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SILICIFICATION OF WOOD

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This work represents an effort to contribute toward an understanding of the long standing enigma of how wood becomes petrified with silica. Following a general discussion of biogeochemical topics relating to fossil wood, a low temperature laboratory process is reported, describing how contemporary wood can be impregnated with silica to form replicated structures comparable to those observed in natural petrifactions. In the third section, a physical model is presented, depicting how silica is believed to be emplaced in wood with respect to cellular morphology. Next, in section IV, a chemical hypothesis is introduced. This hypothesis suggests chemical bonding to be operative in the mechanism of wood silicification. In the final section, the geochemical parameters inferred for the natural process are summarily discussed.

It might be noted here that some of the thoughts expressed on the topic of petrifaction are admittedly speculative. It is hoped these thoughts will serve as a stimulus for further discussion and study of the problem by others with an interest in wood silicification. It would be desirable to understand further the actual nature of the chemical interaction of silicia in solution with wood components and their derivatives, not just for the petrifaction problem alone, but for the role plant-derived organic matter has in many geologic and soil processes of both academic and economic interest.

I. AN INTRODUCTION TO THE BIOGEOCHEMISTRY OF FOSSIL WOOD

Wood Composition

The principal chemical components of wood are cellulose, hemicellulose, and lignin. Both cellulose and hemicellulose are

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polysaccharides and are collectively termed holocellulose. Together with lignin, these macromolecules account for more than 95 per cent of the total weight of moisture-free wood (Table I.). Of the three, cellulose is the dominant constitutuent in both softwoods and hardwoods, generally averaging between 40 and 50 per cent. Hemicellulose is usually more abundant than lignin in hardwoods whereas in softwoods, the reverse is often true. Together, in both kinds of wood, they constitute roughly half of the total dry wood weight. All other wood components collectively average generally less than 5 per cent. Among the many minor components are pectic substances, proteins, starch, polyphenolic compounds, aliphatic acids, and inorganic salts.

Cellulose provides the framework of wood structure. During tissue growth, lignin and hemicellulose are deposited in intimate association with the cellulosic framework as an incrusting, interpenetrating enmeshing matrix material. Because of this intimate association, it is not yet possible to chemically separate these components entirely from one another without affecting some alteration or modification in their molecular structures.

TABLE I.

Percentages (of total wood weight) of Major Components in Wood of Representative Angiosperms (a, b, and c) and Gymnosperms (d, e, and f). From Timell, in Kirk (1973).

	a	b	c	d	e	f
cellulose	42	45	51	41	41	41
lignin	19	22	24	27	29	33
hemicellulose	38	29	23	31	27	23
total of above	99	96	98	99	97	97

Key:
a. *Betula papyrifer*
b. *Fagus grandifolia*
c. *Ulmus americana*
d. *Picea glauca*
e. *Pinus strobus*
f. *Tsuga canadensis*

The molecules of wood cellulose are roughly a thousand times heavier than those of hemicellulose. They are linear and homopolymeric, composed of some 8,000 to 12,000 glucose units (beta-1,4-glucan). In vascular tissue, they are aggregated into linear bundles, called microfibrils, of some 40 molecules each. The microfibrils possess both crystalline and amorphous regions, depending upon the degree of order in the arrangement of the cellulose macromolecules within the microfibrils. The strength of the plant cell wall is due primarily to the construction and conformation of these microfibrils. Cellulose further imparts the property of elasticity to wood.

The hemicellulose polymers are branched noncellulosic polysaccharides which yield several hexose (mannose, galactose, and glucose) and pentose (xylose and arabinose) sugars upon hydrolysis, the amounts of each monomer being variable, depending upon the particular wood sample. Generally, the mannan content is greater in softwoods than in hardwoods. For xylan, the reverse is true.

Lignin is a complex polymer of variable structure and high molecular weight. It is composed of methoxylated phenylpropane derivatives. Upon mild oxidative degradation, lignins yield substantial amounts of phenolic aldehydes. Vanillin is the dominant aldehyde formed from softwoods. Hardwoods yield both vanillin and syringaldehyde as major products. Because of the persistence of lignin in anoxic sedimentary settings, albeit in somewhat altered molecular form, phenolic aldehydes generated from organic-rich sediments may be potentially useful as geochemical indicators of the contributing source material (Leo and Barghoorn, 1970; Gardner and Menzel, 1974; Hedges, 1974).

Unlike the polysaccharide polymers, lignin is hydrophobic. Furthermore, it is more resistant than holocellulose to decay. Hence, because of these properties and its intimate structural association with the polysaccharides in wood, it helps to protect the latter from decay. In addition, lignin imparts rigidity to the cell wall. Without this property, the upward growth of trees would be severely limited.

Additional detail on the chemistry of wood can be found in Browning (1963), Kirk (1973), Miller (1973), Northcote (1972), Sarkanen and Ludwig (1971), Stewart (1966), and Wise and Jahn (1952). For information on wood structure, see Albersheim (1975), Bailey (1954), Côté (1965), Harlow (1970), Isenberg (1963), Jane (1970), Panshin and DeZeeuw (1970) and Wardrop (1964).

Wood Degradation

Once severed from its association with a living system, wood is ordinarily decomposed beyond recognition within a matter of years. This decomposition is principally biological in nature, effected primarily by fungi, particularly the *Basidiomycetes*, which utilize the holocelluloses and lignins constituting vascular tissue for their metabolic processes.

Fossilization, with preservation of histological detail, apparent or real, is restricted to a limited number of geological situations with suitable biogeochemical histories. The environmental parameters of such situations are essentially those which arrest or curtail microbial activity, particularly that of the lignin-digesting fungi. Among the more important of these parameters are (a) moisture, (b) temperature, (c) aeration, (d) pH, and (e) sedimentary setting. Time appears to be of consequence only in reference to the duration of operation of one or more of the aforementioned factors when functioning adversely in effect.

Moist wood is considerably more susceptible to decay than dry wood. Microbial activity is arrested in wood with a moisture content of less than twenty per cent of the fiber saturation point, the point at which cell walls are fully saturated with bound water but no free water remains within cellular void space. Also, fungal growth will cease when cellular void space is completely filled with water and oxygen is excluded.

Temperature intensifies the rapidity of decomposition. The optimum temperature range for active growth of most wood decay fungi is between 2) and 30 Celsius; below approximately 4 and above about 40 Celsius, fungal activity virtually ceases (Käärik, 1974). Hydrolytic breakdown of the polysaccharides and to a lesser extent, lignin, is promoted when temperatures reach the boiling point of water (Browning, 1963).

Exclusion of oxygen is perhaps the most essential of conditions for the preservation of wood in nature. Most of the organisms responsible for decay of wood, including all of the lignin-digesting fungi, require oxygen for their respiration. Water-logged wood "mined" from stagnant lake bottoms after a hundred or more years of submergence was found to be perfectly sound (Harlow, 1970). Wooden stakes driven into anaerobic muds over 4,500 years ago, when recovered and examined, were found to be histologically intact and recognizable as to botanical taxa (Bailey and Barghoorn, 1942; Barghoorn, 1949). These samples, though highly depleted in holocellulose, retained essentially all of their lignin, albeit chemically modified (Jahn and Harlow, 1942).

Under anaerobic conditions, lignin is the most decay-resistant constituent of the woody plant cell wall (Varossieau and Breger, 1952). Most fossil woods show an increase in the lignin/holocellulose ratio relative to their contemporary counterparts, In fact, specimens of Eogene age and older are usually completely devoid of holocellulosic material. This observation reflects the great difference in susceptibility of the two major structural components of wood toward biological degradation and chemical alteration under the conditions ordinarily attendant in nature. Among the polysaccharides, cellulose is more resistant to decay than the hemicelluloses.

The fungi which attack wood can tolerate a comparatively wide range of pH, from at least 4 to perhaps as high as 9, but their most active growth generally occurs within the region between 4.5 and 7 (Browning, 1963, and Käärik, 1974). Beyond the limits of pH favorable for fungal activity, wood decomposition through chemical hydrolysis is greatly accelerated. This is especially true for environments of high alkalinity, as solutions of strong bases will dissolve a considerable quantity of wood substance, even at ordinary temperature (Browning, 1963). Hence, preservation of unmineralized wood in sedimentary settings of high alkalinity is precluded.

For further discussion of the chemistry and microbiology of decay, the articles by Käärik (1974), Kirk (1973), and Scheffer (1973) are recommended. For further information relating to the chemistry of fossil wood, see the references cited by Sen and Basak (1957) in their review of the topic.

Ancient Wood in the Sedimentary Record

Commonly, fossilization is initiated by the entombment of fresh wood within soft muds beneath a body of water receiving a substantial influx of sediment. The initial stage for many of the fossil woods that are preserved as silicified woods appears to be rapid burial in volcanic ash (Murata, 1940). Both of these situations involve protective isolation of the wood from atmospheric oxygen. Lignin is rapidly degraded only under aerobic conditions, or when oxygen can be transferred or dehydrogenation can take place (Flaig, 1968). The nature of the sedimentary setting is a critical factor in fossilization in that it determines, along with the wood itself, the associated microbiota and the biogeochemical factors affecting the specimen; for example, accessibility to air and water, Eh and pH of the microenvironment, and composition and flow of any permeating fluids.

The most enduring forms of structural preservation are those of fossilization through petrifaction. Although non-mineralized woods have been unearthed from Paleozoic sediments, *Callixylon* wood from the Berea Sandstone, for example, such ancient occurrences are rare. Most commonly, the geologically older specimens are found as petrifactions. Fossil woods are usually discovered in situations where they have become exposed to view through erosion of their protective sedimentary cover, as along a stream bank or on a talus slope. Once exposed to the adverse conditions normally existent at the ground surface, the non-mineralized woods will be relatively short-lived, whereas those impregnated with resistant mineral matter may survive for millenia, although slowly oxidized and weathered in the regolith.

Some forty minerals of widely diverse chemical affinities have already been noted in the literature as petrifying agents (St. John, 1927). The most common petrifactions are siliceous (either hydrous silica or microcrystalline quartz). Of less frequent occurrence are those composed of calcium carbonate and iron sulfide. Most of the remaining mineral forms are rare.

The preeminence of silica as a petrifactant and wood as an object of petrifaction suggests some affinity to be operative between the two materials. The propensity of vascular tissue as a depository or "sink" for silica might be related to the potentiality for hydrogen bonding that exists between soluble silica and the ligno-holocellulosic complexes which constitute wood (see Section IV). The preponderance of silicified plant tissue over that of animal tissue is quite likely a further consequence of the nature of the plant cell wall, its semi-rigidity serving against collapse of internal structure and its permeability permitting infiltration of siliceous fluids (Rolfe and Brett, 1969).

The most perfect preservation of original structure is found in the siliceous petrifactions (Barghoorn, 1960), particularly in the opalized forms (Buurman, 1972). Moreover, silica, when crystalline, is among the least weatherable of all the minerals of common occurrence. In addition to being resistant chemically to most attacking solutions, its hardness and lack of cleavage help it to resist many other agencies of weathering (Deer et al., 1966). Carbonates are considerably less durable, being comparably soft and subject to dissolution, especially when in contact with CO_2-bearing ground waters. Sulfides, in the presence of atmospheric oxygen and moisture, form sulfuric acid which causes rapid deterioration of the petrifaction and eventual obliteration of all histological detail.

Occasionally, woody relics of a former forest ecosystem are preserved *en masse*, usually as an assemblage of silicified petrifactions. At Amethyst Mountain in Yellowstone National Park, there is a time succession of at least twenty-seven such forests (Dorf, 1964). At this locality, many of the tree trunks stand upright, in their original position of growth. More often, as is the case with the Chinle forest of Arizona, fossil forests represent accumulations of drift wood which became silicified at the "forest" site after transport by ancient streams from elsewhere. Petrified woods are unrestricted geographically. They are found in many parts of the world and in a variety of physiographic provinces, from the tropics to the polar regions. They occur in sediments ranging in age from the Devonian, some 400 million years ago, to as recent as the latter half of the past century.

Commonly, the internal organic architecture of the original wood substance is retained in the petrifaction in sufficient detail to permit thorough anatomical description. Woods of many diverse taxonomic groups are known in petrified form. In the Eocene fossil forests of Yellowstone Park alone, more than ten genera of coniferous woods and over thirty genera of dicotyledonous woods have already been recognized (E. Wheeler, personal communication). Considerable diversity among petrified woods is found in the extent to which and manner in which mineral substance is emplaced in vascular tissue. Variety exists between those in which mineral matter is present within the confines of the cell walls and continuous across tissue, to others in which only the larger void spaces (cell lumina and fracture openings) are plugged with mineral substance (see section III).

Siliceous petrifactions generally contain more than ninety per cent, by weight, of silica. In minor elemental composition, they are remarkably uniform. Only iron, aluminum, and the more common alkaline earth (Ca, Mg) and alkali (Na, K) metals are ordinarily present in amounts greater than a few hundredths of a per cent. Of these, iron, aluminum, and calcium are the most abundant. It is not uncommon for one or more of these three metals to be present in amounts in excess of one per cent, by weight. Semi-quantitative emission spectroscopic examination of more than a dozen silicified woods showed that many other elements are normally present in silicified woods in trace amounts (below the level of one-hundredth of a per cent).

In some nonsilicified woods, a relatively scarce element (U, Ge, or Se, for example) may sometimes be concentrated to a substantial amount. The process of enrichment appears to be related to the establishment of organometallic complexes between the soluble metal ion in ground water and reactive organic species formed from the woody tissue during degradation. Lignites have the highest uranium concentration of all caustobiolites; germanium is highest in coalified woods of low ash content (Manskaya and Drozdova, 1968).

On examining fifteen silicified woods ranging from the Upper Devonian to the past century in age and representing a wide variety of wood taxa, boron was found as a trace in only four, zinc in only one, and phosphorous was not detected at all. These three biogenic elements, along with sulfur which was not analyzed for, are the four most enriched elements (relative to their abundance in the lithosphere) in living woods.[2] This might suggest that conditions at the time of petrifaction were sufficiently low in pH to cause B, Zn, and P to be solubilized as acidic species and leached away. Also, the absence of phosphorous might be attributed to microbial mobilization (W. Lyford, personal communication).

In addition to the metal ions, all silicified woods contain water, about one per cent or less, and organic matter, remnants and derivatives of the original wood substance. There is no

[2]The ratios of mean concentrations of biogenic elements in living plants and in igneous rocks have been tabulated by Brooks (1972) as follows: B (1.70), S (0.96), Zn (0.90), P (0.88), Mn (0.40), Ag (0.25), Ca (0.14), Sr (0.13), Cu (0.13), K (0.12), Ba (0.12), and Se (0.10).

consistent time (geological age) correlation with either the amount of wood or its state of preservation.

Silicified woods average around one per cent in total organic carbon, ranging from trace amounts to roughly five per cent. Considering that elemental carbon constitutes about fifty per cent of the dry weight of most woods and that the average specific gravities of wood and silica are roughly in the ratio of one to five, the average volume occupied by organic tissue in petrifactions is estimated to be on the order of ten per cent, assuming no compression.

The physical state of silica in silicified woods of Tertiary age is commonly opaline.[3] Ancient specimens, including all those of Paleozoic age, are composed of microcrystalline quartz, either as submicroscopic equant grains or radiating fibers of chalcedony. Originally, probably all siliceous petrifactions were amorphous, forming from the build-up in concentration and polymerization of monosilicic acid molecules within the woody matrix. With time, the resulting precipitate loses water (syneresis) and becomes opaline. Silica can persist in the opaline state for millenia. Eventually, it will become more compact and take on order — i.e., transform ultimately to the more thermodynamically stable crystalline state.

II. Laboratory Silicification of Plant Tissue at Low Temperature

The critical factors for the natural process of wood petrifaction are not completely known. Nor has a laboratory process been developed which can readily produce specimens comparable in quality to natural petrifactions like those from the Clarno formation (Eocene) in the John Day Basin of Oregon, for example. Attainment of this objective is desirable for the insight it might provide into the actual mechanisms of petrifac-

[3]The terms of opaline silica and opal are not distinguished here and are used in a very general sense, referring to all hydrous silicas — including both those which are compact and vitreous and those which are friable or dispersed. The various structural forms of the hydrous silicas have been subdivided on the basis of their x-ray diffraction patterns into three separate categories by Jones and Segnit (1971). These are: opal-A (highly disordered, near amorphous), opal-CT (disordered α-cristobalite), and opal-C (well-ordered α-cristobalite). This classification might be amended to include the occurrence of tridymite-like structures which have been observed in a number of natural hydrous silicas, including the wood opal described by Mitchell and Tufts (1973).

tion and if implemented under geologically plausible conditions, factors and constraints of importance to the natural process might be recognized and characterized. Described in this section is a procedure which offers some promise in this direction.

Earlier Work

Around 1520, the alchemist, Basil Valentine, reputedly developed a procedure whereby wood could be artificially petrified (Vail, 1928). The silicifying agent was said to be a fluid formed from powdered silica and 'sal tartari', the latter, presumably, being the 'subtartrate of potash' derived from grapes. In the same century, Kentmann (1518-1568) wrote of having prepared a 'lapides igne liquescentes' from alder wood. Meyer (1791) accredits Kentmann with the following statement: "When one brews beer, alder wood is simmered in the pot until the hops are done. Afterwards, one buries the wood for three years in fresh sand or gravel in a cellar, afterwhich, it turns hard, making the best whet- or flintstone." It might be noted here that beer itself is essentially saturated with respect to dissolved silica, a consequence of the high amorphous silica content of grains, particularly the malt husk (Iler, 1955). In an old copy of Moore's Universal Assistant and Compleat Mechanic, Longyear (1941) found the following recipe for petrifying wood: "Gum salt, rock alum, white vinegar, and pebbles powder, of each an equal quantity. Mix well together. If, after the ebullition is over, you throw into this liquid any wood or porous substance, it will petrify it." If this recipe, or Valentine's, or Kentmann's, does truly lead to petrifaction, it has yet to be demonstrated. Experimental verification of the alleged results is prevented, however, either because of insufficiency of procedural information given or because of uncertainty regarding the true chemical nature of the actual materials used.

In more recent times, Schulze and Theden found that an aqueous solution of sodium metasilicate can be easily transported through the ray cells and into the tracheids of fresh pine wood (Buurman, 1972). Later, Drum (1968a, 1968b) was able to show that cellular detail in vascular tissue can indeed be replicated in silica by artificial means. By first soaking fresh birch twigs in sodium silicate solution for 12 to 24 hours and then wet-ashing the impregnated twigs in chromic acid for two to three days, he was able to make siliceous lumen casts from ray parenchyma cells which clearly showed a number of the surface features of the inner cell walls.

Recently, Oehler and Schopf (1971) made a 'fossiliferous chert' which approximates in general appearance the natural bedded cherts of Precambrian age. This was done by first embedding some filamentous blue-green algae (Lyngbya) in a gel and then subjecting the gel to temperatures of about 150 Celsius and pressures between 2000 and 4000 bars for two to four weeks.

The technique described herein employs moderately low temperature, essentially normal atmospheric pressure, and pH conditions near neutral. It is based on the reagent, ethyl silicate. The use of ethyl silicate as a silica source stems from an earlier unpublished study of petrifaction, begun some twenty years ago by one of us (ESB), and later in collaboration with H. Irwin.

Chemistry

Ethyl silicate (tetraethoxysilane) is a colorless, water insoluble, alcohol soluble, flammable liquid, with a specific gravity of 0.93 and a boiling point of about 165 Celsius. In the presence of water, ethyl silicate slowly hydrolyzes to monosilicic acid, $Si(OH)_4$, the principal soluble form of silicon found in nature.

$$\begin{array}{ccccccccc} & OC_2H_5 & & & & OH & & & \\ & | & & & & | & & & \\ H_5C_2O - & Si & - OC_2H_5 & + & 4HOH \;=\; HO - & Si & - OH & + & 4C_2H_5OH \\ & | & & & & | & & & \\ & OC_2H_5 & & & & OH & & & \end{array}$$

With increase in solution concentration beyond saturation with respect to amorphous silica, silicic acid will begin to polymerize to higher molecular weight species through the formation of siloxane bonds, $-\overset{|}{\underset{|}{Si}}-O-\overset{|}{\underset{|}{Si}}-$, and the elimination of water. This reaction may be represented most simply with the following chemical equation for the formation of the dimer.

$$\begin{array}{ccccccccccc} & OH & & & OH & & & OH & & OH & \\ & | & & & | & & & | & & | & \\ HO - & Si & - OH \;+\; & HO - & Si & - OH \;=\; & HO - & Si & - O - & Si & - OH \;+\; HOH \\ & | & & & | & & & | & & | & \\ & OH & & & OH & & & OH & & OH & \end{array}$$

Continued polymer growth will result in deposition of amorphous silica from solution. Eventually, upon initiation of structural ordering and further loss of water, opaline silica, $SiO_2 \bullet nH_2O$, forms. Ultimately (millions of years, unless subjected to high temperature and/or high pressure), opaline silica transforms through a series of stages to low quartz.

A thorough discussion of the chemistry of silica can be found in Iler (1955). Frondel (1962) treats in detail the mineralogy of silica. Geochemical aspects of the subject have been reviewed by Siever (1963, 1972).

Technique

In preparing siliceous petrifactions of plant material, the following procedure is employed. First of all, the specimen to be mineralized is boiled in water until it is thoroughly waterlogged and gas free. Next, it is alternately immersed in water and ethyl silicate contained in separate ordinary canning jars. During treatment, the jars are sealed with rubber gaskets and stored in an oven maintained at 70 Celsius. Time of exposure to each reagent is not critical and can vary from a few days to a month or more. The sequential operation is continued for a period of from several months to a year or more[4]. Several times during the course of treatment, when in ethyl silicate, the jar is removed from the oven, uncapped, and placed into an evacuating chamber. There it is subjected to vacuum for approximately one half hour or more to facilitate diffusion of liquid phase into the specimen. While the wood is immersed in ethyl silicate, caution must be exercised to avoid gelation of the entire fluid in the jar. This is probably brought about by drainage of excess water from the specimen. Should polymerization exterior to the specimen be indicated by a notable viscosity increase or by the appearance of cloudiness in the reagent, the specimen is immediately transferred to a fesh volume of ethyl silicate or advanced to the water cycle. During the final cycle in water, a

[4]The optimum conditions for the procedure — time of exposure to each reagent and of the entire sequential operation, temperature and pH during each stage of treatment, etc., are not known. Until the ideal parameters of the process are established, it is suggested that the wood be immersed in each reagent at four-day intervals, at seventy degrees, and that the sequential operation be continued for a minimum of three months. The procedure is most effective with small specimens of wood (less than 3 cm^3) and large volumes of ethyl silicate (more than 500 cm^3). Afterwards, the specimen should be stored in water.

small amount of nitric acid is added (about 1 ml of acid per 250 ml of water) to hasten hydrolysis of the organic silicate within the wood. Since prolonged or repeated breathing of ethyl silicate vapor can be harmful, contact with this reagent should be minimized as much as possible.

Removal of all organic matter from the silica-impregnated specimen of plant material to form a lithomorph, i.e., a petrifaction free of organic matter, is accomplished in a fume hood by oxidation with Schulze's solution — a mixture of concentrated nitric acid and crystals of potassium chlorate (Jane, 1970). The specimen is placed in the acid in a beaker and then the beaker is heated gently. While warm, crystals of potassium chlorate are carefully added. Oxidation is continued until all organic matter is removed. Time of treatment varies from only a few hours to several days or more, depending on the size and permeability of the specimen. Completeness of removal can be tested for by heating the specimen in concentrated sulfuric acid. Should a trace of organic material be present in the lithomorph, it will become discolored and develop a yellow tinge. Larger amounts of organic material will turn the synthetic petrifaction black. After oxidation, the lithomorph is carefully washed and then stored in water. Upon drying out, there is a tendency for silica to develop minute fractures and to partially granulate. Slides for microscopic study in white light are prepared by gently macerating the lithomorph and mounting the macerate upon the slide with glycerine jelly.

