Altschul (1964) on the origin, evolution, and morphology of the genus offers additional evidence that it was the primary source of archaeological Andean snuff preparations. Von Reis Altschul (1964:38) has suggested that the genus *Anadenanthera* originated in the southern Brazilian highlands and may date to the Mesozoic. This genus comprises two species, each of which has two varieties. Today only one of these four, *A. peregrina* (L.) Speg. var. *peregrina*, exists north of the equator (von Reis Altschul 1964:8–12). There is no evidence to suggest that *A. peregrina* was used as a hallucinogen before *A. colubrina* was so used.

Both species of *Anadenanthera* reported to be used as the source of hallucinatory snuffs prefer open savanna habitats. *A. peregrina* var. *peregrina* prefers lowland savannas. *A. colubrina* is adapted to a wider variety of environments (von Reis Altschul 1964:35); it can be found on river banks and dry slopes up to an altitude of 2,500 m in the south-central Andes. Von Reis Altschul (1964:40) states,

> Neither species of *Anadenanthera* is represented, to my knowledge, in western Amazonas nor in the Andes of northern Peru, Ecuador and Colombia. This circumstance is probably due to an inability of the representatives of *A. peregrina* var. *peregrina* to tolerate the true rain-forest conditions through which they would have to pass in a westward dispersal. There is equally little reason to believe that representatives of *A. colubrina* var. *cebil* would descend from the Andes into lowland rain-forest.

In his extensive investigations in the northwestern Amazon of Colombia Schultes (1967:297) was surprised to find not only the complete absence of *Anadenanthera* snuff but also not a single tree of *A. peregrina*.

Schultes and another, earlier thorough investigator, Richard Spruce (1970 [1908]), did, however, encounter extensive use of *A. peregrina* var. *peregrina* snuff (*yopo*) by the Indians of the Llanos, the savanna area of the Orinoco drainage. Schultes (1967:297) concludes by say-

ing that the belief in the widespread preparation and use of *yopo* snuff throughout the northwestern Amazon is the result of "numerous erroneous generalizations." It would appear, then, that *A. peregrina* var. *peregrina* snuff use was confined to northeastern South America—the Orinoco Basin, southern Guyana, and the Rio Branco and Rio Madeira regions of Brazil. The northern use of *A. peregrina* var. *peregrina* was not halted by its encounter with the Caribbean; the use of *A. peregrina* snuff on some of the islands of the Greater Antilles almost certainly indicates human introduction (von Reis Altschul 1964:42). The evidence suggests, then, that the use of a hallucinogenic snuff preparation from *A. peregrina* was limited to northern South America and some of the islands of the Antilles.

It is evident from the early chronicles of the European explorers that they were referring to powders prepared from the seeds or beans of a tree. According to Oviedo y Valdés (1851–55 [1535], vol. 1:347) the *cohoba* snuff of the Taíno was obtained from a tree whose pods contained lentil-shaped seeds. Aguado (1956 [1560], vol. 2:599) described the *yopo* snuff of Colombia as prepared from the seeds or beans of a tree. Bernardo de Vargas Machuca (1892 [1599], vol. 2:111), writing in the 16th century, and the 18th-century Jesuit explorer José Gumilla (1955 [1791]:123–24) both described the source of snuffs as the seeds of a tree. Later, in 1802, Alexander von Humboldt (von Humboldt and Bonpland 1852–53) observed among the Otomac the use of a snuff prepared from the fermented seeds of a tree. In 1850 Spruce (1970 [1908]) also witnessed the preparation of a snuff powder from the seeds of a tree. In the Peruvian Andes the early chroniclers, such as the 16th-century writer Santa Cruz de Pachacuti (Yacovleff and Herrera 1934–35:43) reported snuff preparations based on seeds or beans.

What, then, was the source of the snuff utilized in the northwestern Amazon? Schultes (1967:300) gives us the answer: *yákee* (or *paricá*) was prepared from the bark of several species of the myristicaceous genus *Virola*, a genus of tropical-forest trees abundant in the Amazon Valley (Schultes and Hofmann 1980:123). His self-experiment with a conservative (by native standards) dose of this preparation demonstrated its great psychoactive effect (Schultes 1954:250–51). Descriptions of a snuff prepared from the bark or resin of a tree such as the *Virola*-based *yákee* are absent from the early accounts. This type of snuff was either of later invention or escaped notice until the fieldwork of the German ethnologist Theodor Koch-Grünberg in the early 20th century. Koch-Grünberg did not identify the plant, but he observed the preparation of a snuff from the bark of a tree during his stay among the Yekwanás of the upper Orinoco in 1911–13 (Schultes 1979:212).

While Wassén and Naville have viewed snuffing as having originated in the northern Amazon Basin, proposing a north-to-south migration of the pattern, the gap of nearly two millennia between the earliest evidence of snuff usage in the area and in the south-central Andes indicates an earlier acceptance of hallucinogenic inhalants in the latter area. In addition, northern Chile and northwestern Argentina have the highest concentration of snuffing paraphernalia in pre-Columbian America. We can tentatively propose, then, that *Anadenanthera*-based snuff preparations could instead have diffused from south to north.

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