Discussion of the Technique

This technique differs from that of Drum (1968a, 1968b) in that the silicification is accomplished in molecular silicic acid in solution at pH conditions near neutral and the degree of impregnation is greater to the extent that the siliceous replica does not readily disaggregate upon loss of its organic template.

Further improvement of the laboratory technique will probably depend largely upon the successful modification of two factors. First, it will be necessary to achieve a more thorough penetration of mineral matter into the specimen, particularly within and across cell walls. This may require some chemical alteration or modification of the wood constituents to make the wood more permeable to fluid infiltration and more susceptible to silica uptake. Second, it would be desirable to render more permanence to the siliceous lithomorph. Further induration could be achieved if water content were lowered and some semblance of crystallographic order imparted, without effecting excessive contraction and disaggregation in the lithomorph — i.e., by converting the silica to opal-CT or, better, opal-A, without any appreciable distortion or destruction in form.

The use of ethyl silicate as a source of silica for laboratory studies of the petrifaction process provides several distinct advantages over the use of other silica sources such as colloidal silica suspensions, alkaline solutions of silicate ions, and saturated solutions of silicic acid.

First of all, the form of soluble silica released from ethyl silicate upon decomposition is monomolecular silicic acid, the most probable silicifying agent operative in natural processes. This is the only common form of soluble silica found in natural waters, both fresh and marine (Siever, 1972). Furthermore, being of small size and in true solution, these molecules can penetrate cellular openings too small to accommodate passage of species of colloidal-sized dimensions.

Secondly, ethyl silicate is an unusually rich source of silicic acid. A saturated aqueous solution of monomolecular silicic acid contains only about 1.4×10^2 ug. of the acid per ml of solution (equilibrium solubility). The same volume of ethyl silicate, on the other hand, has the potential for releasing 4.3×10^5 ug. of the acid, a three thousand-fold increase. Moreover, the silicic acid is released inside the wood within cellular interstices where it can immediately interact with the woody chemical constituents.

Thirdly, the ethyl silicate system is free of alkali, permitting experiments to be performed under near neutral conditions and, therefore, more in keeping with conditions inferred for the natural process. In contrast, even very weak solutions of sodium metasilicate are strongly alkaline.

Fourthly, the use of an organic fluid helps to prevent pit aspiration, thereby maintaining communication among cells. Aqueous solutions, on the other hand, promote adhesion between the torus and pit border, thereby tending to obstruct fluid diffusion through the xylem tissue (Comstock and Côté, 1962).

Macroscopically, the resulting lithomorphs closely resemble a number of natural petrifactions of geologically young age. Comparable specimens include (1) a monocotyledonous wood (*Cordyline* sp.) of Recent age (mineralized with silica as a consequence of burial in volcanic ash from an eruption in 1886 of Mt. Tarawera in New Zealand, (2) a silicified coniferous wood from Wyoming, radiocarbon dated at less than 3000 years b.p., and (3) a silicified dicotyledonous wood of Miocene age from Colorado. The freshly formed silica of the synthetic lithomorphs, although brittle, is ordinarily sufficiently coherent and continuous to permit removal of all organic matter without damage in form or structure of the lithomorph. It is highly permeable and will imbibe water readily, becoming less opaque and more translucent in doing so. Compositionally, it is a silica gel with appreciable water content; crystallographically, it is essentially amorphous. Its x-ray diffraction pattern (highly disordered alpha cristobalite) is like that observed by Jones et al. (1964) for most natural opals (opal-C), such as the common 'potch' associated with precious opals. The aforementioned less than century old natural petrifaction from New Zealand was x-rayed also and the pattern obtained was identical to that obtained from the synthetic lithomorphs.

Although the lithomorphs generally are not of sufficient strength and induration to permit preparation of transverse thin sections for microscopy purposes by conventional techniques or without first embedding, macerations of longitudinal sections can be easily prepared by simply teasing apart the siliceous tissue replica with a dissecting needle. Scanning electron micrographs and white light photomicrographs of sections prepared in this manner appear in Plates 1 through 4. The transverse sectional views appearing in the scanning electron micrographs in Plates 5 and 6 were prepared by fracture of the specimen to expose a fresh cross-sectional surface and then mounting the specimen upright on an aluminum stub. It is apparent from these micrographs that even the detail of such delicate cellular features as the bordered pits in conifer tracheids and scalariform perforation plates in angiosperm vessel elements has been faithfully replicated in silica. These micrographs of silica replicated features in the synthetic lithomorphs are essentially indistinguishable from those prepared from untreated specimens of unmineralized wood. Moreover, applicability of the technique is not restricted to woody tissue alone. It has been used successfully with other forms of plant tissue, including cotton fibers, fungi *(Agaricus campestris* and *Polyporus betulina),* and an algal mat (Figs. 6 and 7, Plate 3).

The micrographs appearing in Plates 1 through 6 are fully described in the explanatory texts accompanying each illustration. A few additional comments appear below and in the following section.

The siliceous deposits formed within the contempory woods by treatment with ethyl silicate have a particulate texture under high magnification (see lumen casts in Fig. 4 of Plate 1, Figs. 1 and 4 of Plate 5, and Figs. 1 and 2 of Plate 6), which conforms to the dense variety of silica observed by Scurfield et al. (1974) in the ray parenchyma cells of some living plants. This particulate texture appears to diminish with increasing proximity to wood substance.

Also, the parallel series of siliceous rungs appearing on the silicified wall of the vessel element lithomorph pictured in Figure 3 of Plate 4, and the siliceous deposits in the pit cavities of the ray parenchyma cells shown in Figure 4 of the same plate, are two additional features which have been observed by Scurfield et al. (1974) in the tissues of certain living plants.

As suggested by these authors, perhaps the natural deposition of amorphous silica in the vascular tissue of certain plants may represent the very earliest stages of the petrifaction process occurring in non-living wood and may provide some information into the mechanism of the process.

III. A Physical Model of the Silicification Sequence

The inferred mode of emplacement of silica, with respect to histological detail in wood, during the incipient stages of the process, is schematically depicted with the model in Plate 7. In this illustration, wood substance is portrayed in white, and silica in black. Figure (a) represents a portion of two adjacent tracheid walls, including a bordered intercellular pit-pair, of a specimen of wood prior to mineralization. The torus, which is not critical to this discussion, has been purposely left out of the drawing, in order to impart greater clarity to the model.

Figure (b) represents the beginning stage of wood silicification. The upper figures differ from the lower only in the extent of mineral deposition, the quantity being greater, - essentially filling the entire pit chamber, in the latter case. The distinction is drawn now for reasons which will become clear shortly. In this early stage of the process, silica deposition occurs primarily upon the more accessible cellular surfaces in woody tissue, particularly on the inner cell wall forming the perimeter of the lumen and on the lining of the pit chamber. Growth of the deposit is directed outwards with further mineral input. If deposition is limited to the extent shown in part (b), and the specimen is macerated, i.e., all wood substance is oxidatively removed and the siliceous lithomorphs of the tracheids separated from one another, the structures pictured in part (c) will result. It might be noted here that the ease with which silicified vascular plant tissue can be macerated is a reflection of the extent to which silica has penetrated across cell walls and into the intracellular organic substance.

With the model just described, a basis is provided for interpreting the morphological characters observed in siliceous lithomorphs, both synthetic and natural, in terms of their development. For example, the siliceous discs appearing in the micrographs of the petrified specimens of the Taxodiaceae (Plates 2 and 3) are infillings formed within the pit chamber. The biconvex lenses in Figures 1 through 5 in Plate 3 correspond to the lower figures of the model in Plate 7, where deposition of silica has essentially filled the entire cavity of the pit chamber. Upon maceration, with the separation of individual tracheids, these near-solid lenses remain intact. Depending upon the exact point of detachment of the lens from the wall in the region of the pit aperture, the lens will assume a superimposed architecture of either a short protruding knoll or knob (Fig. 3 in Plate 3) or a shallow hollow or cavity (Fig. 4 in Plate 3). Because the attachment of the lens to each adjoining cell wall replica is rather tenuous[5], owing to the relatively small diameter of the pit apertures and, hence, of the mineral depo-

[5]When silicification proceeds to more advanced stages, with considerable mineral impregnation of wall substance, extensions of silica, other than that through the pit aperture, probably exist between the wall and pit chamber, permitting more firm attachment.

sits extended within, both attachments are sometimes broken, causing total detachment of the lens from the rest of the cell. Note the absence of several lenses in a number of the micrographs, especially in Figure 5 of Plate 3.

The single concave lenses appearing in Figure 4 of Plate 2 correspond to the upper figures of the model, in which silica did not build away appreciably from the pit chamber surfaces, leaving their centers empty. Upon maceration, these hollow discs become divided, each symmetric half remaining with its adjacent wall replica.

Even in the earliest stages of silicification, however, it appears that some silica does penetrate the cell wall and does deposit within the wall in intimate association with organic substance. For example, the degree of petrifaction achieved with the ethyl silicate technique does go somewhat beyond that depicted in part (c) of the model. In some cases, appreciable deposition occurs in the middle lamella region (Fig. 3 in Plate 5). Furthermore, the micrographs of the organic-free specimens in Plates 5 and 6 appear to indicate some silica did deposit within the secondary layer of the cell wall. Some of the lumen plugs, upon contracting, tore away portions of the wall, suggesting penetration and firm attachment with wall substance. Since void space in the relatively densely packed organic substance of an essentially undergraded cell wall is small, the silica deposited in this condition can be expected to be somewhat limited, fragile, and discontinuous — hence, subject to facile disruption and loss from the lithomorph upon removal of all organic matter during maceration. This might account for the total absence of silica in the former wall space of the deorganicized ray parenchyma cells appearing in Figure 4 of Plate 4.

The foregoing discussion was concerned largely with wood in only its beginning stages of petrifaction, when wood substance is still present and, though probably having undergone some chemical alteration, is still structurally intact. While in this condition, the bulk of the silica deposition occurs on the exposed cell wall surfaces, from which it builds outwards to fill the void spaces, particularly the lumina. The outline of the siliceous lumen casts shown in the figures of Plates 5 and 6 indicate deposition began on the surface of the lumen perimeter and then grew concentrically into the lumen interior with further input of silica. But, upon setting, the lumen casts underwent substantial contraction. In nature, the shrinkage probably would not have been so extensive, as the environment would have been more protective than that in the laboratory. Changes in parameters such as rate of water loss, temperature fluctuations, etc. would have been moderated. Also, further input of silica would probably have entered the void spaces created in contraction, maintaining the total occupation of the lumen. Perhaps this may be how the agate-like concentric bands of silica, so commonly found in the lumina of cells of naturally silicified woods, arise.

Since the wood is serving as an active template for silica deposition during petrifaction, the condition of the wood prior to mineralization, i.e., the nature and extent of deformation and deterioration of wood structure at the commencement of impregnation, will be reflected in the quality of the retention of histological detail achieved in the petrifaction. The silicified *Ginkgo* woods from the John Day Basin of north central Oregon, with their near perfect preservation of structural detail, must have been essentially undegraded when initially silicified some 40 million years ago.

As the silicification process proceeds to more advanced stages, the woody template, which initially sets the pattern and form of silica emplacement, begins to deteriorite, creating open space in which subsequent silica influx can deposit. In this manner, the entire cell wall may be filled with silica.

The time sequence of silica deposition with respect to the subdivisions of the cell wall probably follows the same sequence as that observed by Barghoorn (1952) for cell degradation. In other words, after penetration of the middle lamella region, deposition next occurs largely within the S2 layer of the secondary wall. The other structural units of the wall, which are volumetrically much smaller but more resistant to decay due to lower polysaccharide to lignin ratios, remain physically intact at the perimeters of both sides of the wall during silica infilling of the S2 layer. In this manner, they contribute to the maintenance of wall shape and form during build-up of silica within the cell walls. Hence, these more resistant structural units provide for the retention of the physical integrity of structure at the anatomical level of morphology. These factors collectively permit direct comparison of silicified woods with their living counterparts in botanical identification of the woods. Hence, silicification is not a single stage event, but a process which occurs in a continuous sequence of stages. It should be further noted here that silica, when in the amorphous or near-amorphous condition of a gel or low ordered opaline state, is hygroscopic and highly permeable to fluid flow. And the rate of transformation to the relatively impervious crystalline state is extremely slow, even in terms of geologic time. Thus, even long after silicification has begun, wood substance can continue to degrade and migrate from the specimen, thereby providing additional space for further silica deposition. Moreover, the degradation products from the former process may have a role in promoting or abetting the latter process, as both proceed simultaneously (see Section IV). In nature, this mechanism of wood removal and directed mineral deposition is never totally perfect. Nor does it usually go to completion. Most silicified woods, even many which have converted to microcrystalline quartz, contain some organic matter. A specimen of *Callixylon* wood from the Olentangey shale of Ohio, for example, is 4.1 per cent by weight in organic carbon, suggesting much of the original wood substance is still present, albeit chemically altered. This specimen is Upper Devonian in age, approximately 400 million years old!

Many mineralized woods, when subjected to stress, tend to fracture radially — in the same preferred direction of breakage displayed by non-mineralized woods when they check and rupture through differential shrinkage upon drying. This tendency toward radial longitudinal fracture in many petrified woods can probably be attributed to a combination of two factors — one, the presence of substantial amounts of wood substance in the petrifaction and, two, an uneven distribution of silica through the specimen, with a pattern of discontinuities predetermined by the original wood structure at the time of petrifaction. In those cases in which the silica underwent crystallization to quartz, with substantial crystal growth not dictated by the structure of the original organic template, no preferred direction of fracture can be expected during breakage.

If a specimen of wood should lose all organic substance during silicification and, in so doing, is entirely infilled with only silica, a question which arises is how can one recognize the object as a result of petrifaction. If the silica was deposited continuously and homogeneously, completely filling the entire volume of the former sample of wood, it is quite likely that one could not recognize it, as no cellular structure; not even in thin section, would be apparent. Moreover, without any clear organismic identity, it is questionable whether such an object can even be referred to as a petrifaction. It is quite possible that some of the opaline and cherty objects occurring as scattered, isolated bodies in sedimentary rock units may have originated in exactly this fashion. It is not uncommon to find in a locality of silicified woods, specimens which are recognized as such only because of their associated occurrence with petrifactions displaying traces of botanical identity. Specimens in a single petrified forest usually display considerable variety in degree of structure retention. And even in certain individual petrifactions, it is quite common to find that some portions are totally devoid of any structure. It might be noted here that sometimes gross morphology such as growth rings is retained in silica, providing the only evidence that the object once was a part of a living system.

The visual appearance of cellular detail in a petrifaction can be retained or assumed in more than one manner. These are:

(a) by the actual presence of wood substance itself, in essentially intact form;

(b) by degradation products formed from deteriorated wall substance, immobilized in silica at or very near their site of origin;

(c) by variations in the mineralogy (color and texture) of different generations of silica, deposited at intervals during the silicification sequence (Schopf, 1971), and the presence of impurities in trace amounts;

(d) by infiltration of foreign tar-like organic matter into the specimen (Went, 1972);

(e) by patterns of entrapped air which darken silica surfaces (Went, 1972).

Before continuing further, it should be emphasized that the emplacement of silica in wood does not proceed as a 'molecule-for-molecule' replacement of organic polymers by silica, a popular misconception which persists to this day, in spite of a number of reports offering evidence to the contrary (St. John, 1927; Arnold, 1941; Barghoorn, 1960; Schopf, 1971). Petrifaction is fundamentally a process of infiltration and impregnation, wherein wood substance serves as an active template for silica deposition. Examination of the lithomorphs appearing in Plates 1 through 6 strongly support this postulate.

In the specimens treated with ethyl silicate, wood structure is faithfully replicated in silica without any appreciable concomitant loss of wood substance. Also, in many natural specimens which are thoroughly silicified — such as the specimen of *Callixylon* wood mentioned earlier, much of the original woody tissue is still present and can be recovered by dissolution of the silica with concentrated hydrofluoric acid. Furthermore, a molecular replacement process involving such chemically dissimilar molecules as those in the quite diverse ligno-holocellulosic groups with those of soluble silica is theoretically unsound and chemically untenable.

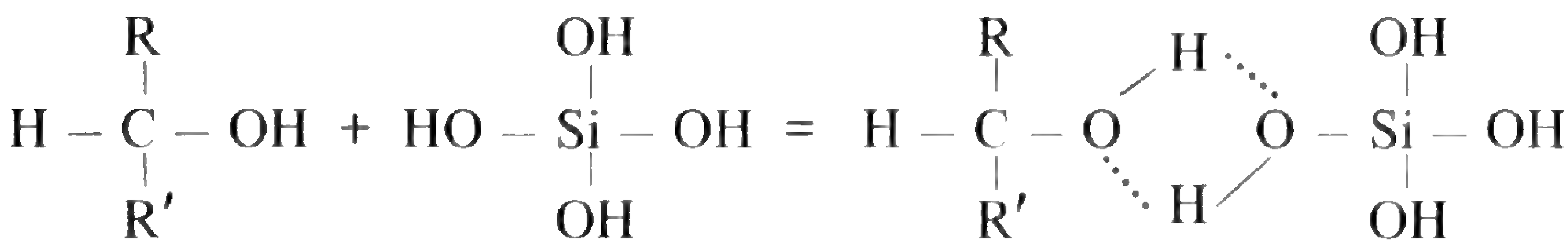
IV. A Chemical Hypothesis of the Silicification Process

The emplacement of silica on vascular tissue of plants during petrifaction may involve the establishment of actual chemical bonds, probably hydrogen bonds, between the two materials.

The principal chemical components of vascular tissue are (a) the holocelluloses — a group of polysaccharides, including cellulose, and (b) the lignins — complex polymers composed of phenylpropane units. Both materials, as well as their degradation products, contain abundant functional groups, particularly the hydroxyl group, that are capable of forming hydrogen bonds.

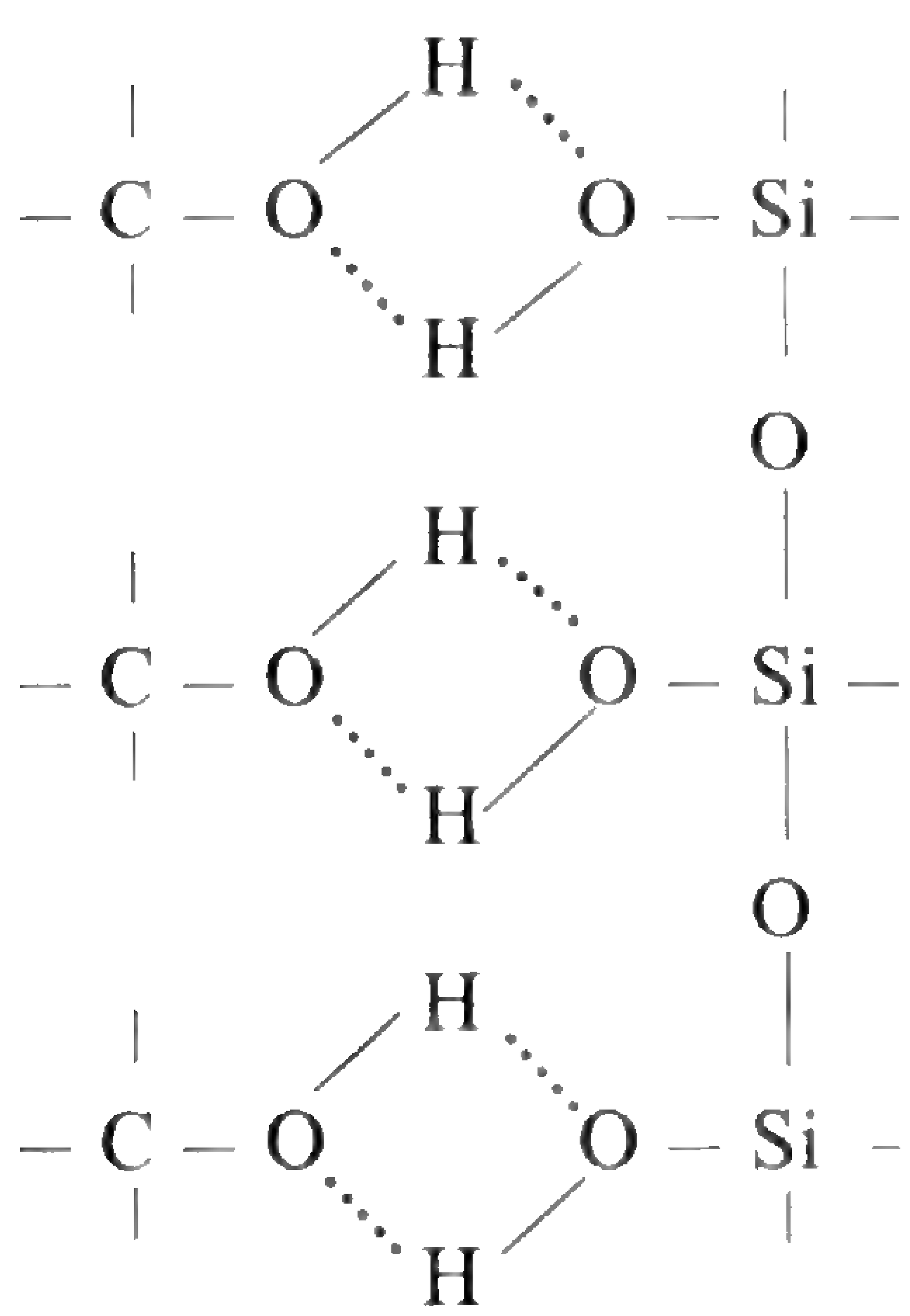
Molecular silicic acid is the most probable silicifying agent involved in petrifaction. Suspended colloidal particles do not exist in solutions dilute in silica and, furthermore, are too large in size to penetrate into the finer cellular interstices — a requisite for faithful reproduction of histological detail. The silicate ion is also an unlikely agent as it forms only in solutions of pH above about 9 — a degree of alkalinity seldom attained in natural situations. Silicic acid, on the other hand, is the only common form of soluble silica found in nature. It is the form of silica released in volcanic ash devitrification and in clay mineral diagenesis (Siever, 1957). Silicified woods almost always have an environmental history which includes either former burial in ash or occurrence in altered sediments — especially for former event. With four hydroxyl groups per molecule and molecular dimensions of relatively small size, the probability of silicic acid penetrating and interacting strongly with vascular tissue, through hydrogen bond formation, would appear to be high.

This suspected interaction is illustrated below.



Thus, as silicic acid in dilute solution infiltrates and permeates the wood, it is selectively removed by oriented attachment to the molecular constituents of the wood by means of hydrogen bond formation. With continued build-up in concentration inside the wood, the silicic acid monomers will begin to interact and polymerize, forming siloxane bonds and eliminating water. With still further polymer growth, silica begins to deposit as a film along cellular surfaces and, in so doing, replicates the histological character of the wood.

The actual agent in the mechanism of petrifaction through hydrogen bond formation may not be monomolecular silicic acid, however, but a water soluble, low molecular weight polymer thereof. R.K. Iler (personal communication) suggests polysilicic acid, with its capacity for forming multiple hydrogen bonds, as the more probable agent of petrifaction.



Although not of common occurrence nor of long-term stability in natural waters undersaturated with respect to silica, polysilicic acid is known to occur in nature, forming from the very rapid weathering of certain aluminosilicates with a high silicon to aluminum ratio, such as plagioclase and some of the mafic minerals (R. Siever, personal communication). When released into natural waters, it is likely to depolymerize to monosilicic acid. But if wood is encountered before depolymerization can take place, there is the possibility it might be absorbed into the wood through hydrogen bond interaction with the hydroxylated wood constitutents. Thereafter, through further polymerization as before, the silica can build up as a gel of gradually increasing density. Hence a petrifaction results. It would be most interesting to learn if the specific types of volcanic ash, which have served as sources of wood silicification in the past, do truly release polysilicic acids when they are fresh and first exposed to the elements of weathering.

It is not clear whether or not a certain amount of degradation is essential for attaining a high degree of petrifaction under sedimentary conditions. Decay would significantly increase permeability of cell walls, create greater void space in which more silica could be deposited, and perhaps more importantly, increase the number of active sites for potential bonding interaction. The removal of one or more of the wood constituents — hemicellulose, cellulose, or lignin, would leave free sites available for bonding on the molecules remaining. Also, the degradation products from both the lignins and the polysaccharides, e.g., phenolic aldehydes resulting from mild oxidative degradation (either microbial or chemical) of lignin or pentose or hexose monomers from polysaccharide hydrolysis, would result in chemical entities with more active sites per unit volume than their parent materials. Such degradation products might not immediately migrate from the cell wall region from which they were derived and might possibly be immobilized within the cell wall by reaction with silicic acid. Unless decay has progressed to an advanced stage, this situation would not be detectable by light microscopy alone.

Consideration of the nature of water in wood lends further plausibility to the suggestion of bonding involvement in petrifaction. The hysteresis[6] effect in wood is attributed to the presence of hydrogen bonds among the polysaccharides in

[6]Hysteresis is the term applied to the variance in the sigmoid moisture content — relative vapor pressure curves, depending on whether equilibrium is approached from a higher or a lower relative vapor pressure (Wise, 1944).

wood and between the polysaccharides and water, and the necessity of rupturing these bonds when passing from one condition to the other (Kretovich, 1966). Although hydrogen bonds are rather weak (ca. 105 kcal./mole) in comparison to covalent or coordinate bonds, the cumulative effect of relatively large numbers of them does impart considerable adhesive force. This idea may be extended further to account for the initial fixation of soluble silica to the woody template. Silicic acid, by virtue of its four hydroxyl groups per molecule — or even more in the case of polysilicic acid — might be expected to bond securely to the organic matrix because of its potential for forming multiple hydrogen bonds.

There are a number of observations which appear to be in accord with the theory that bonding, probably hydrogen bonding, is involved in the silicification of wood.

First, coalified wood does not silicify as well as relatively unaltered wood. This might be explained by the appreciable loss of active sites, i.e. functional groups capable of forming bonds with silicic acid, from the former during coalification. In fact, Heathcoat and Wheeler, who determined the hydroxyl percentage in coal as function of rank, failed to identify hydroxyl oxygen beyond the rank of 83% carbon (Van Krevelen, 1961).

Secondly, the quality of replication of woody structure in petrifactions mineralized with carbonate and sulfide are quite inferior to those formed from silica. Also, they are of less common occurrence. In this case, the explanation may lie in the inability of the carbonate or sulfide ions to establish hydrogen bonds with the ligno-holocellulosic components of wood and, therefore, deposition is chemically independent and non-oriented.

Thirdly, silicified woods often occur in a matrix of encasing sediment which is not consolidated with silica cement, suggesting once again that the differential affinity might be explained by the potential capacity for wood to bond with and therefore serve as a 'sink' for silica.

As a final note, it should be mentioned that in a recent study of silica in living plants, Scurfield et al. (1974) observed that silica particles often occur with starch grains or with polyphenolic material in the same cell, and suggested a casual relationship to be operative. Perhaps here too the association and mechanism of accumulation might be explained through hydrogen bond formation.

V. Geochemical Factors of the Natural Process

Summarized below are some of the more important parameters inferred for the geochemistry of the process of wood silicification, as it is postulated to proceed during natural sedimentary processes.

Agent

The most probable agent of petrifaction is molecular silicic acid — either the common monomer or some low molecular weight polymer thereof, in true solution. Colloidal silica suspensions and aqueous solutions of ionic silicate are improbable natural petrifactants for the reasons already noted in the previous section.

Site

During petrifaction, the wood is probably buried in sediment, in a topographical depression or some structural setting which allows water saturation of the sediment and waterlogging of the wood.

The cover of sediment protects the wood against rapid decay. Also, the sediment serves as an immediate and abundant source of available silica. Most commonly, this entombing sediment is volcanic ash (Murata, 1940). Petrified woods often occur in tuffs — fine-grained, compacted, atmospherically or water deposited sediments derived from volcanic ash. Volcanic ash weathers rapidly, liberating large amounts of soluble silica (see Hunt, 1972). Less commonly, silicified woods occur in sediments with no history of volcanism. This is true for a number of pre-Tertiary occurrences of petrified woods. It is also true for two acid sulfate soils of Recent age, in Thailand and in the Netherlands (Buurman, 1973). In these situations, the petrifactant is released in silicate mineral diagenesis. A number of the phyllosilicate minerals, when transforming from one type to another, with a lower silicic to alumina ratio — such as in the case of montmorillonite diagenesis to kaolinite, liberate silica (Siever, 1962).

It does not appear that siliceous thermal springs, whether acidic or alkaline, have been major sites of wood petrifaction in the past. The beginning stages of the silicification process, however, can be observed in woods taken from such springs. H.E. Merwin (in Allen and Day, 1935) macerated several wood specimens removed from the Norris Geyser Basin and other areas in Yellowstone Park, Wyoming, and found that woody features had indeed been replicated in silica. The lumen cast appearing in Figure 5 on Plate 6 was prepared by the authors from tissue taken from the interior of a large, heavily encrusted limb of lodgepole pine *(Pinus contorta)* recovered from Tree Top Spring — a siliceous thermal spring in the Sylvan Springs area of Yellowstone Park. At the time of collection, pH was 5.5 and temperature 85 Celsius. Since this spring did not exist prior to 1959, having formed as a result of an earthquake at that time, the total time of immersion of the wood in the spring could not have exceeded 13 years.

The role of water in petrifaction is of paramount importance. Water is a necessary agent for ash alteration and mineral diagenesis. Saturation of the sediment serves to exclude oxygen, thereby inhibiting deterioration of tissue structure, through the maintenance of reducing conditions. Waterlogging dispels entrapped air, and maintains the wood in a swollen and plastic state, thereby maintaining maximum permeability. Also, it is the medium for transport and dispersal of soluble silica into and through the specimen.

Conditions of temperature and pressure during petrifaction are probably very near those close to ambient shallow depth sedimentary environments. Excessive pressures would result in severe deformation of wood shape and tissue structure; excessive temperatures (greater than 100°C) would result in destruction of wood substance.

The pH of the permeating fluid, *within the wood,* during silica emplacement is probably in the near neutral or, even more likely, somewhat acidic range of the pH scale. Either highly acidic or especially highly alkaline conditions rapidly destroys all wood substance, and hence, the initial template for deposition. Furthermore, high alkalinity would prevent silica deposition. Above the pH 9, soluble silica dissociates, causing an abrupt increase in silica solubility with rising pH — whereas below this approximate value, silica solubility is essentially independent of pH (Siever, 1972). Moreover, strongly basic media would interfere with hydrogen bond establishment between silicic acid and the hydroxylated organic substances in wood.

It is quite possible that pH may undergo considerable change during the course of the process. During the initial stage of the process, pH may have been quite high (alkaline), promoted by weathering of the source material of the silica — volcanic ash, for example. Alkali and alkaline earth metal ions would be among the first components to be released to solution. This would cause a rise in pH which, in turn, would promote silica dissolution. In this manner, a large quantity of soluble silica can be concentrated which later is available for emplacement in wood as the metal ions migrate from the site and pH is lowered. In addition, perhaps the alkaline conditions might expedite the silicification process by partially removing some of the lignin polymers enmeshing the architectural framework of the wood, the cellulose microfibrils, providing greater exposure of the latter to the petrifying agent and freeing active sites on the cellulose for bonding attachment with silica. Then, with decrease in pH and lowering of silica solubility, perhaps abetted by the humic material formed earlier from lignin degradation, as well as base metal loss, silica deposition is enhanced. Organic matter in solution may further aid the process by accelerating removal of aluminum and iron. Under somewhat acid conditions, there is a much greater tendency for aluminum and iron to be chelated into mobile complex ions than silicon. The ashen gray eluviated horizons observed in the profiles of podzol soils are developed in this fashion.

Product

The physical state of silica in all newly formed petrifactions is best characterized as amorphous or nearly amorphous. During the early history of a petrified wood, the organic substance is still present and subject to deterioration, and this wood substance may ultimately be lost from the petrifaction without physical alteration of the siliceous lithomorph. This is a consequence of the highly hygroscopic and permeable nature of the initial silica deposit. The propensity of vascular tissue as a depository or sink for silica may be related to the potentiality for hydrogen bonding that exists between soluble silica and the dominant molecular constituents of wood — in particular, the polysaccharides. Any porous material can be infilled with silica by direct precipitation, but the replication of fine detail probably requires chemical 'fixing'. As noted before, the process itself is one of impregnation and emplacement — not chemical replacement. As the wood is serving as a template for deposition, faithfulness in replication of histological detail is contingent on the condition of the wood at the time of silica emplacement.

Time

In terms of geologic time, the emplacement of silica in wood, as a molecular film, probably occurs rapidly. Conversion of the initial deposit to the opaline state — a change characterized by decrease in permeability, water content, and hydroxyl content, and an increase in refractive index, hardness, and specific gravity, all consequences of the assumption toward order — probably requires a much longer time. The mineralogy of the specimen of Cordyline mentioned earlier, which can be only eighty years old at the most, lies somewhere between these two arbitrary states. The ultimate fate of all silica is transformation to low quartz. Under the conditions normally present at or near the surface of the earth, this conversion may require millions of years (Siever, 1972, estimates a time scale of from 10^7 to 10^8 years for the transformation). In the presence of organic matter, however, crystallization to quartz may be appreciably accelerated (C. Wohlberg, personal communication).

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EXPLANATION OF THE ILLUSTRATION

Plate 1. Fossil oak wood, approximately 4500 years old, from the Boylston Street Fishweir deposits, Boston, Massachusetts. Wood silicified with ethyl silicate and then polished on one transverse surface with cerium oxide powder. Specimen appearing in Figures 2 through 4 was further treated by partial etching of silica with concentrated hydrofluoric acid. Original wood was not mineralized.

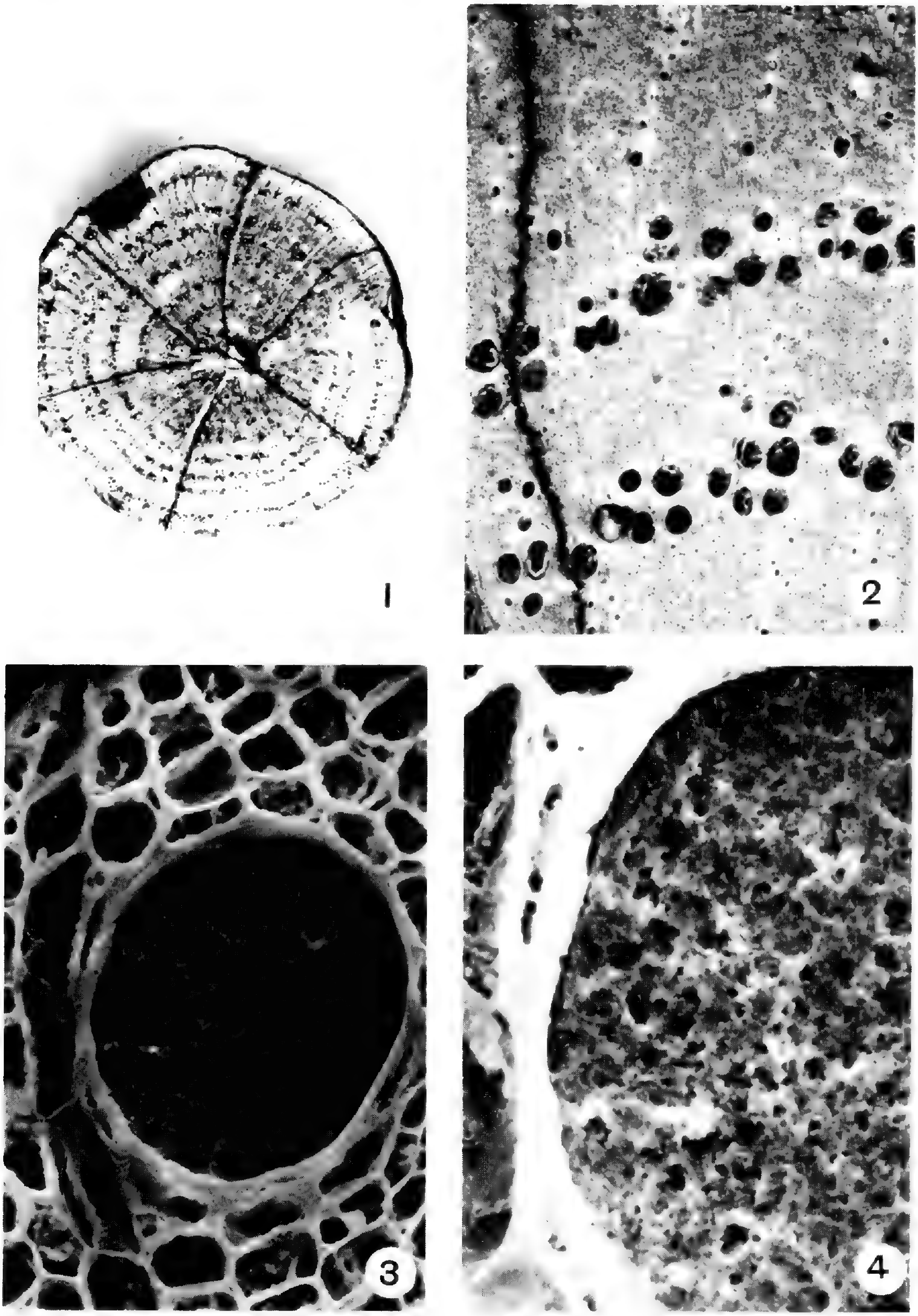
Fig. 1. White light photograph of stem cross-section. Radial fractures resulted from accidental breakage in handling. Magnification: ca. X2.

Fig. 2. Scanning electron micrograph (SEM) of a polished transverse surface sectioned from the specimen illustrated in Figure 1. X300.

Fig. 3. Enlargement of a portion of the surface shown in Figure 2. SEM. X600. Note deposits of silica in lumina of the prosenchymatous cells.

Fig. 4. Further enlargement of the above, emphasizing silica deposit in lumen of the vessel element. SEM. X1200.

PLATE 1



EXPLANATION OF THE ILLUSTRATION

Plate 2. Scanning electron micrograph (SEM) of silica replicated structures from three petrified woods of the Taxodiaceae, emphasizing tracheid end walls. All three specimens were deorganicized with concentrated nitric acid and potassium chlorate prior to maceration.

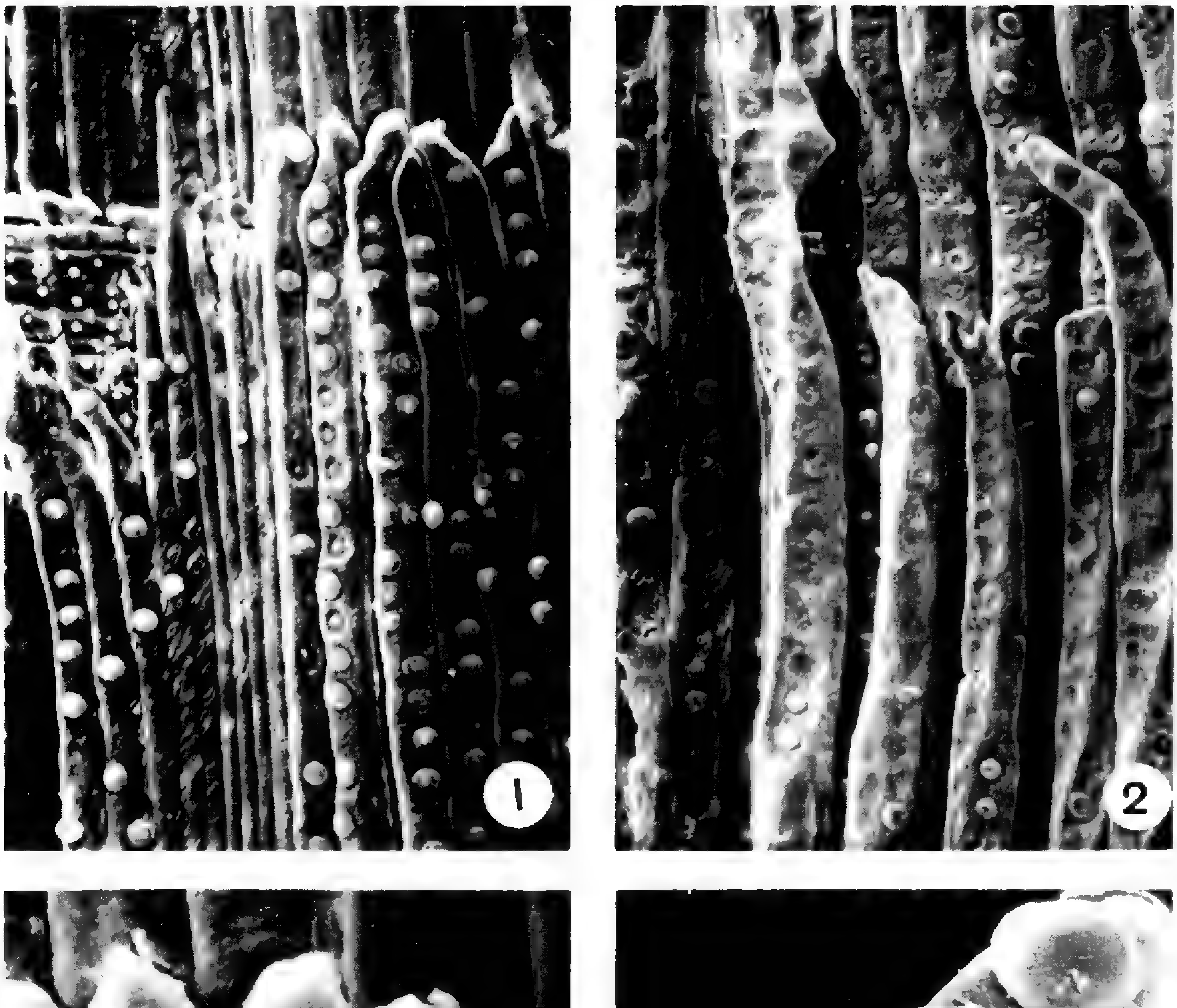
Fig. 1 Radial longitudinal view of a contemporary wood, *Sequoia sempervirens* (redwood), silicified with ethyl silicate and then deorganicized. SEM. X200.

Fig. 2. Radial longitudinal view of a naturally silicified wood of Upper Oligocene age from near Florissant, Colorado. SEM. X200.

Fig. 3. Enlargement of a portion of the surface of the specimen illustrated in Figure 1. SEM. X500.

Fig. 4. Tracheid tip from a fossil Sequoia of Niocene age from near Emigrant Gap, Sierra Nevada Mountains, California. SEM. X1000.

PLATE 2



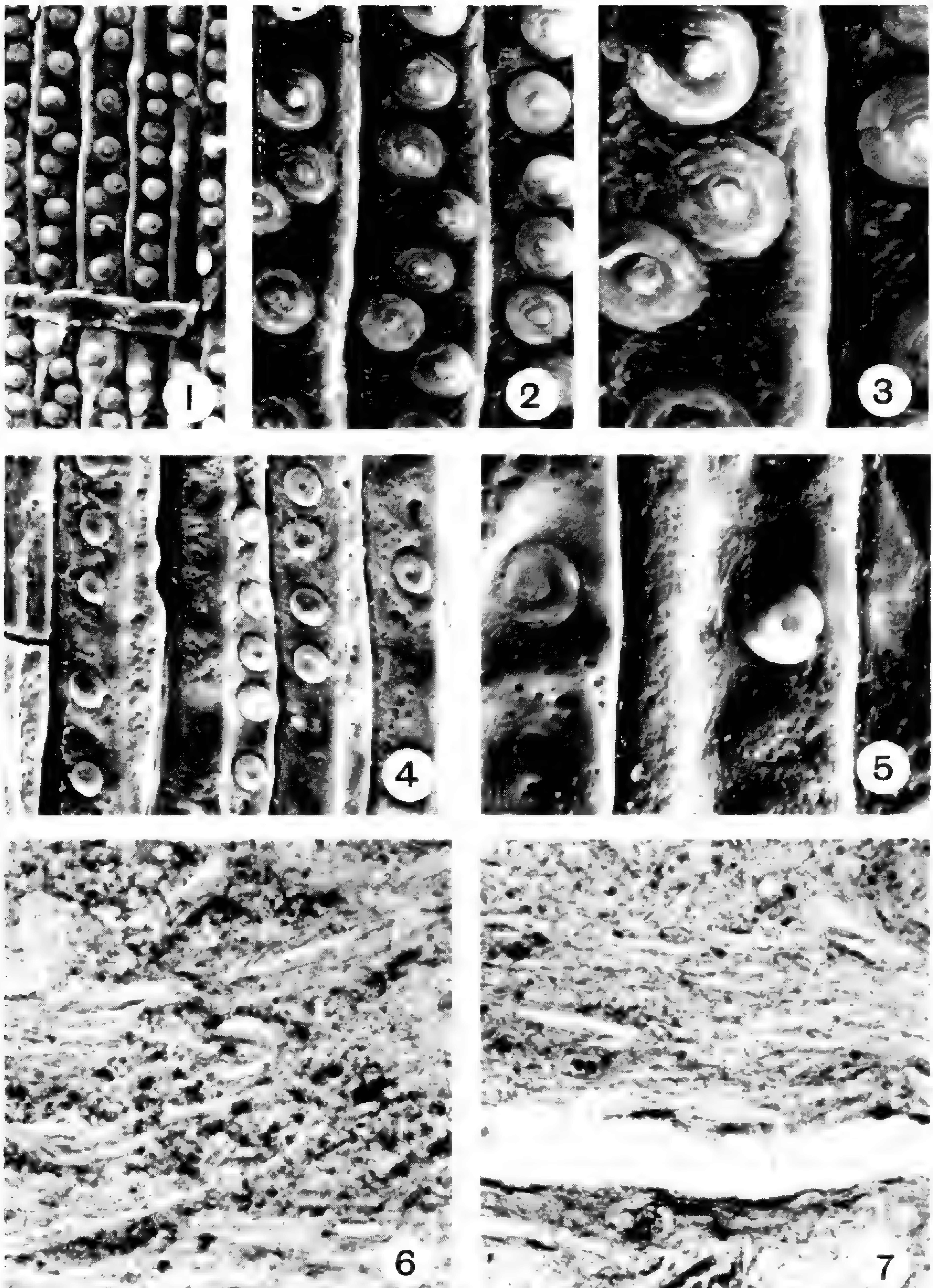
EXPLANATION OF THE ILLUSTRATION

Plate 3. Figures 1-3. Radial longitudinal views of silica replicated tracheids from a laboratory silicified specimen of contemporary *Sequoia sempervirens* (redwood). Material was deorganicized prior to maceration. SEM. Magnifications: Fig. 1 (X200), Fig. 2 (X500), and Fig. 3 (X1000).

Figures 4-5. Comparable views from two deorganicized, naturally silicified, fossil Taxodiaceae. The discs are biconvex lenses which formed within the pit chamber. These lenses tend to break away from the cell wall surfaces during preparation of the specimen for microscopy. Figure 4: Fossil Wood (*Sequoia* sp.) of Miocene age from Virgin Valley, Nevada. SEM. X300. Figure 5: Fossil wood (Taxodiaceae) of Oligocene age from near Florissant, Colorado. SEM. X750.

Figures 6-7. White light photomicrographs showing a vertical section through a multilayered algal mat from the Persian Gulf which was silicified with ethyl silicate. White area appearing in Figure 7 is a vein of silica produced during silicification. Both X260.

PLATE 3



EXPLANATION OF THE ILLUSTRATION

Plate 4. Scanning electron micrographs (SEM) and a white light photomicrograph (WLP) of cellular features from a contemporary specimen of *Gordonia lasianthus*. Figures 2 through 4 are from wood silicified in the laboratory and then deorganicized prior to maceration.

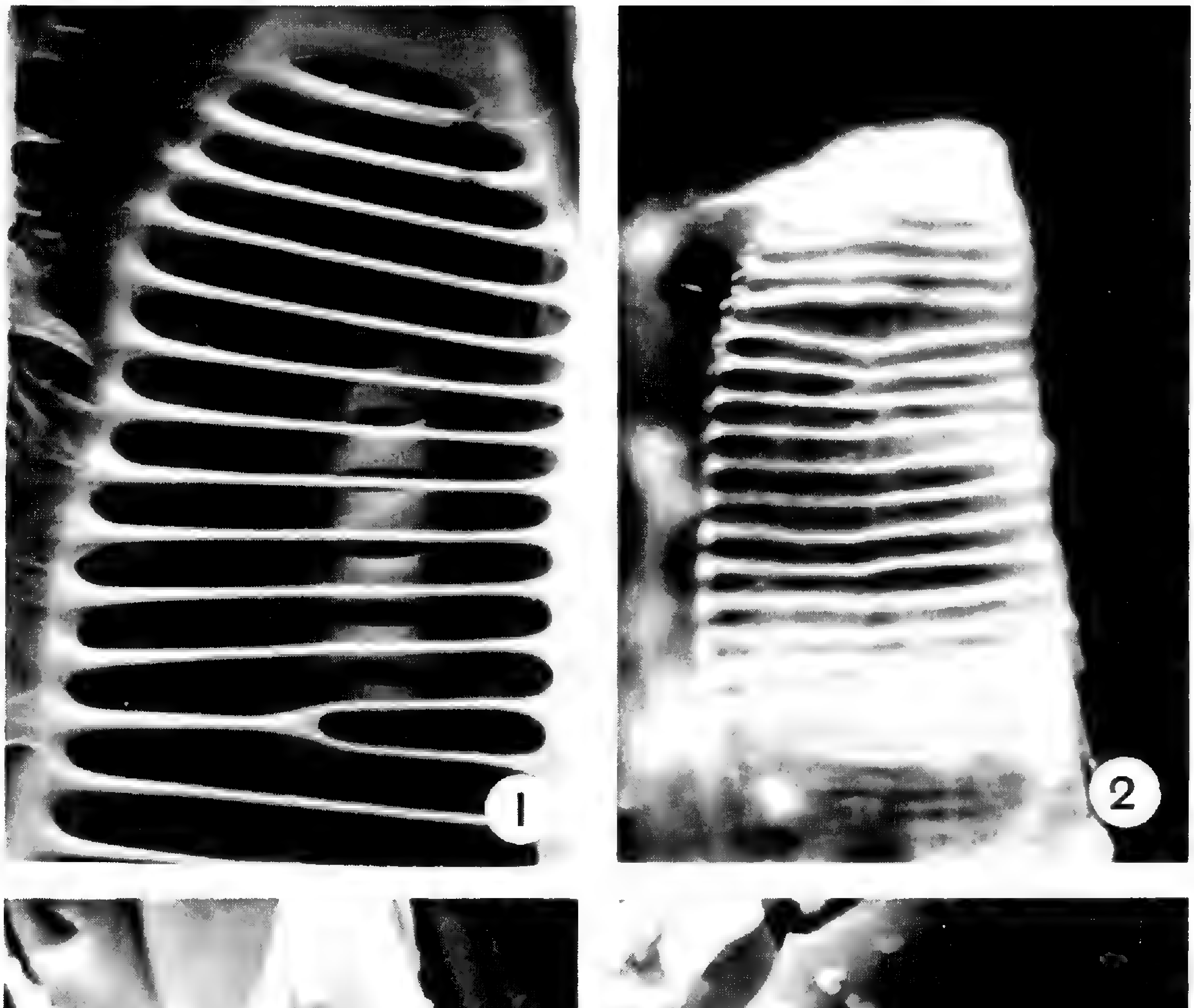
Fig. 1. Scalariform perforation plate. Untreated wood. SEM. X1000.

Fig. 2. Siliceous lithomorph of a scalariform perforation plate. WLP (reflected light). X570.

Fig. 3. Lithomorph of a vessel element. The series of bars in the lower right corner are plugs of silica which deposited in the openings of a scalariform pit member between this vessel element and an adjoining cell. SEM. X500.

Fig. 4. Lithomorph of ray parenchyma cells, showing impregnated pit cavities. SEM. X2000.

PLATE 4



EXPLANATION OF THE ILLUSTRATION

Plate 5. Scanning electron micrographs (SEM) of laboratory prepared petrifactions of contemporary redwood, *Sequoia sempervirens*. All four figures are transverse fracture sections. Specimen in Figure 4 was 'etched' with hot nitric acid-potassium chlorate mixture to remove wood substance.

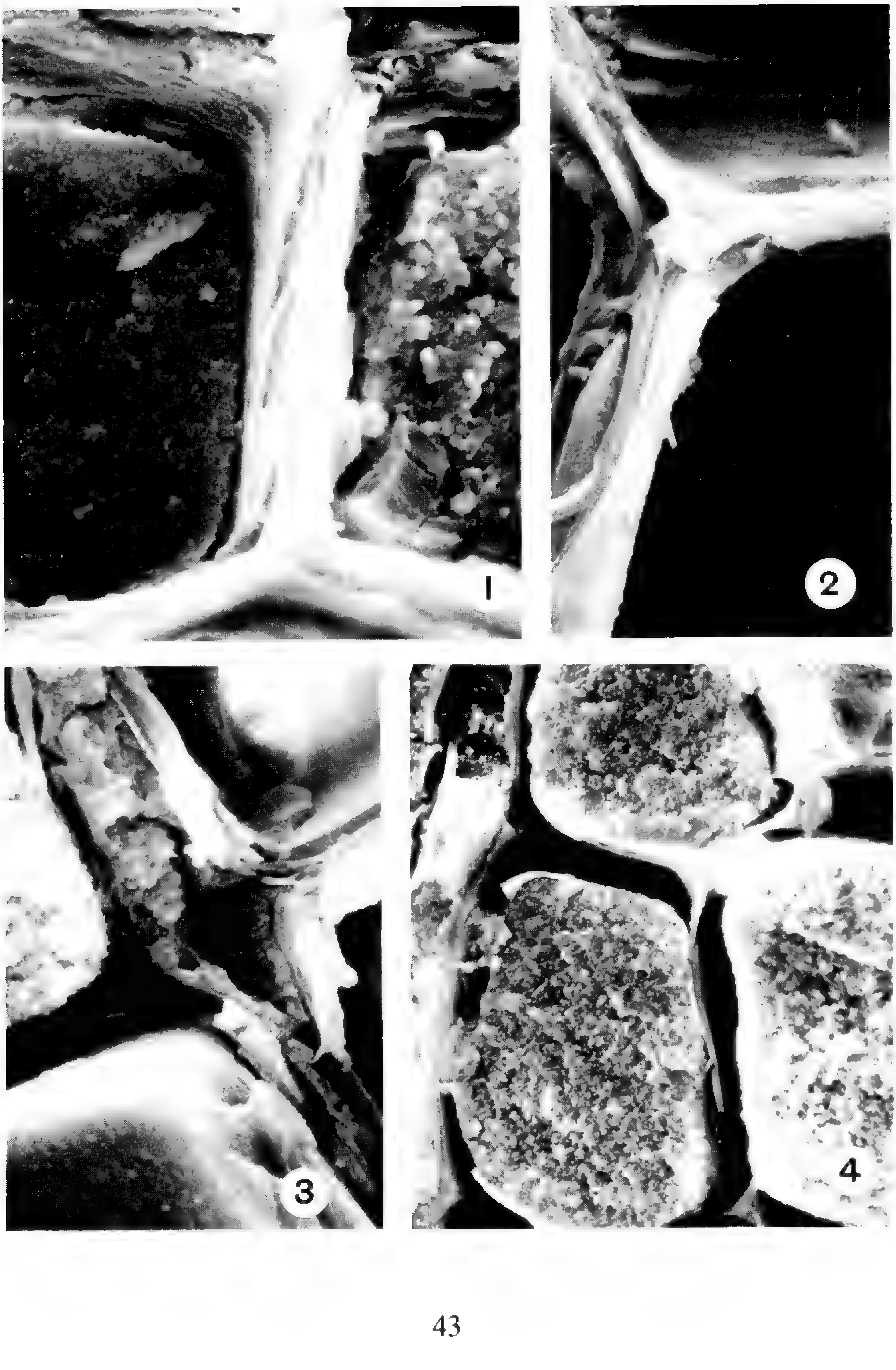
Fig. 1 Tracheid lumina infilled with silica deposits. SEM. X2000.

Fig. 2. Juncture between three tracheids, showing siliceous lens in pit chamber (left). Shredded tissue overlying chamber, resulting from fracture of the specimen during preparation for microscopy, helped to prevent its loss. SEM. X2000.

Fig. 3. Juncture between several tracheids, showing silica deposits in the middle lamella region. SEM. X2000.

Fig. 4. Lumen casts of tracheids and ray parenchyma cells in the deorganicized sample. SEM. X1000.

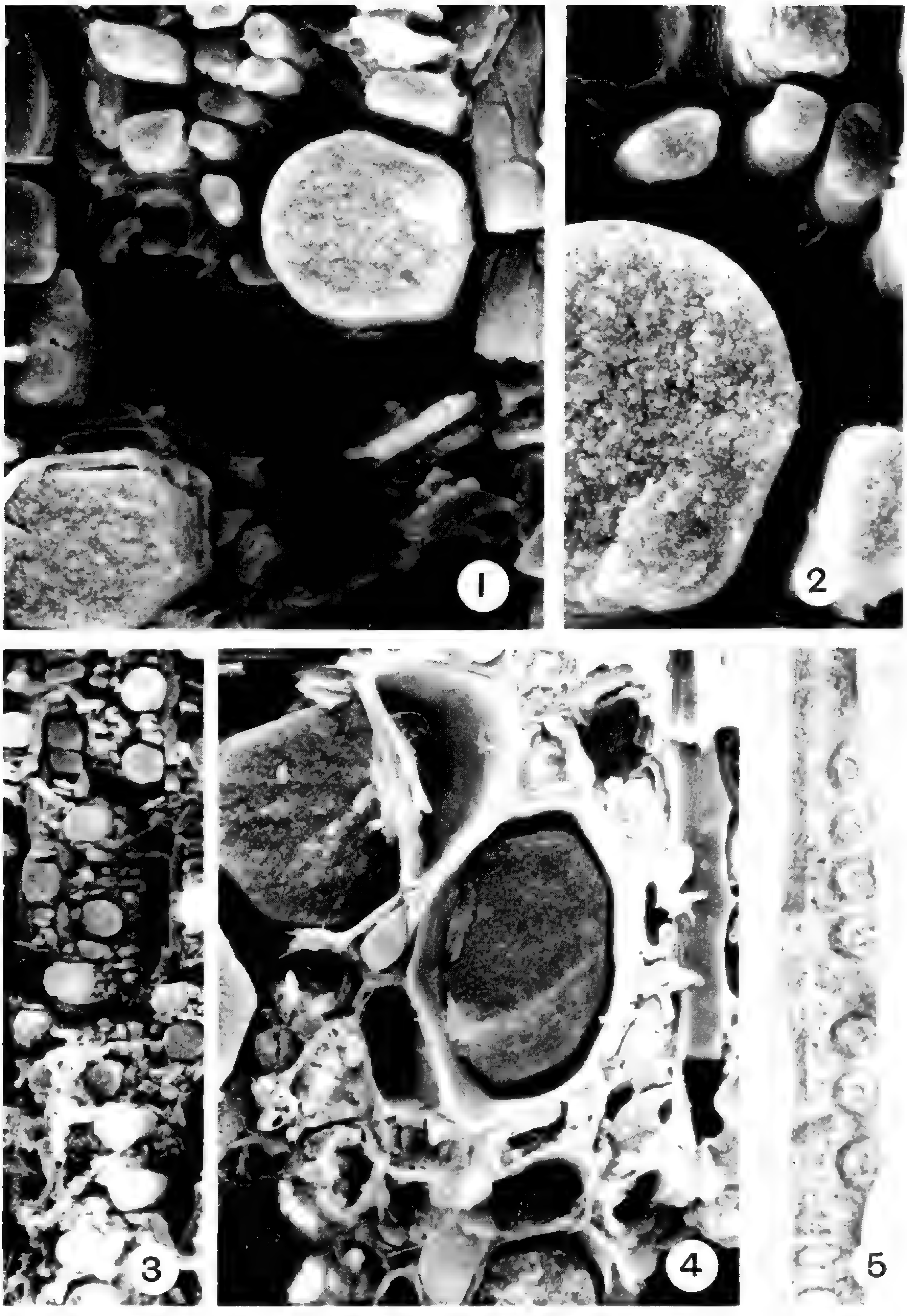
PLATE 5



EXPLANATION OF THE ILLUSTRATION

Plate 6. Figures 1 through 4 are scanning electron micrographs of transverse fracture sections of artificially silicified specimens of contemporary *Gordonia* wood. Figures 1 through 3 show one sample after organic matter was removed by oxidative 'etching'. In Figure 4, wood substance is present. Featured are casts of tracheid and vessel element lumina. Magnifications are: Fig. 1 (X500), Fig. 2 (X1000), Fig. 3 (X100), and Fig. 4 (X500). Figure 5 is an internal cast of a tracheid lumen from a specimen of lodgepole pine. This specimen came from a siliceous hot spring (Tree Top Pool) in the Sylvan Springs area of Yellowstone National Park. Prior to microscopy, organic matter was removed by oxidative treatment. White light photomicrograph. X450.

PLATE 6



EXPLANATION OF THE ILLUSTRATION

Plate 7. Model of mineralization of wood (white) with silica (black), schematically relating silica deposition to vascular tissue structure.

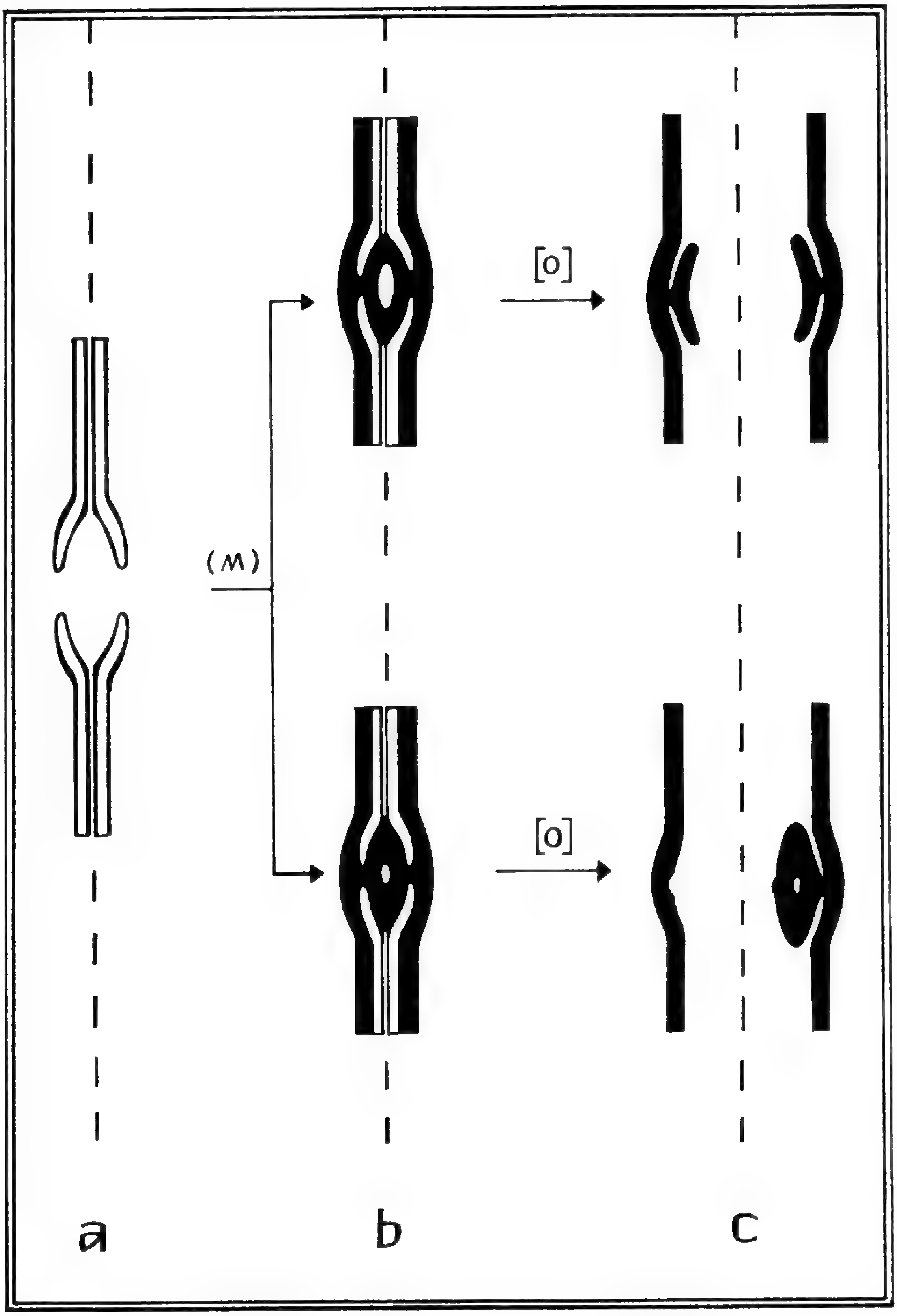
a. Unmineralized wood. Wood prior to mineralization, showing two adjacent tracheid walls and their bordered pit pair interconnection.

b. Petrified wood. Wood during early stages of impregnation with silica, with silica coating cell wall rimming the lumen and partial (upper) or complete (lower) infilling of pit chamber.

c. Lithomorph. Silica replicated structure, devoid of woody substance. Tracheid separated by maceration.

This model is discussed in further detail in the text.

PLATE 7



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THALIA MARAVARA AND THE RIGID AIR-BLOSSOM

Notes on some species of *Acampe* (Orchidaceae)

GUNNAR SEIDENFADEN*

Hendrick Adriaan van Rheede tot Draakestein had prepared the 12th volume of his "Hortus Indicus Malabaricus" before he died in 1691, but possibly the century had turned before his drawing of *Thalia Maravara* was published as the first representative of the later described genus *Acampe* Lindley. See Plate 8. To trace the history of this plant (Rheede 1703: t.4) with all — or at least some — of its ramifications through 250 years, one must enter into the dense jungle of orchid taxonomy and nomenclature with all the dangers of getting on the wrong trail or being completely lost. In the case of *Thalia Maravara*, we are today still not in the clear, for the name *Acampe praemorsa* (Roxb.) Blatt. & McCann, under which it is usually known, is nomenclaturally illegitimate and taxonomically uncertain.

In the hothouses of the Botanical Gardens of Copenhagen, for many years we have grown several large plants which I collected in Thailand, and which in "Orchids of Thailand" (Seidenfaden & Smitinand 1965: 703, Fig. 523) we called *Acampe longifolia* Lindl. Some years ago, P. F. Hunt (1970: 98) categorically stated that the correct name for Lindley's *Acampe longifolia* was *A. rigida* (Buch.-Ham. ex Smith) P. F. Hunt, and its distribution is limited to Thailand and the Malayan Peninsula, while *Acampe multiflora* (Lindl.) Lindl., with which it had often been confused is found to the west of Thailand in the Himalayas and adjacent parts of India. I was intrigued by this statement because the

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type-specimen of *A. rigida* must be a Nepalese plant, and the type-specimen of Lindley's *Vanda multiflora* Lindl., of which Lindley considered *Aerides rigida* Buch.-Ham. ex Smith a synonym, clearly was a plant from the Far East, originating in China. Earlier, Senghas (1964: 165), when uniting a series of African taxa under *Acampe pachyglossa* Rchb.f., remarked that he could not see any differences in the flowers of the African plants and those from Sikkim which he also called *Acampe longifolia*.

Consequently, when revising the treatment of *Acampe* in "Orchids of Thailand", I felt it necessary to investigate this problem more deeply. This led me not only far away from Thailand, but into an area with insufficient material for study.

As stated above, volume 12 of "Hortus Indicus Malabaricus" was prepared for printing before Rheede died. The effective publication, however, took place only in 1703, according to the title page. Commelin in his "Flora Malabarica", the preface of which is dated December 1696 (Warner 1920: 292), has already cited all the plates of Rheede, including those in volume 12. Also, Rudbeck in his "Campi Elysii, liber secundus", published in 1701 (p. 222, Fig. VIII), cited Rheede's figure under the polynomial "*Orchis abortiva flor: luteis minoribus, radiis rubris O.R.*".

I believe Linné was the first to complicate matters. In his second edition of "Species Plantarum" (1763: 1348), he based his *Epidendrum fulvum* on Rhumphius's figure of *Angraecum octavum & fulvum* (Rhumphius 1750, Vol. 6: t. 46, Fig. 1), but he wrongly included Rheede's figure of *Thalia*. The error was obvious and was soon rectified. I have not followed that trail since it leads to another problem surrounding *Vanda Roxburghii* and its allies.

In 1795, Roxburgh identified one of his Coromandel plants with Rheede's *Thalia Maravara* and applying the Linnean binominal system, called it *Epidendrum praemorsum* Roxb. (Corom. Pl. 1,2: 34, t.43,1795). Comparing the pictures and considering the habitat, I see no reason to doubt Roxburgh's judgment and his epithet must, therefore, be associated with *Thalia Maravara*. We need only to note in passing that Swartz (1799: 75) called the plant *Cymbidium praemorsum* (Roxb.) Sw., which name was maintained until 1818, when J. E. Smith (Rees Cycl. 39, 1819), transferred it to *Aerides* with a new name:

Aerides undulata J. E. Smith, because of an earlier *Aerides praemorsa* by Willdenow (1805: 103).

Keeping the chronology, we must now introduce a new plant listed by J. E. Smith in Rees's Cyclopedia side by side with *Aerides undulata*, namely "The Rigid Air-Blossom", *Aerides rigida* Buch.-Ham. ex Smith. It is clear from his notes that Smith had not seen actual specimens of this plant, but based his description on a drawing of a Nepalese plant by Buchanan. This drawing is known to exist in three copies, one of which is found in the India Office in London and is completely colored, while the other two in the British Museum and in the Linnean Society are only partly colored. They are otherwise identical and all three lack details of the flower. According to Miss Phyllis Edwards in the British Museum, their copy belongs to a set provided by Buchanan for Dr. John Fleming. There is no doubt, however, that the copy in the Linnean Society was the one upon which J.E. Smith based his description of *Aerides rigida*. With the kind permission of the Council of the Linnean Society this drawing is reproduced here on a smaller scale. See Plate 9. It is labelled "*Epidendrum rigidum* B.", the "B" indicating Buchanan; the other copies have the locality "Nepaul" added.

A difficulty with *Aerides rigida* is that no corroborating specimen seems to exist which could be considered as the holotype, and therefore, we have to rely on the above-mentioned drawing which is unsatisfactory because of the lack of floral details. The only relevant material I have come upon is a specimen in the Wallich herbarium at Kew, No. 7325, collected by Buchanan-Hamilton on August 21, 1808, in Gulapore called by him *Cymbidium praemorsum*, Swartz's old name for *Thalia Maravara*. The complication here is that Lindley in Wallich's Catalogue listed No. 7325 as *Vanda multiflora*. Although Lindley does not cite this number in his "Genera and Species of Orchidaceous Plants" (1833: 216), this collection must be the one he referred to when he added "Napalia, Hamilton, Wallich" to the habitat of *Vanda multiflora*, the type of which, however, came from China. At the same place Lindley lists as a synonym "*Aerides rigidum* Smith! in Rees Suppl.". The exclamation mark can only indicate that at the time he considered Wallich 7325 to be identical with it. He did not draw the natural consequence of this by renaming the Chinese plant *Vanda rigida* as he should have done. Actually, Wallich 7325 could well be considered an isotype specimen of *Aerides rigida*, even if we, as explained above, undoubtedly must consider Buchanan-Hamilton's drawings as the holotype.

It might be noted here that my Harvard colleague, Dr. Garay, located in the British Museum another drawing representing an *Acampe*, labelled "Dr. Hamilton" and numbered 397 which has a series of names by different hands: "*A. striatum* Wall. (Epidendr. Hamilton)", "*Aerides praemorsum?*", "*Vanda sp.?*", and "*?Saccolabium papillosum*". I believe this drawing also represents the Rigid Air-Blossom, *Aerides rigida*.

When considering *Vanda multiflora* described and illustrated by Lindley in his "Collectanea Botanica" t. 38, January 1826, we get to a critical phase of the history. The plant in question, which was said to come from China, flowered in Mr. Cattley's conservatory in July 1822, and Lindley had a drawing made of it. Dr. Garay sent me a photograph of the original engraving for the plate t.38, which is in the British Museum, pointing out that the engraved name on the drawing is *Sarcanthus praemorsus* (Roxb.) Lindl.

This particular combination was first used in print by Lindley in the tenth edition of James Donn's "Hortus Cantabrigiensis", published in March 1823. It was entered as a *nomen nudum* and stated that the plants had been introduced from China in 1800. This must be the same specimen as mentioned in the ninth edition (1819) of "Hortus Cantabrigiensis" under the name *Cymbidium praemorsum* (with a reference to Roxburgh's plate in Coromandel) even if that one was said to have been introduced from "E. Indies" also in 1800. It is clear that Lindley in 1822 and 1823 believed that the Chinese plant was *Thalia Maravara*. In August 1824 (Bot. Reg. 10, sub t.817) Lindley gave a generic description of the new genus *Sarcanthus*, which he typified by *Cymbidium praemorsum* (Roxb.) Willd., i.e., *Thalia Maravara*.

Before the publication of Plates 38 and 39 of "Collectanea Botanica" in January 1826, Lindley had changed his mind on two highly important points.

First, he decided that the drawing of the plant from Mr. Cattley's garden was not *Thalia Maravara*, and he had the name *Sarcanthus praemorsus* erased from the copper plate and substituted the name *Vanda multiflora*. In the Ames Orchid Herbarium copy of "Collectanea Botanica" the weak outline of the older text can still be seen; in our copy in Copenhagen it has been completely removed. At the same time the title *Vanda multiflora* is engraved in a different handwriting from the one in the Harvard copy. What is behind this little mystery I have not tried to solve, as it seems irrelevant. In the 11th edition (1826) of "Hortus Cantabrigiensis" the entry, *Vanda multiflora*, has been substituted for the previous *Sarcanthus praemorsus* with a reference to "Coll. Bot. t.38", and with the old source "China 1800".

Secondly, Lindley in "Collectanea Botanica" in 1826 gave up the idea of maintaining his *Sarcanthus* of 1824 typified by *Epidendrum praemorsum*, but proposed it anew and typified it by *Sarcanthus rostratus* Lindl., a very different looking plant from China.

All this was drawn to our attention by Dr. Garay (1972: 199) who points out that the consequence is that — while *Sarcanthus* Lindl. 1826 (quite apart from being a later homonym, and hence illegitimate) is a later synonym for *Cleisostoma* Bl. — *Sarcanthus* Lindl. 1824 was legitimately published and therefore takes priority over *Acampe* Lindl. from 1853. Consequently, if the generic name *Acampe* is not conserved, the correct name today for *Thalia Maravara* must be *Sarcanthus praemorsus* (Roxb.) Lindl., and all other *Acampe* names must be changed in like manner.*

Reconsidering *Vanda multiflora*, we are in the same predicament as in the case of *Aerides rigida;* namely, we cannot establish with certainty if a type-specimen still exists. Lindley does not tell us what happened to Mr. Cattley's plant or who brought it to him. When, a few years later, in 1833, he lists *Vanda multiflora* in his "Genera and Species of Orchidaceous Plants", Lindley simply says "China". When transferring it to *Acampe* in 1853, however, he mentions two collectors, Reeves and Champion, without any reference to Mr. Cattley. What is more important, however, is that he has omitted the distribution "Napalia". See below.

According to Breitschneider (1898: 251) John Reeves Senior resided in Canton between 1812 and 1831. Although he mostly

*Since these lines were written, I have proposed the genus *Acampe* for conservation (Taxon 24: 389, 1975) and it has been approved by the committee. Thus, the name should be used until the final decision will be reached during the next International Botanical Congress.

sent living plants to the Horticultural Society in London, we cannot exclude the possibility of his supplying plants of *Vanda multiflora* to Mr. Cattley in 1821 or 1822, particularly since we know from Lindley (Coll. Bot. sub t. 39B) that *Sarcanthus rostratus,* imported in 1821 by the Horticultural Society also ended up in Mr. Cattley's garden. I was, however, not able to find any material in the herbaria bearing his name. On the other hand, Dr. Garay sent me a photograph of a nicely executed drawing from the collection in the British Museum made by Chinese artists under Reeves's supervision. This drawing carried the usual crest of Mr. Reeves and the name "Golden Orchid" in Chinese letters, as well as in faint pencil "*Vanda multif.*". It is reasonable to believe that this drawing was the basis for Lindley's entry of Reeves in 1853, but the drawing itself could not have been the basis for his original description in 1826, since it does not show the minute details mentioned there. The picture gives us no clue to the origin and whereabouts of the type-specimen. Mrs. Hu (1972: 41) informs us that Reeves's plant came from Kwangtung, but she based her opinion on the information given by Breitschneider.

Since Champion collected in Hongkong between 1847 and 1850, he could not have supplied the type-material. There is one problematic sheet in the Lindley Herbarium labelled *Acampe multiflora* on which is found a small piece of an inflorescence with two flowers flanked by loose leaves. The left leaf is attached to the paper by a small label inscribed "*Vanda multiflora* Hongkong 528" and beside it is written "Major Champion". Considering the old practice of gluing specimens of different origin on the same herbarium sheet, the possibility cannot be excluded that the right leaf and perhaps the inflorescence come from the Cattley material. Prior to 1830, Lindley did not annotate his material carefully. Should one consider not to regard the plate in "Collectanea Botanica" to be the type, then the sheet in the Lindley Herbarium must be chosen as the lectotype, since it was identified and cited by Lindley.

The next binomial chronologically is *Saccolabium papillosum* Lindl. (18: t. 1552, Jan. 1, 1833). Having decided that the Cattley plant was not *Thalia Maravara,* Lindley described it again on the basis of a collection by Wallich (No. 7305) from Prome in Burma. Under the description he included in synonymy *Epidendrum praemorsum* Roxb. as well as *Thalia Maravara.* When moving Rheede's plant to *Saccolabium*, Lindley should have made the combination *Saccolabium praemorsum*, but he did not due to its having been pre-empted in another manuscript of his already in press, which, however, did not appear until May 1833 (Gen. and Sp. Orch. Pl. pt. 10: 221). According to the International Code of Botanical Nomenclature Lindley's *Saccolabium papillosum* is illegitimate because at the time of publication the combination *Saccolabium praemorsum* was available. In transferring the epithet to *Acampe* in 1853, Lindley did not make things better for he still ignored *Epidendrum praemorsum* as a name-bringing synonym.

It may be noted parenthetically that Hooker (1890: 63) accepted *Saccolabium papillosum*, but excluded *Thalia Maravara* (for the latter he proposed the transfer *Saccolabium praemorsum* (Roxb.) Hook.f.), all in accordance with the then valid Kew Code.

Lindley in his "Genera and Species of Orchidaceous Plants" (p. 215) describes another *Vanda* species belonging to this complex, *Vanda longifolia* Lindl., which he based on a plant brought from Tavoy by Wallich. Here we are on safe ground because Lindley clearly indicates that his type-specimen is Wallich No. 7322, still kept in the Herbarium at Kew. *Vanda longifolia* has been maintained up until recently under the name of *Acampe longifolia* (Lindl.) Lindl., although with varying taxonomic content.

Some years later (Bot. Reg. 25: Misc. p. 61, 1839) *Vanda congesta* was added to this interrelated complex by Lindley based on a plant from Ceylon. When listing this taxon in his first enumeration of *Vanda* species (Paxt. Fl. Gard. 2: 21, April 1851) Lindley seems to have reached the opinion that the plant was identical with already discussed *Saccolabium papillosum* because he lists it as a synonym together with all previous synonyms given in 1833, instead of using the earliest available epithet from *Epidendrum praemorsum*.

Lindley, however, did not insist that in *Vanda congesta* he just had a new name for *Thalia Maravara*. In "Folia Orchidacea Acampe" he states that he had mixed up his specimens and that *Vanda congesta* is something different from *Saccolabium papillosum*. This opinion has been sustained by Hooker (1890: 63), although with some hesitancy regarding the circumscription of his transfer, *Saccolabium congestum* (Lindl.) Hook f.

When Lindley published his account of the genus *Acampe* in his "Folia Orchidacea", he described *A. dentata* as a new species. Apparently he overlooked his earlier described *Saccolabium ochraceum* Lindl. (Bot. Reg. 28: Misc. p. 2, 1842) for Hooker discovered them to be conspecific. In the genus *Acampe* the correct name is *A. ochracea* (Lindl.) Hochr.

Among Wight's Icones (1851) there are two representatives of the group. The first is No. 1670, called *Vanda Wightiana* Lindl. mss., which is based on a fruiting specimen in the Lindley Herbarium at Kew. Lindley transferred it to *Acampe Wightiana* (Lindl.) Lindl. (Fol. Orch. Acampe 2, 1853), but according to Blatter and McCann it is conspecific with *A. praemorsa*. Thus, in Wight's plate we have another illustration of *Thalia Maravara*. The second illustration is Wight's No. 1672, called *Saccolabium papillosum*, but Hooker believes it to be the same as *A. congesta* as was mentioned above.

When Lindley established the genus *Acampe* he undoubtedly coined the generic name after "The Rigid Air-Blossom" in using the Greek word *akampes*, meaning rigid. Reference has already been made to most of the taxa listed there. In addition to *Acampe dentata* mentioned above, the list contains two additional new taxa. One of them, *Acampe excavata* Lindl. is reduced by Hooker to a synonym of *Saccolabium praemorsum*, while *Acampe cephalotes* from Sylhet is maintained by him under *Saccolabium cephalotes* (Lindl.) Hook. f.

Reichenbach, in Walper's Annales 6: 872–874, 1864, reproduces verbatim Lindley's treatment from 1853. His *A. intermedia* from 1856 is of some interest because, as far as I can see, it is identical with what I have called *A. longifolia;* another of his species, *A. Griffithii* from 1872 appears to be referable to *A. ochracea*. In 1881, Reichenbach published *A. pachyglossa* and *A. Renschiana* from Africa. These were later followed by *A. madagascariensis* and *A. mombasensis* by Kraenzlin in 1891 and Rendle in 1895, respectively. The African species, including *A. nyassana* Schltr. from 1915 have been studied, as mentioned earlier, by Senghas (1964). They are of special interest because they seem to be so close to *A. longifolia* as to appear to be conspecific.

Several references have already been made to Hooker's outstanding work of Flora of British India in 1890. I wish to add at this point that Hooker seems inclined to combine Lindley's A *multiflora* and *A. longifolia,* which also expressed my own feelings. While he does not discuss the problem in detail and limits himself to question marks, it is undoubtedly due to his most sensible wish to keep within British India and not spread out to China or Africa. We find in this field, as in the general field of taxonomic work in our area, that Hooker's big work marks the end of an era, for the following 80 years taxonomical works on the flora of the Asiatic mainland have been very meager both in size and in quality.

With this perspective in mind we may now turn to look at the actual plant material connected with *Thalia Maravara* and *Aerides rigida.* The main question is: are there any differences between the Himalayan plants called *Aerides rigida,* the Chinese plants called *Vanda multiflora,* and the Tenasserim plants called *Vanda longifolia?*

Needless to say, more detail on the identity of *Vanda multiflora* is necessary in addition to its early history already summarized above. There is no reason to doubt that the type-specimen came from China, be it from Mr. Reeves or some other traveller around 1820 or earlier, and unless some misplaced specimens are found, we have to declare Lindley's figure in "Collectanea Botanica" the holotype. Among the characteristics in the rather long original description we find one very essential distinguishing character of the lip: "*sacco intus glabro inappendiculato*". Several years later, in Paxton's Flower Garden (1851: 21) Lindley maintains that the plants occur both in China and Nepal, but adds a new description of the lip, "*basi linea media pilosa in calcar decurrente aucto*".

This chaotic changing becomes finally clarified in Lindley's treatment of *Acampe* (Fol. Orch. Acampe, 1853) when he states that *A. multiflora* has its occurrence limited to China (Reeves, Champion) while the description of the lip reads, "*Labello ovato acutiusculo, calcare vacuo*" which is a mere rewording of the original description. Lindley adds the following explanation: "I seem to have formerly confused with it specimens of *A. longifolia,* which differs from among other things in having a hairy raised line inside the sack of the lip". From this we learn that Lindley ended up by maintaining that Buchanan's plant from Nepal is not *Acampe multiflora,* and that in his opinion the lack of hairs and calli, "*calcare vacuo*", is the most important distinguishing character of the Chinese plant. The Nepalese plant, however, has disappeared.

To verify Lindley's observations I started to look for good material of the Chinese plants. There are very few collections and mostly they are without flowers. I found one of Hance's good specimens in the British Museum, and from Hongkong Dr. Lau sent me a fresh plant. In Singapore I obtained a flower from a Hainan plant. Champion's plant in Kew had two flowers left, strongly glued to the sheet for more than 100 years — I loosened one for dissection. As can be seen on Plate 10, all these flowers are very hairy on the lower part of the lip and have a longitudinal hairy keel running down in the sack, *"basi linear media pilosa in calcar decurrente aucto"*. Naturally, we cannot exclude the possibility that Mr. Cattley's plant with "calcare vacuo" is so rare that it has not turned up for more than 150 years, but I believe we are safe to conclude that the eastern *Acampe multiflora* does not differ from the Western plants in this important character. Moreover, I have not been able to see any other differences in the flowers.

The distribution of *Acampe longifolia,* of which the type-specimen is Wallich 7322 from Tavoy, has not been extended until Hooker (1890: 62) mentions that there is a picture of it from Sikkim in the Calcutta Herbarium; he also cites a collection from Upper Assam by Mann. Since 1890 several collections have been reported from the Himalayas through Thailand, Yunnan and Indochina to the Malayan Peninsula. Most of the older herbarium sheets have passed through many hands and they carry two, three or more annotations. The question is: are there differences in the flowers of these plants? Ridley, (1896: 358) who considers *Acampe longifolia* conspecific with *Vanda multiflora* (noting them both in Tenasserim, but not in the Himalayas or China), says that his *Acampe penangiana* differs in having no spur. Guillauman (1930: 336) does not link his new *Vanda viminea* from Indochina to any other species, but just declares that *"il est inconcevable qu'une Orchidée de cette taille.... soit nouvelle pour la science"*, in which he is right indeed. Hunt (1972: 98) localizes *Acampe multiflora* in the Himalayas and limits *Acampe longifolia* to Thailand and the Malayan Peninsula, declaring it nevertheless a synonym of the Nepalese *Aerides rigida*. He emphatically states that *A. multiflora* is a distinct species.

Accordingly, I have studied flowers of plants from different places. I have had available the type-specimen of *Vanda longi-*

folia; Dr. Chang of Singapore kindly sent me type-material of *Vanda penangiana;* from Dr. Garay I got copies of Ridley's original drawings; from Paris I have studied material of *Vanda viminea*. Wallich 7325 which I believe, as stated above, could be considered an isotype of *Aerides rigida*, is unfortunately not accessible, but Mr. Taylor kindly sent me a good photograph of it from the Wallich Herbarium. Below in the list of localities I have indicated with an "!" are other specimens I have seen, including our own Thai material.

On Plate 11 I have assembled sketches of some of these flowers. I am not able to find any differences among the flowers sketched or among other flowers investigated for there are no separating characters. Some of my colleagues have suggested that there might be separating characters in the vegetative aspects, especially in the leaf tips that might be equally or unequally bilobed, etc. On Plate 12 are the outlines of the leaf tips of several plants from the different geographical areas. My conviction is that the variation is not sufficiently constant to be of specific significance. Dr. Garay pointed out that the Chinese plant is almost equal at the tip, whereas the western plants are decidedly unequal at the tip. It is true, as will be seen in the figure, that the little evidence we have from the single leaf of Champion 528 and the picture of the type of *Vanda multiflora* indicate almost equal tips, but the fresh material sent by Dr. Lau from Hongkong and the specimens collected there by Taam seem just as unequally bilobed as some of the western plants and vice versa. The same is true of the Hainan plants I saw recently in the Peking Herbarium.

Maybe when more material is available for study, we will be able to distinguish local forms, but for the time being I must consider all these plants as belonging to one species. This Asiatic case seems to be paralleled in Africa, where Dr. Senghas reduced all taxa to *Acampe pachyglossa*, admitting only two geographical subspecies, based on leaf characters. Incidentally, I find it highly probable that further studies will consider also *Acampe pachyglossa* as being conspecific with *Acampe rigida*, but I have not studied the African material.

Finally, it should also be mentioned that Dr. Garay sent me a copy of Reichenbach's drawing of *Acampe intermedia* Rchb.f. Reichenbach speaks in his diagnosis of "*foliis aequaliter bilobis*", but one of his sketches shows a very unequal leaf tip;

there are no leaves preserved with the type-material. Reichenbach suggests a possible hybrid between *A. multiflora* and *A. papillosa*. For the time being I consider this species as a probable synonym for *A. rigida*.

The following taxonomic presentation summarizes our knowledge of "The Rigid Air-Blossom":

Acampe rigida (Buch.-Ham. ex J.E. Sm.) P.F. Hunt in Kew Bull. 24: 98, 1970; Seidenfaden in Bull. Mus. Nat. Hist. Nat. Paris ser. 3, 71, Bot 5: 105, 1972 (1973); *ibid.* 1975: 4.

Basionym: *Aerides rigida* Buch.-Ham. ex J.E. Smith, in Rees, Clycopedia 39, 1819.

Syn.: *Vanda multiflora* Lindl., Coll. Bot. t. 38, January 1826; Lindl., Wall. Cat. No. 7325, 1832; Lindl., Gen. and Sp. Orch. Pl. 216, 1833; Lindl. in Paxt. Fl. Gard. 2: 21, 1851.

Vanda longifolia Lindl., Gen. and Sp. Orch. Pl. 215, 1833; Lindl. in Paxt. Fl. Gard. 2: 21, 1851.

Acampe multiflora (Lindl.) Lindl., Fol. Orch. Acampe 1, April 1853; Benth. in Hook. Journ. Bot. 7: 35, 1855; Rchb. f. in Walp. Ann. 6: 872, 1864; Rolfe in Journ. Linn. Soc. Bot. 36: 36, 1903; Dunn & Tutcher in Kew Bull. Add. ser. 10: 266, 1912; Schlechter in Fedde, Rep. Beih. 4: 295, 1919; Merrill & Metcalf in Lingnan Sci. Journ. 21: 5, 1945; Tang & Leung, Check List 59, 1967; Hu in Quart. Journ. Taiwan Mus. 24: 41, 1972.

Acampe longifolia (Lindl.) Lindl., Fol. Orch. Acampe 1, 1853; Rchb. f., in Walp. Ann. 6: 872, 1864; Holttum, Orch. Malaya ed. 2, 625, 1957; Seidenfaden & Smitinand, Orch. Thailand 4(2): 703, Fig. 523, 1965; Kerr in Nat. Hist. Bull. Siam Soc. 23: 210, 1969; Hara, Fl. E. Himalaya, 2nd Rep. 176, 1971; Rao & Balakrishnan in Bot. Surv. India 20: 204, 1973; Banerji & Thapa in Bomb. Nat. Hist. Soc. 70: 26, 1973.

?Acampe intermedia Rchb.f. in Allg. Gartenz. 24: 217, 1856; Hook. f., Fl. Brit. Ind. 6: 66, 1890.

?Acampe pachyglossa Rchb.f., Otia Bot. Hamb. 2: 76, 1881; Rchb.f. in Bot. Zeit. 49: 449, 1881; Senghas in Die Orchidee 15: 165, 1964.

?Acampe Renschiana Rchb.f., Otia Bot. Hamb. 2: 77, 1881; Finet in Soc. Bot. Fr. Mem. 9: 8, pl. 1, f. 7-12, 1907.

Saccolabium longifolium (Lindl.) Hook. f., Fl. Brit. Ind. 6: 62 & 197, 1890; Grant, Orch. Burma 281, 1895; King and Pantling in Ann. Roy Bot. Gard. Calcutta 8: 220, Pl. 202, 1898; Prain in Rec. Bot. Surv. India 2: 343, 1903; Bengal Plants 768, 1903; Gagnepain in Fl. Gen. Indochine 6: 502, 1934; Panigrahi & Joseph in Bull. Bot. Surv. India 8: 157, 1966.

?Acampe madagascariensis Krzl. in Gard. Chron. ser. 3, 10: 608, 1891; Perrier in Humbert, Fl. Madag. Orch. 2: 120, Fig. 55, 2, 1939.

?Acampe mombasensis Rendle in Journ. Linn. Soc. 30: 386, 1895.

Acampe penangiana Ridl. in Journ. Linn. Soc. 32: 358, 1896; in Mater. Fl. Malay. Pen. 1: 149, 1907; in Journ. Str. Br. Roy. As. Soc, 59: 197, 1911; Fl. Malay. Pen. 4: 155, 1924.

?Acampe nyassana Schltr., in Engl. Bot. Jahrb. 53: 594, 1915; Mansf. in Fedde, Rep. Beih. 58, t. 58, Nr. 380, 1932; Verdoorn in Fl. Pl. Afr. 30, Pl. 1175, 1954.

Vanda viminea Guill. in Bull. Soc. Bot. Fr. 77: 336, 1930; Gagnepain in Fl. Gen. Indochine 6: 525, 1934; Guillaumin in Bull. Mus. Nat. Hist. Nat. Paris, ser. 2, 34: 478, 1962.

?Acampe pachyglossa ssp. *Renschiana* (Rchb.f.) Senghas in Die Orchidee 15: 165, 1964.

DISTRIBUTION

Africa: EAST AFRICA FROM KENYA TO TRANSVAAL *(Acampe pachyglossa ssp. pachyglossa, fide* Senghas). MADAGASCAR, COMORO ISLANDS *(Acampe pachyglossa ssp. Renschiana, fide* Senghas); Aldabra RENVOIZE 02071 (K)! **India:** NEPAL; Gualpore Buchanan-Hamilton drawing (BM)! WALLICH 7325 (K)!; Khebang-Bharomedin *fide* Hara; Sibganja-Maharabahara *fide* Hara; "Common" *fide* Banerji & Thapa. Sikkim: PANTLING 250 (K)! BHUTAN: Tashigong, BALAKRISHNAN 41293, *fide* Rao & Balakrishnan. SUNDRIBUNS; Supoti, HAINIG, *fide* Prain; "Calcutta" imported by Schiller, Herb. Reichenbach 45173, type of *Acampe intermedia*. NEFA: Tirap, *fide* Panigrahi & Joseph. ASSAM; Upper Assam, MANN 3 (K,W)! **Burma:** Myitkyina, SWINHOE 66 (K)!; Tavoy, WALLICH 7322 (K)!, type of *Vanda longifolia*.

Thailand: I; Muang Fang, KERR 263 (K)!, GT 204 (C)!, GT 462 (C)!; Mae Tang, Chiengmai, KERR 02 (K, BKK, C)!, Cumb. 1165 (C)!, Chiengdao, GT 194 (C)! II; Phu Phan, GT 4477 (C)! not yet flowered, GT 5730 (C)! VI; Sisawat 800m, GT 4256 (C)! VII; Koh Tao, KERR 0645 (K)!; Terutao, CURTIS *s.n. fide* Ridley. **Laos:** Col Den Din, Louang Prabang, GT 974 (C)!; Sayaboury, KERR 0323; Vientiane, SIGALDI 307 (P)! KERR 0970; Phonthane, Khammouane, SPIRE 189 (P)!; Ka Khe, Savannakhet, HARMAND 427 (P)!; Mouang Pren, POILANE 1916, *fide* Guillaumin. **Cambodia:** Stung Treng, COUDERC, *s.n. fide* Guillaumin. **Vietnam:** Cana, EVRARD *s.n., fide* Gagnepain; Bien Hoa, PIERRE 6560, *fide* Guillaumin (this one or one of the following is the type of *Vanda viminea)* Phanrang, Capia, POILANE 8573, *fide* Guillaumin; Tonkin, BON 3219, *fide* Guillaumin; Tankeuin, BALANSA 314, *fide* Guillaumin; Ocach, BON 2329, *fide* Guillaumin; Kien Khe, BON 2733, *fide* Guillaumin; Dalat, TIXIER 1/59, *fide* Guillaumin; Hanoi, SIMOND *s.n.* drawing No. 4 (P)!, questionable. **China:** *sine loc.,* Mr. Cattley's conservatory, Lindley's drawing (BM)!, type of *Vanda multiflora;* FABER 15 (W)!, sterile. Yunnan; Houang Tsao Pa, CAVALERIE 4603 (K)!, fruiting; Southern Yunnan; living, Canton Bot. Gard., GT 8144 (C)!; *sine loc.,* HENRY 13613 (K)!, fruiting; Cheli, WANG 75647, 76342, 77947 (PE)! Kwangtung; REEVES, drawing (BM)!; Ting Wu Mts., METCALF 17034 (K)!; Ng Tung Shan, TSUI 256 (K)!. Hongkong; CHAMPION 528 (K, HK)!, HANCE 1334 (BM)!, LAMONT 764 (BM)!, HU 7352 (K)!, sterile; Lantao Isl; *fide* Dunn & Tutcher; New Territories, *fide* Dunn ?& Tutcher; Aberdeen, TAAM 1986 (H)!; Cape d'Aguilar, LAU 2024 (C)! Hainan; Pak Chik Ling, LEI 946 (K, SING, PE)! *sine loc.* CHUN & TSO 43815 (PE)! *fide* Merrill & Metcalf. Kwangsi; *sine loc., fide* Merrill & Metcalf. **Malaya:** Government Hill, Penang, CURTIS 1963 (SING, K)!, type of *Acampe penangiana;* Langkawi, WILLIAMS *s.n., fide* Ridley; Pulau Chupa, Langkawi, CORNER *s.n.* (K)!

A logical end to this paper would be to prepare a similar synthesis for *Thalia Maravara.* A considerable part of this work has already been done by Blatter and McCann (1932: 495). It seems that Rheede's old plant is not present in Thailand for its main distribution is Southern India. I, therefore, prefer to leave further studies to my colleagues engaged in research in that region.

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PLATE 8

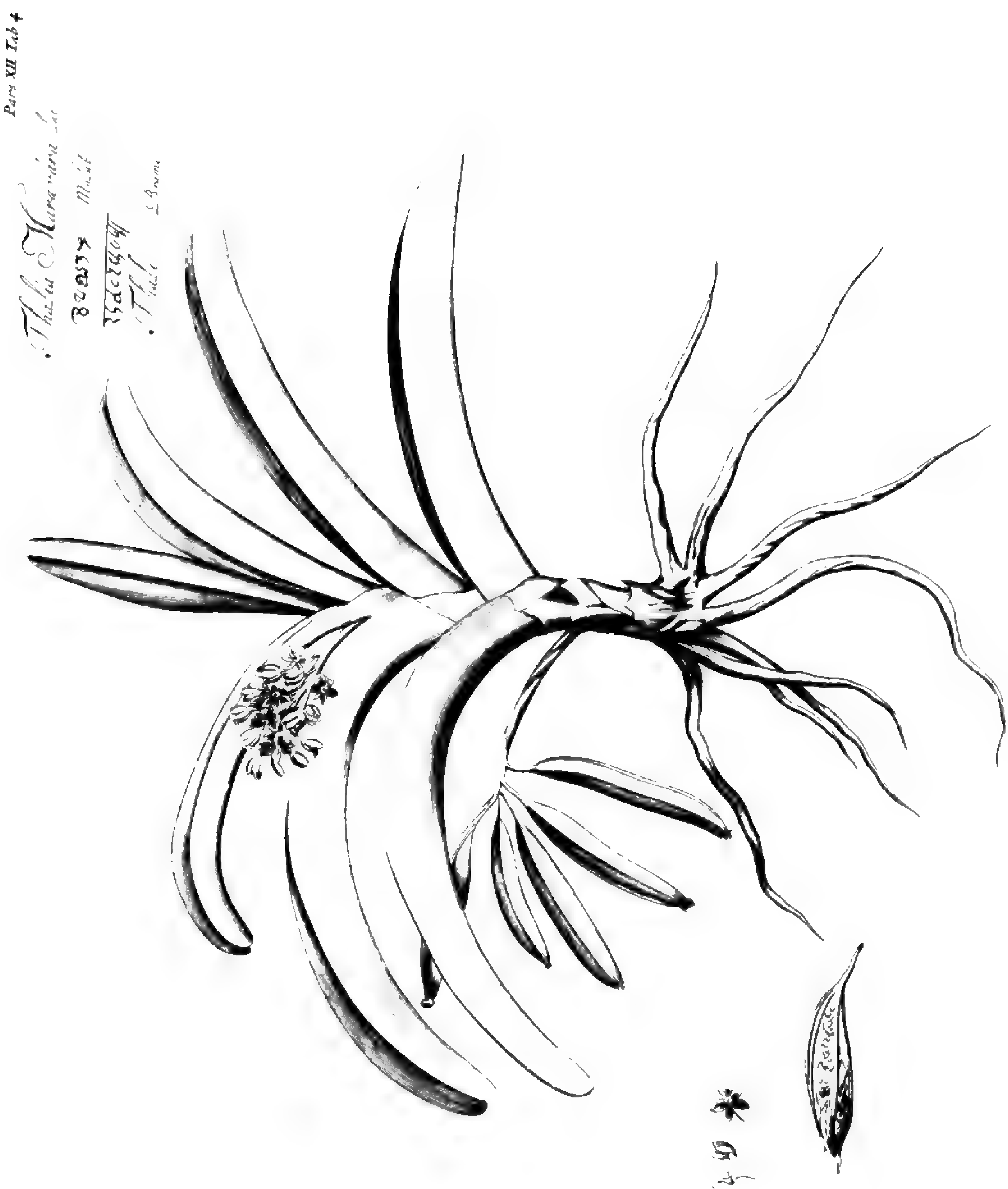

Plate 8. *Thalia Maravara,* now called *Acampe praemorsa* (Roxb.) Blatt & McCann, reproduced from Rheede, Hortus Indicus Malabaricus 12: t. 4, 1703. Much reduced in size.

PLATE 9

Plate 9. The Rigid Air-Blossom, i.e., *Acampe rigida* (Buch.-Ham. ex J. E. Sm.) P. F. Hunt. The Buchanan-Hamilton drawing of the holotype from the Archives of the Linnean Society of London.

PLATE 10

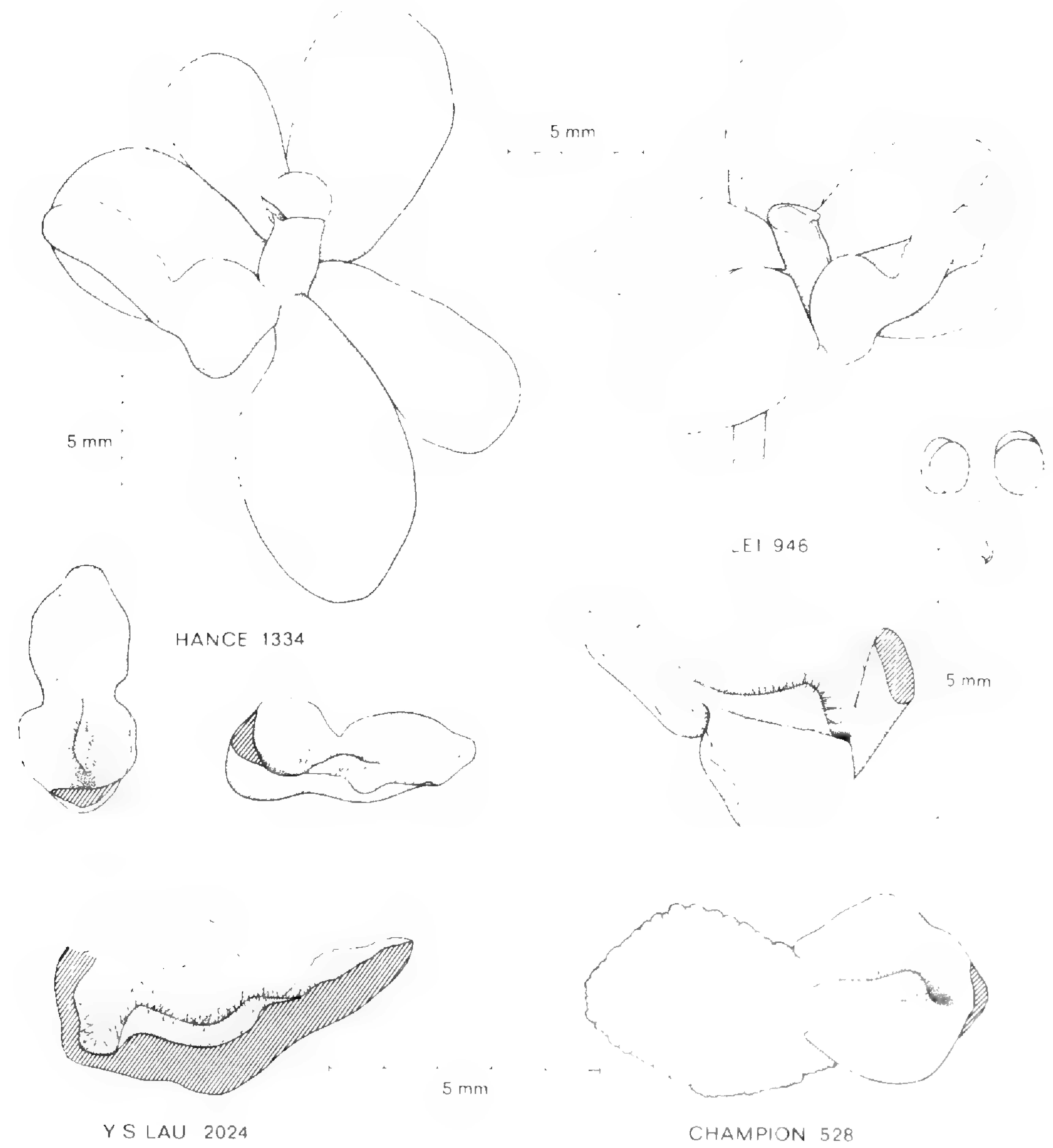

Plate 10. *Acampe rigida* (Buch.-Ham. ex J. E. Sm.) P. F. Hunt. Flowers, lips and pollinia from various Chinese specimens.

PLATE 11

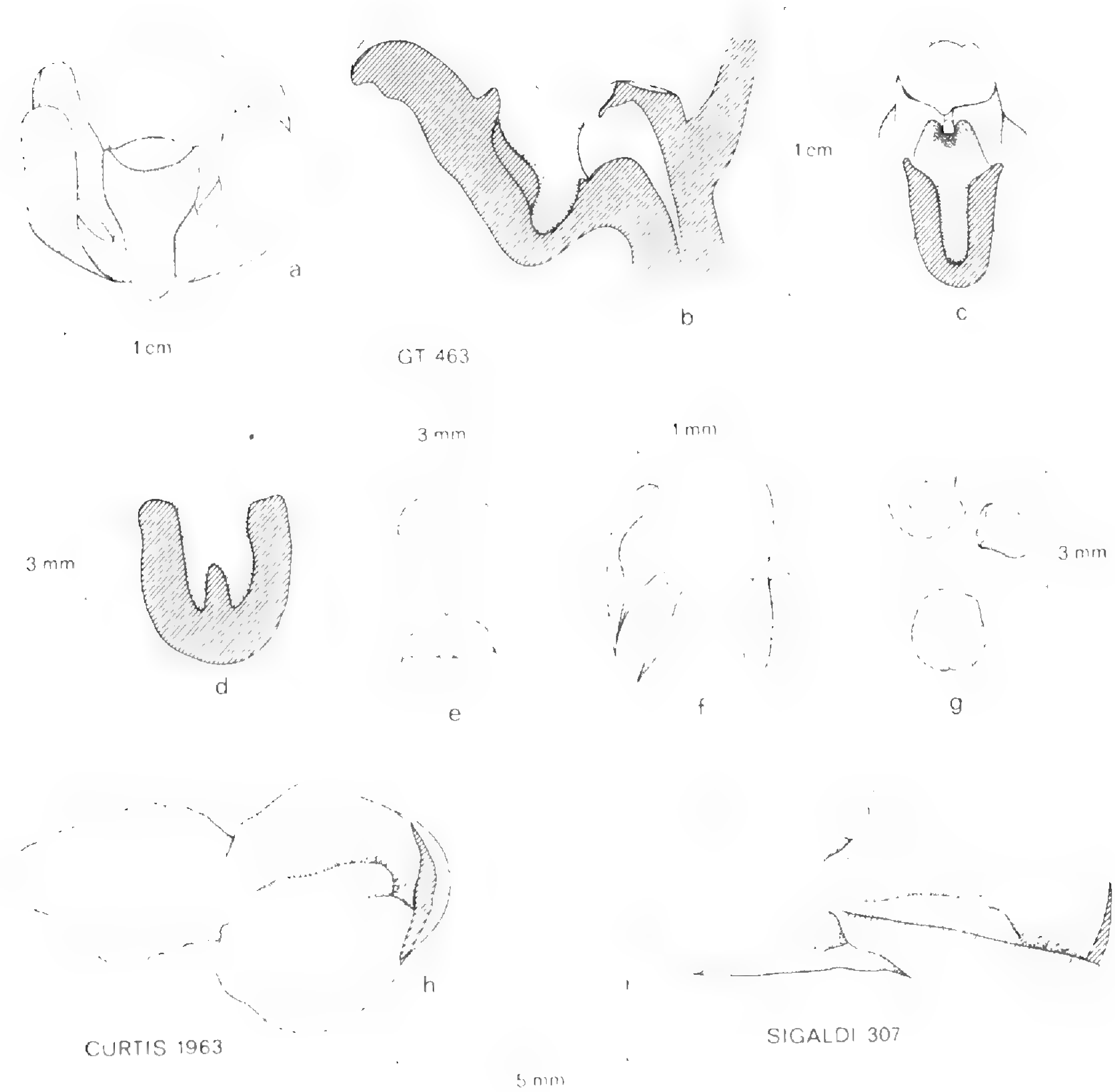

Plate 11. *Acampe rigida* (Buch.-Ham. ex J. E. Sm.) P. F. Hunt. Floral details: a-g — material from Thailand; a. flower, b. longitudinal section of column and lip, c. column from front showing sectioned spur of lip, d. cross section of basal part of lip, e. anther or operculum, f. stipes and gland of pollinia, g. pollinia; h. *Acampe penangiana* Ridl., lip from type specimen, i. lip from a Laotian specimen.

PLATE 12

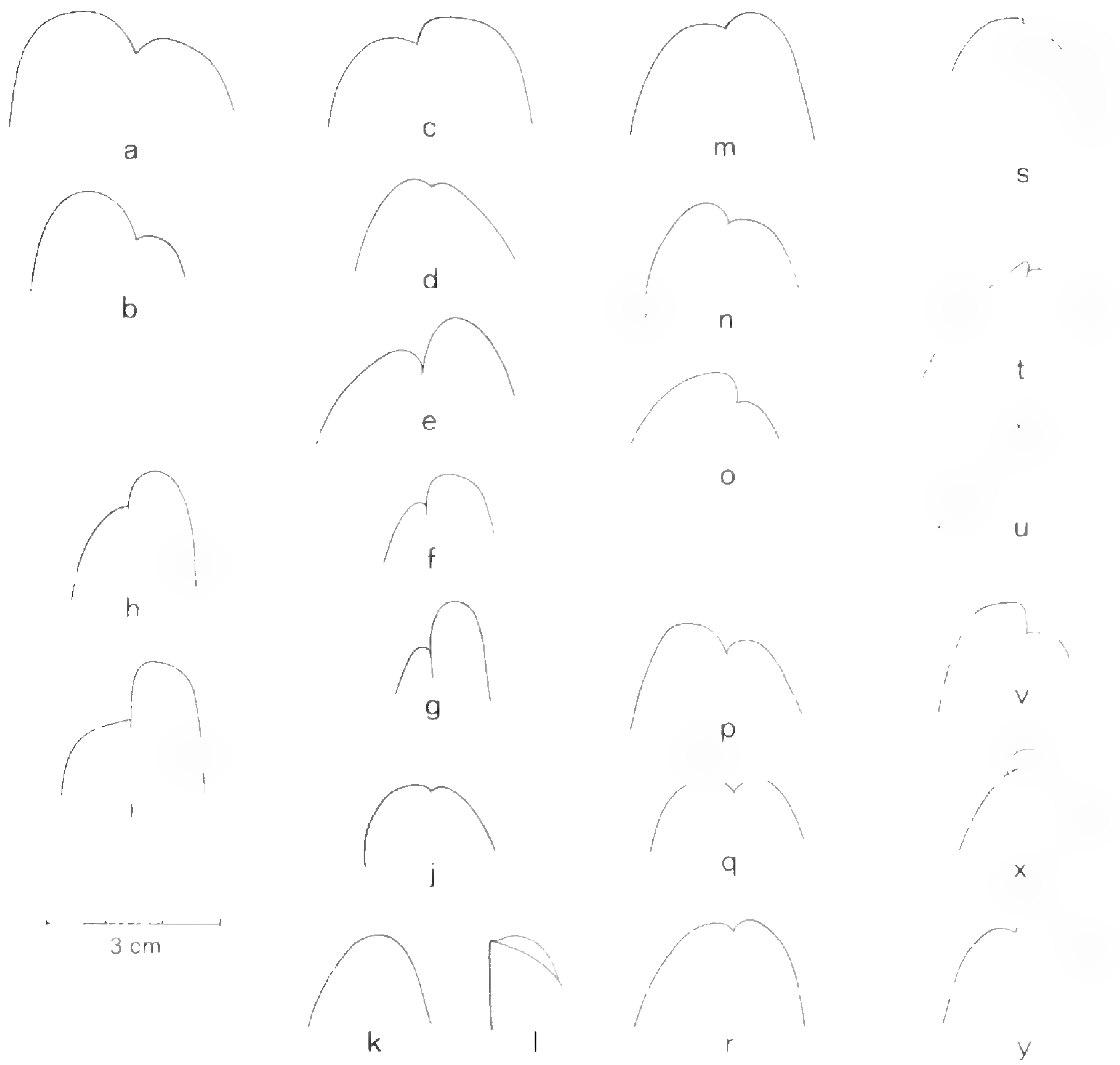

Plate 12. *Acampe rigida* (Buch.-Ham. ex J. E. Sm.) P. F. Hunt. Outline of leaf-tips from different areas: a-b. Nepal (Wallich 7325), c-g Sikkim (Pantling 250), h-i. Tavoy (Wallich 7322), j-l. Malaya (after specimens from Langkawi and Penang in Herbarium in Singapore, sketched by Dr. Chang), m. Laos (Poilane 1916), n,o. Vietnam (Poilane 6560 & 8573 in Paris, sketched by Dr. Hallé), p-r. Thailand (Kerr 02 & Curtis *s.n.*), s-y. China (Champion 528) (s), Lindley's t.38 in Collectanea Botanica (t-u), and Lau 2024 (v-y).

ICHTHYOTOXIC PLANTS AND THE TERM "BARBASCO"

DOROTHY KAMEN-KAYE*

One hundred years ago, Richard Spruce wrote a paper entitled "Indigenous Narcotics and Stimulants Used by the Indians of the Amazon", in which he stated: "This does not profess to be a treatise on all known South American narcotics, or I should have to speak of a vast number more, such as (for instance) the numerous plants used for stupefying fish. Some of these, but especially the timbó-acų *(Paullinia pinnata)*, are said to be also ingredients of the slow poisoning which some Amazonian nations are accused of practising . . . " (25). "Timbó" is the more common of two Brazilian terms equivalent to the Spanish "barbasco"; the other is "tingui". It would be the word that Spruce heard most frequently, since most of his exploration took place in the Brazilian parts of the Amazon valley. Since, however, he spent about six months on the Orinoco and its uppermost tributaries and several years in Peru and Ecuador, he must also have been familiar with the term "barbasco".

I

"Barbasco" is a generic term in Spanish-speaking countries of South America for ichthyotoxic plants. Although it is customarily applied to all plants with this property, a qualifying or descriptive term is occasionally added. Thus, *Lonchocarpus Nicou* is often referred to as "barbasco legítimo" (genuine barbasco) or *Tephrosia Sinapou (T. toxicaria)* as "barbasco de raíz" (root barbasco). Actually, neither of these terms was current among New World Indians utilizing plants as piscicides; they had their own names for fish poisons, such as "hairi" (Guyana) or "nekoe" (Surinam).

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Rudd (21) reports the use of a vividly descriptive name used in Florida, where a *Piscidia* is known as "Jamaica fish-fuddle tree" or "Florida fish-fuddle tree". It is likely that this name is used also in Jamaica since, as Rudd points out (pers. comm.), the name "sounds like an English-West Indian concoction" and states that the generic epithet *Piscidia* and its synonyms *Piscipula* and *Ichthyomethia*, were based upon the observations that Jamaican natives used these plants to poison fish.

The term "barbasco" comes from *Verbascum*, a genus of the *Scrophulariaceae*, some members of which have been utilized for centuries as piscicides throughout Europe and around the Mediterranean. The common mullein, *Verbascum Thapsis*, is the species most often mentioned. At least two other species, *V. sinuatum* and *V. undulatum*, are said still to be in use for this purpose in Greece.

The Spanish words for mullein are "verbasco" and "gordolobo". As the Venezuelan lexicographer Lisandro Alvarado (1) points out, however, the spelling "barbasco" is very old and is connected with "barba" (beard). According to some authorities, the name of the genus should correctly have been *Barbascum*, in reference to the bearded stamens and the generally woolly appearance of these plants. Another possible and perhaps more logical explanation of the "b" rather than the "v" may be the interchangeability of "b" and "v" in Spanish usage. "Barbasco" does not appear in the Spanish Academy's *Diccionario de la Lengua Española*. The entry "varbasco" refers the enquirer to "verbasco", where it is stated that "verbasco" is "gordolobo" (mullein) and that the seeds of this plant are used "para envarbascar el agua" (to poison water). No further explanation is here offered, but a search discloses that "envarbascar" means "to poison water with verbasco" or a similar substance, to stupefy fish. Indicative of the validity of the use of the term "barbasco" is its inclusion in Santamaría's *Diccionario General de Americanismos*, where neither "varbasco" nor "verbasco" appears.

Since Old World fish-poisoning goes back at least to Classical times and since this use furnishes a background to the interpretation of many aspects of New World use, it merits a brief discussion.

The history of fish-poisoning is summed up by Ernst in a monograph published in 1861 (4). Ernst, who came to Venezuela in 1861 and who published some 400 papers on botany, zoology and related subjects, states that, to the best of his knowledge, his monograph is "the first attempt to present this subject as a special study". Ernst cites Aristotle's reference in his *History of Animals* to fish dying of "plómos", with which the Greeks fished in certain rivers and reservoirs. He further states that the Phoenicians caught ocean fish in this way. Although there are dissenting opinions, most translators agree that "plómos" is a plant. Ernst believes this to be true, since even today, in Greece, *Verbascum sinuatum* is known by the common name "plómos" or "phlómos". Nevertheless, he warns that Aristotle's word "plómos" might refer to more than one plant, since vernacular names are often confused or are applied to plants with actual or fancied similarities. Ernst also refers to Dioscorides' mention of a plant known as "tithymalos platyphyllos" which resembles "phlómos" and which, crushed and thrown into water, kills fish. This plant, *Euphorbia Platyphylla*, is toxic to fish. Ernst quotes Pliny's statement, "pisces necat".

Verbascum was used for drugging fish in Spain during the Moorish occupation. King Juan II prohibited its use in 1453, and his edict was followed by similar laws under Carlos I and Felipe II. In 1805 the law read: "from now on, no person of whatever rank or condition he be, may throw into rivers quicklime bait, nor henbane, nor flax-leaved daphne, nor mullein, nor any other poisonous substance with which fish are killed or stunned".

Obviously, then, the use of *Verbascum* — verbasco or barbasco — was common enough in Spain so that Spaniards arriving in the New World and encountering fish-poisoning as a native technique, would apply to plants so employed, the common name of familiar plants used for the same purpose.

Ernst further speculates about the reason that Spain did not extend this prohibition of fishing with poisons to the American possessions. In 1828 a law was passed in Venezuela stipulating that "no owner of a hato (cattle ranch), owner of a farm, overseer, or anyone whatsoever, may fish with barbasco or other kinds of poison in those streams or rivers which, although on their lands, can endanger cattle or their neighbors" (1). In spite of this law, fish-drugging is practiced to this day in remote areas of the country, and apparently goes unpunished.

II

The stupefying of fish to secure food in quantity with relatively little effort is one of the most widespread and possibly one of the oldest activities of primitive peoples. In the Old World, it has a long history in diverse areas. Although the plants used there differ in toxic constituents from those of South America, the techniques employed the world over are strikingly similar.

Since reports of fish-drugging in the New World were available only after the Discovery, its antiquity there cannot be determined. Accumulated evidence sustains Heizer's conclusion (9) that "...we are dealing with a single, widely distributed concept which has a South American focus of origin, dispersal center, and highest and most complex development..." To support this conclusion, he mentions the presence of rivers and streams rich in fish and of many plants appropriate for this use. Heizer's tables of regional fish-poison plants — among the most comprehensive available — are based on lists published by Ernst, Greshoff, Rostlund and Howes, as well as Radlkofer, and are supplemented by material from various ethnographical accounts. He issues a *caveat:* "these [tables] are not complete, and give only a sampling of the plants used and places where piscicides are employed".

Going a step further than Heizer in pinpointing the focus of origin and a dispersal center for the use of fish-poisoning plants, Hornell (10) and Schultes (22) suggest that it lies in the Amazon basin. Denying that independent invention may account for this trait, Schultes comments: ". . . this continent seems to represent the center from which this custom has developed in the greatest degree, to judge from the number of species used. Moreover, recent studies have indicated that the area of the northwest Amazon may easily be considered as the epicentre of greatest degree of development of fishing with poisons in all South America".

Schultes has spent many years in exploration of the Amazon flora. He and his students have found sundry new fish-poison plants in the northwest Amazonia of Colombia, some of them new to science and some in families never suspected as having toxic principles. Several of these are cultigens of such age that they are no longer known in the wild state. He reports that the most commonly used in the area belong to the genera *Phyllan-*

thus (Euphorbiaceae), *Clibadium* (Compositae), *Tephrosia* (Leguminosae), and *Lonchocarpus* (Leguminosae). *Philodendron craspedodromum* (Araceae) represents a new and local fish-poison plant the use of which involves an unusual technique not hitherto reported in the literature. The Desana of the Vaupés gather the leaves of this aroid and tie them into bundles which they leave on the forest floor for two or three days to ferment. The leaves are then crushed and thrown into the water. Nothing is known of the chemistry of this plant. The same lack of chemical knowledge holds for other fish poisons recently discovered, such as the bombacaceous *Patinoa ichthyotoxica* among others (22, 23).

Parallels of this process of fermentation of the leaves of *Philodendron craspedodromum*, which may alter the toxins or their effects, are found in the preparation of two Old World piscicides which are lightly roasted before use (8, 11). One, *Ophiocaulon cissampeloides*, contains free hydrocyanic acid; the other, *Jagera pseudorhus (Cupana pseudorhus)*, is cyanophoric. Subjection to gentle heat would seem to be a means of heightening the toxic effects, and fermentation might well act somewhat similarly. Descriptions of the preparation of *Manihot esculenta*, — which itself can be used as a piscicide — mention both heat and soaking as altering its toxicity, due to the presence of a cyanogenic glycoside.

The discovery of new piscicides in the northwest Amazon suggests that the focus of origin and dispersal center of their use may extend beyond this area. The Orinoco basin with which it merges and the tribes of which share culture traits with its peoples, may also prove to be significant. Up to the present, comparatively little botanical and ethnological explorations have taken place along the Middle Orinoco. This possibility, as well as that of independent invention, should therefore be considered in the drawing of conclusions.

Plants used as fish poisons may be lianas, bushes, or small trees. Depending on age and other conditions, the same plant may be all three of these in form. Its effectiveness as a piscicide may vary with seasons, since the concentration of the toxic constituents may vary not only with location but also with time of year. The plants may grow wild or they may be cultivated in small plots or even in large plantations called "barbascales" (13). Their cultivation, as with certain food plants such as maize and manioc, elevated fish-drugging from a hunting-fishing trait alone, to that of a sedentary, agricultural level of economy (11). Some fish-poisoning plants have been cultivated so long that they are no longer known in the wild.

III

Whether the toxic plant be called "varbasco", "barbasco", "timbó", "plómos" or any number of local names, the purpose and technique of fish-drugging are almost identical wherever this method of catching fish has been noted. The purpose everywhere is to catch a large quantity of fish with the least effort and in the shortest time. The technique presupposes not only this need but also certain practical knowledge. "The universal feature of fish-stupefying is simply the recognition of a narcotizing, sometimes lethal effect on the fish by introducing the poisonous principle of a plant into the water. An effective plant piscicide must fulfill certain conditions, among which are solubility, rapid diffusion in the water, and high potency . . . and it must have such an effect that the fish itself does not have a toxic quality when eaten by humans" (9). Either a pool or a sluggish stream is selected for the operation, or a rough dam is constructed to make a temporary pool. In either case, an area suitable for restricting and concentrating the action of the poison and for penning up the fish is essential.

The toxic principles of piscicides differ. Some are tannins, some alkaloids, some glycosides. Whether fish die or are only stupefied may depend on the kind of toxin, the strength or concentration of the poison, and the size of the fish (17).

In the most common type of fishing with toxic plant material — introduction of crushed vegetal material into the water — the animal's respiratory apparatus is affected, apparently paralyzed. Fish rise "gasping" to the surface. There is also some evidence that certain poisons affect the nervous system (9). In any case, the result is a stupefying effect followed usually by death, unless the fish are able to escape from the poisoned water.

There are various methods for introducing the poison into the water. Sometimes, crushed plants or parts of plants (such as bark or root only) are thrown directly onto the surface of the entire area to be fished. On other occasions, the crushed material is placed in a canoe with a little water, where it is stamped to extract the active principle. Then either the canoe is overturned into the pool or its contents are ladled out into the water with calabashes to distribute the poison. Often, the crushed material is placed in loosely-woven bags or baskets which are then plunged up and down or dragged through the water. A variant of these procedures, reported by Schultes (pers. comm.), is employed in eastern Colombia by the Kubeo. They pound the fruits of a species of *Caryocar* (Caryocaraceae) in a mudhole. The resultant mixture of fruit pulp and mud is then cast into pools. Fishing with toxic plant material is always a collective enterprise in which several or many men participate. It is not customary for the women of most South American groups to take part in the actual fishing, though they may sometimes carry the catch to the village. It is not certain, from reports, whether or not barbasco (timbó) fishing in central Brazil is exclusively a masculine operation. It is stated that the women carry the catch back to the village to avoid bringing bad luck to the fishermen (16).

In a somewhat different type of fishing, characteristically practiced by women, plants which act as a stomach poison are utilized. The plant material is ground, mixed with a substance attractive to fish, and made into small pellets which are thrown into the water. Among these is cuna (an Achagua word for barbasco (19), probably *Tephrosia* spp.) the root of which is mixed with maize dough. Another is *Clibadium asperum*, which is mixed with finely chopped meat. Most accounts of the use of toxic plants describe the fish as stunned and sometimes dying almost immediately, rising to the surface within a few minutes after the poison is thrown into the water. With the use of some stomach poisons, however, hours or even days may elapse before they appear on the surface. Results are believed to vary depending on the type of toxin in the plant utilized. Alkaloids seem to produce more immediate effects than saponins and tannins (11).

A notable characteristic of fish-drugging is its recreational aspect. The men of a primitive community regard a fish-poisoning expedition as a holiday from their daily tasks. It cannot be considered a sport, though it provides a diversion, since for these peoples it is a necessary part of the food quest.

One of the few early European eyewitness descriptions of two kinds of fishing with plant poisons by South American Indians is that of Father Joseph Gumilla, a Jesuit missionary in the 1700s to groups along and near the Orinoco between the Meta and Apure Rivers. Gumilla confines himself to procedures and omits mention of special body-painting for barbasco expeditions — a significant detail which is described by his fellow-missionary, Father Juan Rivero.

Attributing choice of designs to individual caprice, Rivero states that they use their finest paints — black, yellow, red, white — to apply circles around their eyes, spots on their cheeks, lines down their noses, and their entire bodies red (19). Both Gumilla and Rivero most probably refer to the Achagua, among whom were their mission Indians.

Gumilla(7) describes fishing by both men and women. Of the first, he writes: "They . . . fish in small rivers and brooks to vary their diet or for amusement. They grow two kinds of roots for this purpose, one called 'cuna' . . . similar to turnips except for the smell and taste; each is harmful to the fish, crushed in the water; it is enough for them to smell it and they are intoxicated and stupefied in such a way that the Indians can go about putting them into their baskets with their bare hands. . . . The other root with which they fish is called 'barbasco' and is of the same color and shape as the stock of a grapevine, and also has the strength of cuna. This is a very diverting kind of fishing, and ordinarily very merry for the Indians; because to this one, as it jumps out of the water, a fish gives a slap in the face or to another a tap in the ribs; the rest . . . make fun of this; then the same thing happens to them, which makes them laugh."

The second kind of fishing described by Gumilla was done by women and children: "Very easy, and odd, is the way the Indian women fish with cuna. They grind cooked maize and set aside a ball of that dough. With the rest, they grind one or two cuna roots . . . They go to the nearest river or stream and throw in the dough which is not poisoned; a great number of sardinas, codoyes, and other medium-sized fish gather around the dainty. When they have them enjoying the tidbits, they take the other dough which is poisoned with cuna, and their children go into the water . . . below the pool, each with his basket . . . they throw in little balls . . . and when the fish swallow them, they become intoxicated and motionless . . . . The current carries them downstream and the youngsters collect them with much noise and shouting. It is certainly an unusual way to fish, and aside from its usefulness, is an amusement."

Whereas Gumilla presents a very human scene observed by a sympathetic outsider, Goldman records the anthropologist's view in a report of the Kubeo of the Colombian Vaupés (6). Fishing is one of the tribe's regular male-oriented activities. Since the basic Kubeo diet consists of manioc and fish, fishing is an important part of the food quest. Fishing is usually individual, by a man (sometimes accompanied by a young son) in a canoe, with a hook and line, or — in the shallows — with a bow and arrow. However, during the summer, when the water is low and fish are trapped in shallow pools, collective fish-poisoning parties are occasionally organized. One group of the men puts up a weir; another gathers and prepares the poison. The nature of this poison is not mentioned, but the word "gather" suggests a plant. According to Schultes (22) the Kubeo utilize the stems and roots of two connaraceous vines *(Connarus opacus* and *C. Sprucei)*, in addition to the usual types. Each man loads his catch in his canoe, collecting the stunned fish with his bare hands or with a net, or shooting with bow and arrow, large fish still able to move. The total catch is later distributed to each household. This fishing is accompanied by horseplay and by jocular remarks to the fish themselves.

The detail about addressing the fish may not be, as implied, a general and casual joking situation. Goldman supplements the above account with a description of a festival which takes place only when the Indians are in the mood for it. Each man mounts a dried fish on a stick and dances with it. The dancers wear headdresses shaped to resemble a fish-basket and carry staffs decorated with the feathers of fishing birds — the heron and the river eagle. They sing songs honoring the fish. The ritual or ceremonial character of this festival is denied by the Kubeo. Goldman (6) suspects that either they no longer recognize the instrumental motive or else refuse to acknowledge it, since they insist that it is not intended to increase the catch.

Features of collective barbasco fishing among the Desana (18) seem to have significant overtones. These Indians, who, like the Kubeo, inhabit the Colombian Vaupés, prepare themselves ritually for fishing as well as for hunting. They observe a special diet beforehand and make themselves attractive to the fish with special designs of face-paint for which they use a red pigment and the sap of plants. Motifs representing fish fins and eyes are painted on the cheeks. A Desana fisherman carries with him a tubular container made of deer or peccary bone containing a supply of pigments so as to alter these motifs in accordance with the kinds of fish he may find. In addition to these precautions to secure quantities of fish, the Desana shaman invokes the help of the Master of Fish. His invocation will "open a path", so that the poison will be effective. Women do not participate in the fishing but are obliged to bathe in the water where the toxic material is being thrown. If they have any share in the operation, it is only when many hands are needed to collect the catch.

Why do the Kubeo, the Desana, and many other groups attach more than mundane importance and significance to the utilization of barbasco? Evidence of magic associations here — as in many other aspects of the food quest among primitive peoples — may be found in their myths and beliefs about food plants and animals. Barbasco itself is of supernatural origin, as recounted in myths (16) the consistency of which throws much light on the custom of utilizing fish poisons. For example, the death of fishes is frequently associated with the bathing of a human being in the water where they swim. The Desana bring about this association by having their women bathe in the water into which they throw poisonous plant material so that many fish will be stunned and die. The fish-dance of the Kubeo and its accompanying songs honoring the fish, their addressing the fish during the fishing operation, as well as Desana face-painting in pisciform patterns thought pleasing to the fish, are procedures designed to secure the prey's favor and cooperation by magical means.

Ritual purifications by rigorous diets or by abstention from sexual activity for a certain period, typified by the Desana (18) and the Makiritare (26), are examples of taboos, observance of which is believed to give man magical power to achieve a desired end.

Fishes, like other animals, have a Master or Owner. They are the "people" of these guardian spirits who watch over and protect them. Long ago, it is recounted, men did not kill more animals than they needed for food, and therefore, these spirits helped them to fish and hunt. But when men began to kill large numbers of animals and to waste them, their Masters became ambivalent in their attitude. Therefore, their help must be ceremonially invoked by an individual whom they respect, the shaman. Also, precautions must be taken not to incur their ill will or their anger.

The Warao of the Orinoco delta fish reluctantly with piscicides, because they are an essentially fishing people and are afraid of offending the Owner of Fish, who will move away, taking all his "people" with him if too many of them are killed or wasted. They use barbasco only in inconspicuous places, where they hope their fishing will pass unnoticed. A Warao will preserve the larger fishbones in the roof-thatch of his house along with other objects that he believes have magic qualities, to ensure the good will of the Owner of Fish — and his own future luck in fishing (26). It is not known whether he shares a widespread belief among primitive peoples that, if the bones are preserved, the soul of the dead fish is propitiated and may even return to life, clothed anew in flesh.

IV

Because of wide distribution and similarity of techniques, fishing with piscicides (mostly of plant origin) must be assumed to be very ancient. Since by its nature this occupation cannot have left vestiges in material cultures, it is only on reports of observers that any facts or theories can be based today. As the earliest observers were not trained scientists, much that they have recorded must be accepted *cum grano salis*. Modern reports may also be deficient. For example, a botanist may fail to mention significant details of procedure, and an ethnologist to give clues as to the identity of a plant.

One interesting type of surviving evidence of the use of piscicides by primitive peoples and their beliefs about them may be found in myths. Originating in pre-literate societies, they reveal as perhaps nothing else can, basic attitudes and beliefs. Evolved from the life-experiences of generations, transformed again and again by countless re-tellings, myths form a body of "truth" often more significant than facts can ever be.

Several "origin" myths of South American Indian tribes (16) tell of the origin of fish poisons. According to an Arawak myth, "an old man who was fond of fishing one day took his son with him to the river. Wherever the lad swam, the fish died. And yet it was safe to eat them. The father took the lad with him to bathe day after day, until the fish knew of his plans and resolved to defeat him. They made up their minds to slay the boy. They dared not attack him in the water, so they chose as the scene of the slaughter an old log where the boy, after his swim, would bask in the sun. There the fish attacked him, and the stingray fatally wounded him. The father carried his son into the forest. When the dying youth saw his blood drop onto the ground, he told his father of the curious plants that would grow wherever his blood took root, and he forecast that the roots of these plants would avenge his death."

The plants, of course, were barbasco. This myth is strikingly reminiscent of the Greek myths about Hyacinthus, from whose blood, dropping on the ground, sprang the hyacinth; about Ajax, from whose spilled blood a flower sprang up bearing the letters AI (woe) on its petals; about Adonis (Tammuz in Syria), from whose blood anemones sprang.

An Arecuna myth from Guyana recounts how a woman bathed a male child in a river, and quantities of fish died. Consequently, she washed the child each time there was a shortage of food. Finally the boy was killed by a supernatural being under the surface of the water. The woman put the body into a basket to carry it home. Blood oozed from the basket, then pieces of flesh fell out of it, creating timbó.

In a myth of the Mundurucú of the central Amazon, a frog-sorcerer told a woman whose body was covered with soot to bathe in the river, but warned her to face upstream and not to look behind her. The soot was washed off and it had the effect of timbó; fish died on the surface after beating the water three times with their tails. But the woman turned around to see what was causing the noise, and the fish came back to life and swam away. When the frog-sorcerer came to collect the fish he was furious. If she had obeyed him, he told her, Indians would no longer have to look for wild timbó.

A Carib variant, suggestive of the punishment in the garden of Eden, begins: "In ancient times, men knew nothing of disease, suffering and death. . . ." The spirits of the forest then lived with men. An Indian woman cruelly murdered the baby of one of these spirits. In her grief, the spirit declared that henceforth the children of men would also die and also know grief. And men would no longer be able to drain pools and pick up fish but would have to work to find roots with which to poison them.

These and many similar myths lead to a conclusion that fish-poisoning techniques must have been known by South American Indians for uncounted generations and that at least one piscicidal plant was counted among the magical and, therefore most important, bases of their existence.

V

The moot question of diffusion versus independent origin arises anew when the question of plant piscicides in North America is considered. There is ample evidence of their use in both southeastern and western North America, but apparently none were employed between the Mississippi River and the Great Basin. There is not enough literary source material to assume a connection between the Gulf Coast and Mexico. Consequently, "it seems likely that [the southeastern United States area of piscicides] may be related to the Antillean (and ultimately South American) area of fish-drugging" (9). Successive Carib and Arawak migrations into the Caribbean from northern South America might account for the presence of piscicides in the Antilles, just as it accounts for the snuffing of *Anadenanthera peregrina* and other culture traits involving plants. Heizer (9) lists the following fish poisons employed in the southeastern United States; Choctaw, Delaware, Creek, buckeye *(Aesculus* sp.*)* nuts; Cherokee, Delaware, walnut *(Juglans* sp.*)* bark and green nuts; Catawba, black walnut *(J. nigra)* nuts; Yuchi, devil's shoestring *(Tephrosia virginiana)* roots; Florida, Jamaica dogwood *(Piscidia piscipula)* and dogwood *(Cornus* sp.*)* roots.

A somewhat different list for this area has been offered (20): (north to south) Indian turnip *(Arisaema triphyllum)*; pokeweed *(Phytolacca decandra)*; devil's shoestring *(Tephrosia virginiana)*; buckeye *(Aesculus* sp.*)*; *Cocculus carolinus*, sometimes called "false jessamine". Several species of *Aesculus* are called "buckeye". The most likely to have been utilized in this area is *A. pavia*, the red buckeye. The common name of *Cocculus* is "Carolina moonseed", a climbing vine found from Virginia to Florida. False jessamine is probably *Gelsemium sempervirens*, a climbing vine found from Virginia to Florida and Mexico, all parts of which contain poisonous alkaloids.

Rostlund (20) concludes that it is not safe to assume that fish poisoning was an aboriginal trait in eastern and southern United States: he suggests that it could have been introduced in relatively recent times, possibly by Europeans or by Africans from the West Indies.

Available comments are contradictory and evidence is sparse. Plant piscicides may have been used infrequently by Indians and consequently may not have been noticed by observers or were not considered worthy of mention. Why, for example, did William Bartram, a keen observer and a competent botanist, not mention this custom?

Early reports from this area, do, however, include details of interest in an overall picture. The procedure described is like that of South American utilization of plant material: the plants are pounded, steeped in water in a trough, and scattered on the surface of a pond which is then stirred with poles to spread the poison; the stunned fish are collected in baskets. In South Carolina, nuts of *Aesculus pavia* were ground and mixed with wheat flour to make a thick dough which was thrown into the water. It is not clear whether this was an Indian or a European practice.

The picture in western North America is no clearer than in the southeast. Rostlund states that, as far as he knows, the earliest report of fish-poisoning in that area was made by Powers in 1877. He believes it improbable that the trait could have been introduced at that time and concludes that it "seems safe to think that it was aboriginal on the west coast".

Plants utilized in this area (north to south) are: toza root *(Leptotaenia dissecta);* a plant called by variants of the name "Solomon" *(Smilacina* spp.*);* turkey mullein *(Eremocarpus setigerus);* blue curl *(Trichostema* spp.*);* soaproot *(Chlorogalum pomeridianum);* manroot *(Echinocystus* sp.*);* buckeye *(Aesculus californica).*

Ample evidence is available of the use of fish poisons in northwestern Mexico, and it is known that California Indians utilized such plants as turkey mullein, soaproot, and the buckeye. There is a great block of tribes between these two centers, however, that did not eat fish. Heizer concludes that if a historically connected Mexican-North American practice of narcotizing fish existed, it must either have started to the west of the areas where fish were not eaten, or was transferred — probably along the coast — before a taboo against fish-eating was in operation.

Rostlund's suggestion that possibly the use of plant piscicides was introduced into southeast North America by Africans from the Caribbean (possibly by escaped slaves) or by Europeans, is mentioned by Heizer. One introduction by Europeans is discussed by Wilhelm (27), but since contact between Indians and settlers does not seem to be involved, this example cannot be accepted as an instance of the effective introduction of a technique. It may rather represent simply the use of an already known procedure in a new environment.

VI

Quite aside from the great age of use of piscicides among primitive peoples, and returning to *Verbascum* and the common term "barbasco" — there remains the question of the use of mullein *(Verbascum* spp.) described by Wilhelm among the mountaineers of the southeastern United States.

These people, who were of English, Scotch-Irish and German descent, emigrated to the Blue Ridge area in the 1700s. For food, they had to rely on hunting, fishing and gathering until their harvests became dependable. Although there were at least twenty species of fish in the region, these settlers — except for those who already had a fishing tradition — much preferred hunting or collecting to fishing. However, some of them did fish regularly. They built dams, fish weirs or traps, and they used mullein as a piscicide. A native of this region, whose ancestors had come to America from Germany about 1780, described how his grandfather had used mullein in Europe.

"They'd heard 'bout the new land . . . 'n decided to bring things that'd help them git a start," he said. "Stinging fish [drugging] was one easy way of gettin' food at first, so Feltwort [German common name of mullein] seeds were brung along." Other dwellers of the region commented that fish-poisoning had been practiced "on the sly" by their families in Europe. Inasmuch as these settlers had been working people or farmers, it is quite likely that there they had indulged in a little poaching. Fish-drugging is a poacher's technique in the British Isles, as opposed to the gentleman's method of fishing with hook and line (9). Fish-drugging has been practiced in nearly every European country. There are many specific references in old writings to the use of this technique in Greece, Italy, Spain, France, the Netherlands, Germany, Russia, Ireland and England.

Their knowledge — and mullein seeds — stood these mountaineers in good stead as settlers in a strange land. The women set aside a place in their dooryard gardens for mullein plants — the more especially because, aside from the use of its seeds for fishing, mullein was considered a valuable household remedy. Common mullein *(Verbascum Thapsis)* is a coarse plant which grows from two to six feet high, with a stout, erect stem and a basal rosette of large, velvety leaves. It has tightly-packed yellow or (rarely) white flowers. This is most probably the species brought by these settlers, which, escaped from their Blue Ridge gardens, augmented the weedy flora of the region.

As far as informants remembered, fishermen crushed mullein seeds, mixed them with a little water, and dumped the mixture into a stream. The stunned fish came to the surface, gasping and struggling, and were collected in nets or baskets. Fewer than a dozen people usually participated in these "fish stings", but cooking and eating the catch was a social event for the whole community.

Although *Verbascum Thapsis* is an introduced plant, not native to the New World, the mullein of the Blue Ridge settlers was not the first mullein to grow in North America. A century earlier, before these people brought seed from Europe, mullein grew in New England. John Josselyn, in his *New Englands Rarities*, lists the "mullin [*sic*] with the white Flower" as among "Such Plants as have sprung up since the English Planted and Kept Cattle in New-England" (12).

What species of mullein Josselyn mentions as having been brought to New England before 1621 is uncertain. He mentions a white flower. *Verbascum Thapsis*, does, rarely, have white flowers. Tuckerman, who added notes to Josselyn's account, states that a white floured [*sic*] mullein listed in Gerard is perhaps *V. Lychnitis*, adventive in some parts of the United States. This species is sometimes called "white mullein", but it is scarce and its flowers may be either yellow or white. Another possibility is *V. Blattaria*, the moth-mullein, the flower of which may be white, yellow, or purple-tinged. Since Tuckerman observes that *V. Thapsis* was "common in Cutler's time" — that is, certainly by 1785, when Cutler published a list of plants found in the Massachusetts area — it is very probable that this species is the "mullin with the white Flower" to which Josselyn refers.

Josselyn does not mention the piscicidal properties of mullein. This role of the plant seems to have "gone underground" as a result of laws in many countries prohibiting its use for fishing. By the mid-1700s, its ability to stupefy fish was doubted, although it continued to be valued as a cure for various ills, including coughs in cattle and humans and as a remedy for inflamed eyes. The plant produces a mild narcotic, and tea made from it is said to have a sedative effect.

Verbascum, known commonly as "mullein" in English and as "gordolobo" in Spanish, and bestowing its name, as "barbasco", on hundreds of unrelated plants used to drug fish, apparently has been a servant as well as a companion of man for many hundreds of years.

NOTE: The aboriginal method of obtaining quantities of fish by dispersing ichthyotoxic plant material (collectively known as "barbasco") in water, is employed in a modified form in the United States today. The purpose is primarily for "fish control", to eliminate undesirable species preparatory to stocking with trout. According to Dr. Robert S. McCraig, aquatic biologist (Division of Fisheries and Game, Commonwealth of Massachusetts), various commercial preparations (usually of rotenone, the active principle in many types of barbasco) in the form of finely milled powder or an emulsion, are utilized in the same way that plant material is used by primitive peoples.

ACKNOWLEDGEMENTS

I am most gratefully indebted to Prof. Richard Evans Schultes for his encouragement in the preparation of this study and for his suggestions of specialized source material. I wish to thank Dr. Gene Wilhelm of Slippery Rock College for his suggestion that I investigate the origin of the term "barbasco" as it relates to the genus name *Verbascum*. To Miss Anna Roosevelt, Curator, Museum of the American Indian, I express my appreciation for bibliographical references on the use of plant piscicides by North American Indians. To Ruth Robertson I owe special thanks for her photograph showing how barbasco fishing is carried out. It is taken from her book, *Churún Merú* (1975), an account of her 1949 expedition to the foot of Angel Falls to measure its height for the first time.

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PLATE 13

Plate 13. Kamarata fishing with barbasco near Angel Falls, Venezuela.
Photograph by Ruth Robertson

BOTANICAL MUSEUM LEAFLETS
HARVARD UNIVERSITY

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ALBERT FREDERICK HILL (1889–1977) AND ECONOMIC BOTANY

RICHARD EVANS SCHULTES

Dr. Albert F. Hill died at his home in Surry, Maine, on March 20, 1977. His long and intimate association with the Botanical Museum of Harvard University contributed substantially to the pre-eminence that this institution enjoys in the field of Economic Botany. The following notes, based on my personal discussion with Dr. Hill in 1967, and read at a meeting of the Society for Economic Botany, are offered as a tribute to and an appreciation of his outstanding contributions to this interdisciplinary field of botany and to the Museum.

There is probably no name better known in contemporary economic botany than that of Albert F. Hill. Yet, beyond a few colleagues and students at Harvard University, he is not personally known to many. A most modest scientist, he almost never attended meetings and congresses. Ted, as he was known to all of his friends, said to me when he was asked to address the annual meeting of the Society for Economic Botany, of which he had been president in 1966–1967: "While I am supposed to be an authority in economic botany, except perhaps for nomenclature, my contributions are virtually non-existent. Because, in our 'new society', it is thought improper to reminisce, I cannot prepare a respectable presidential address for the honour that the Society for Economic Botany has just given me. I regret that I cannot attend your meeting, but I would rather do nothing about an address than to make remarks for the sake of making remarks and knowing that I had contributed nothing. I do, nonetheless, deeply appreciate the honour and thank you for thinking of me in this way".

Ted's assertion that his "contributions are virtually non-existent" constitutes a major understatement. His contributions are, to be sure, often more or less recondite and perhaps not

ALBERT FREDERICK HILL
1889–1977

Born Dresden, Germany, September 4, 1889. A.B., Dartmouth College, 1910. A.M., Harvard College, 1911; Ph.D., Yale University, 1921. Assistant Botanist, Harvard, 1911–1913; Assistant Curator of Botanical Collections, Yale, 1914–1935, Instructor in Botany, 1918–1927, Assistant Professor, 1927–1934; Assistant, Harvard, Botanical Museum, 1935–1939, Research Associate, 1939–1957. American Association for the Advancement of Science; Botanical Society; Ecological Society; New England Botanical Club. President, Society for Economic Botany 1966–1967; Fellow, Linnean Society (London). Systematic, geographic and economic botany and ecology.

widely recognized. Since I have been asked to say a few words about our outgoing president, I take this opportunity of telling you about Albert F. Hill, the man, and Albert F. Hill, the economic botanist. I do so humbly and mindful of the great debt that I, as only one economic botanist, owe to him for his friendliness and help during our association in my days as a student and, subsequently, as a staff member at the Harvard Botanical Museum.

Born 88 years ago in Dresden, Germany, of American parents, Ted was nine months old when he came to the United States. Before he was two, his father died, and he grew up in his grandparents' home in Attleborough, Massachusetts, attending public schools there. Upon graduation from the Attleborough High School, he matriculated at Dartmouth College, majoring in botany, in which field he had long fostered a childhood interest. He earned his A.B. *cum laude* with departmental honours in botany in 1910. Dartmouth, at that time, had four great teachers of botany, former students of Prof. Roland Thaxter, the Harvard mycologist. Ted fell under the tutelage of Prof. George R. Lyman, who later joined the United States Department of Agriculture in Washington and to whom Ted owed much of his later success.

He thought of doing graduate work at Cornell University but finally took an Austin Teaching Fellowship at Harvard, attracted by another great teacher, Prof. Merritt L. Fernald, under whose direction he did research on the coastal flora of eastern Massachusetts. In 1911, he earned his A.M. at Harvard and became an assistant in Fernald's course. During his last two years as a graduate student, he served as assistant curator of the New England Botanical Club Herbarium.

In 1914, Ted went to Yale as curator of botanical collections, and, shortly thereafter, he began teaching field botany, followed later by a course in taxonomy. He also taught the course in elementary biology for five years at the Sheffield Scientific School at Yale. During this period, he was put in charge of the library in the Botany Department and was given the administration of the herbarium and the teaching of Prof. Nichols' elementary botany course.

It was during this time that Ted decided to finish his doctorate, so long delayed by teaching and administrative duties at Yale. Ecology was emerging as a distinct field and it appealed to him, although his first interests had been in plant distribution. His

Ph.D. was awarded in 1921 on a thesis dealing with the vegetation and ecology of the Penobscot region of Maine.

Ted's interest in economic botany began specifically during his teaching of elementary botany at Yale, when he included two or three lectures on food plants. Both Prof. Nichols and he felt that a course devoted to useful plants might be of value, and they worked up notes for it which were filed away and forgotten. Eventually, he did institute a course as a seminar, albeit in general education. It began with six students the first year, the second year it had eight or ten, and the third year fifteen registered.

It was then that he saw the need for a reference book, a manual or some kind of text to leave the lecturer freer to develop his subject in lectures more fully and more personally. Ted used to reminisce that "fools rush in where angels fear to tread", but he resolved to write a text, even though almost immediately the great difficulties of such an undertaking became apparent.

Starting with the limited facilities then available at Yale, he prepared five or six chapters, submitting them to one of his former professors, Prof. Edmund Sinnott, who was an editor for McGraw-Hill Company. These preliminary chapters pleased all concerned, and the publishers pressed for completion.

At that time, for personal reasons, Ted came to Harvard, where he met Prof. Oakes Ames who was in charge of the oldest course in economic botany in the United States, which had been taught since 1876. As a basis for this course, the Botanical Museum had extensive library, herbarium, and plant products collections. He had not known of these facilities but immediately sensed the value of them for the preparation of his projected textbook. Ames made it possible for him to finish the book by appointing him to the staff of the Museum. As a result of this appointment and Ted's own persistence, the book that has made *Hill* a household word in economic botany saw the light in 1936.

Many of the publisher's staff felt that this text was destined to be a "dud". The first year, however, showed otherwise, when sales greatly exceeded expectations. Progress was steady and startling. A second edition was published in 1952. Shortly thereafter, a less expensive English edition was published in Tokyo for sale to students in the Asiatic countries. And most recently, an Arabic translation appeared in Cairo, and an edition in Spanish was issued in Barcelona.

Notwithstanding the appearance in 1952 of another good text, the demands for "Hill" have increased over the years, and it is now selling more than ever before and has become the major text in this field in English. Ted's greatest influence in this fast growing field of economic botany has undoubtedly been this scholarly text. Who can tell how many of the recently proliferating college courses in this discipline were inspired by the final availability of a good textbook? A thorough, inclusive, laconic, and decidedly practical production, it is designed for the serious student of plants and their effects upon human affairs. There is, of course, no way precisely to measure its effect in establishing this new interdisciplinary field, but one may safely assert that it has been a major contribution.

Rather wistfully, Ted often said to me: "Never has it been my good luck to carry out any special research in my field". This may be true, but over the years he has been one of the busiest men in economic botany. Nomenclatural and taxonomical problems in preparing his textbook led to several papers in the *Botanical Museum Leaflets of Harvard University,* of which he was the editor for a number of years.

The availability for the first time of a truly international, standardized set of rules of botanical nomenclature meant that sundry, well established but incorrect names of economic species had to be studied; and with Prof. Ames, Ted Hill felt most strongly the need for putting economic botany firmly in line with the new nomenclature. For a number of years, he served on the nomenclature committee of the *United States Pharmacopoeia;* he was responsible for the nomenclature of the encyclopaedic *Wealth of India:* he checked for accuracy the technical names in Edition II of *Standardized Plant Names*. For six or seven years he served as associate editor for the journal, *Economic Botany;* more recently, he was a member of the editorial board for five years; and for many years he held a place on the editorial board of *Rhodora*. During all of these years, he actively reviewed botanical books for *Quarterly Review of Biology*.

In the meantime, his multitudinous duties at the Botanical Museum grew to include many time-consuming tasks in the library, the herbarium, and the products collections. He was appointed, first part-time and then full-time, librarian of the Oakes Ames Library of Economic Botany. Over the many years that Ames, and then Prof. Paul C. Mangelsdorf, offered Harvard's course in economic botany, Ted was close to the students in their preparation of the exhaustive term papers required in the course. Finally, when Prof. Mangelsdorf took half a year's leave in the 1940's, Ted taught the whole course, thereafter continuing to share the teaching with Prof. Mangelsdorf until his retirement in 1958. Long after his retirement he continued to offer a number of lectures in the course.

Ted was married to the late Julia Faulkner in 1934 until her death in 1949. During this period, they lived happily with their books in an apartment near the Botanical Museum in Cambridge and spent summers in their beautiful home, "The Carrying Place" in Surry, Maine, to which Ted retired as his permanent residence a few years ago. He filled his days as never before with multitudinous interests ranging from horticultural clubs and Grange to local history, Boy Scouts, to serving on the board of a New England private preparatory school, to duties connected with local botanical societies and to editorial work on *Economic Botany*, *Rhodora*, and the *Botanical Museum Leaflets*. He kept up an active membership in the American Association for the Advancement of Science, the Botanical Society of America, the Society of American Plant Taxonomists, Sigma XI, Gamma Alpha, the Josselyn Botanical Society of Maine, the American Institute of Biological Sciences and the New England Botanical Club, the treasureship of which he held for more than twenty years. He was elected a Fellow of the Linnean Society of London in 1972.

He kept well abreast of world affairs and progress in botany. His knowledge of current literature was astounding. On his frequent trips to Cambridge, he still had time for friends, colleagues and students. Coming from an unusually long-lived family, he looked forward to many years of activity and productivity, and he was not disappointed in this hope. His record of accomplishments is truly outstanding, even though it cannot wholly be measured in tangible units.

One of Ted's non-botanical pursuits was the study of Shakespeare, and even after his retirement north to Maine, he remained an active member of Cambridge's Shakespeare Society. I have often heard him quote in casual conversation a snatch from the great English master, but now it is my turn to say that every time that I think of what Ted Hill has done for economic botany and the Botanical Museum I recall a passage from *King Henry VI* that seems to epitomize his contributions: "Sir, he made a chimney in my father's house, and the bricks are alive to this day to testify it''.

DE PLANTIS TOXICARIIS E MUNDO NOVO TROPICALE COMMENTATIONES XV

Desfontainia: a new Andean hallucinogen

RICHARD EVANS SCHULTES

In 1965, Dr. Carlos Mariani Ramírez (*Témas de Hipnosis,* 362–363, tab. 23, Editorial Andres Bello, Santiago, Chile) published a most interesting report which stated that the leaves of *Desfontainia spinosa* var. *Hookeri* are employed in Chile as a narcotic and stomachic. He further maintained that the leaves are as bitter as gentian and that the local Mapuche Indians use them as a source of yellow dye in their textiles. The vernacular names of this shrub in Chile are *taique, chapico, michai blanco* and *trautrau*. An excellent drawing of the plant accompanied the report in lieu of a voucher specimen.

On the basis of this Chilean record, *Desfontainia* has recently been included in several books on hallucinogenic plants (Schultes, R.E., *Hallucinogenic Plants* (1976) 150–151, Golden Press, New York; Schultes, R.E. in [B.M. DuToit, Ed.] *Drugs, Rituals and Altered States of Consciousness* (1977) 48, 263, A. A. Balkema, Rotterdam; Schultes, R. E. in [P. T. Furst, Ed.] *Flesh of the Gods* (1972) 52, Praeger Publishers, New York; Schultes and Hofmann, *The Botany and Chemistry of Hallucinogens* (1973)219; W. A. Emboden, Jr., *Narcotic Plants* (1972)76, tab. 63. Macmillan Co., New York).

During my years of ethnobotanical studies in Colombia, I was able twice to collect *Desfontainia spinosa* with annotations concerning its use as a native hallucinogen. In both cases, the use was centered in the Valle de Sibundoy, a mountain-girt valley at 6700 feet, east of the Colombian city of Pasto. The valley is the abode of Kamsá and Ingano Indians and is an area where native medicine men make unusually extensive use of hallucinogens (species of *Datura* [*Brugmansia*], *Methysticodendron Amesianum, Iochroma fuchsioides)* in their magico-medical practices.

It is not easy, however, to procure much information on Desfontainia, partly because it represents an hallucinogen which, unlike the others employed in the region, is wild, apparently never cultivated. It grows in the moors or *páramos* surrounding the valley, and medicine men must go afield to secure their supply of leaves.

The first time that I learned of the narcotic use of Desfontainia was in 1942, when, while collecting in the Páramo de Tambillo, northeast of the Valle de Sibundoy, one of my guides — the son of a shaman — volunteered the information that native medicine men took a tea of the leaves of *D. spinosa,* known locally as *borrachera de páramo,* when they "want do dream." Later, in 1953, while collecting in the Páramo de San Antonio on the road between Pasto and Sibundoy, several Indians volunteered the information that "in Sibundoy, witch doctors use a tea of the leaves to see visions and diagnose illness." One Indian indicated that the medicine men "go crazy" when they take the drink.

There is an urgency to learn more about this drug plant, as native lore in the region is fast disappearing. I have on several occasions questioned local medicine men about the plant but have met with reluctance to discuss its use. This reluctance in itself is an indication possibly that its employment is held more in secret because of a very special place that the plant holds in magico-medical practice.

No psychoactive constituent is as yet known from the genus *Desfontainia*. Material from several herbarium specimens of *D. spinosa* from Argentina, Chile, and Ecuador have been spot-tested with Dragendorff reagent for alkaloids with what appear to be negative results. These reports of similar use in such distant points in the Andes, however, tend to suggest that the genus does actually possess psychoactive principles.

Voucher specimens are enumerated as follows:

COLOMBIA: Comisaría del Putumayo, Páramo de Tambillo, nordeste del Valle de Sibundoy, 2700–2800 m. "Tree. Flowers: sepals red, petals yellow. *Borrachero de páramo.*" December 13–14, 1942. *R. E. Schultes et C. E. Smith 3127.*

Comisaría del Putumayo, Páramo de San Antonio, road from Pasto to Sibundoy, 9300–9600 feet. "Bush, Sepals vermillion, petals yellow." March 13, 1953. *R. E. Schultes et I. Cabrera 18898.*

While there is little doubt that the two Colombian collections do represent *Desfontainia spinosa,* what other species and varieties occur in Colombia is not yet clear.

The genus *Desfontainia* and its species have long been enigmatic. *Desfontainia* was described by Ruíz and Pavón in 1794 and placed in Linnaeus' *Pentandria monogynia* (Fl. Peru. Chil. Prodr. (1794)29). Humboldt and Bonpland suggested that it belonged in the Solanaceae (Pl. Aequin. 1(1808)157). Most taxonomists of the first half of the past century tended to follow this concept. D. Don, however, allocated it to the Gentianaceae (Edinb. Phil. Journ. (1831)274). Meisner placed it uncertainly in the Aquifoliaceae (Gen. Pl. 1 (1839)252). Endlicher located it at the end of the Solanaceae but indirectly (as "Tubiflorae Incertae Sedis") suggested that it represented a distinct family: Desfontainiaceae (Gen.Pl. 1(1839)669; Enchiridion (1841)336). In 1856, Bentham placed it in the Loganiaceae (Journ. Linn. Soc. 1(1856)97), as did Bentham and Hooker twenty years later (Gen. Pl. 2(1876)794). Hutchinson included the genus in the family, Potaliaceae, in 1959 (Fam. Fl. Pl., Ed. 2(1959)371; Ed. 3(1973)460). Leeuwenberg, in his monograph of the genus, has maintained it in Loganiaceae, placing it in a distinct tribe Desfontainieae near the Potalieae and Retzieae (Acta Bot. Néerl. 18(1969)669-679). Chemotaxonomically, the tendency has been to place *Desfontainia* in the Loganiaceae (Hegnauer, R., *Chemotaxonomie der Pflanzen* 4(1966)414; Gibbs, R.D., *Chemotaxonomy of Flowering Plants* 3(1974)1332). Most modern taxonomists appear to have accepted *Desfontainia* as a member of the monotypic family Desfontainiaceae (e.g., Solereder in Engler and Prantl Natürl. Pflanzenfam. 4(2)(1895)50; Hallier, Medel. Rijksherb. Leiden (1911)28; Pulle, Compendium . . . (1950)333; Lawrence, Tax. Vasc. Pl. (1951)667; Johnson, Tax. Fl. Pl. (1931)484; Weberbauer, Mund. Veg.

Andes Peru. (1945); Muñoz P., Sin. Fl. Chilena, Ed. 2(1966)96. Melchior (in Engler, Syllab. Pflanzenfam., Ed. 12, 2(1964)408) has kept Desfontainiaceae, but has noted that the systematic position is still not clear. Similarly, Takhtajan (Flow. Pl., Origins and Dispersal (transl. Jeffrey) (1969)203) maintains Desfontainiaceae as a separate family but remarks: "relationships not very clear". Macbride (Field Mus. Nat. Hist. Bot. Ser. 13, pt. 5, no. 1 (1959)249) and Skottsberg (Bot. Ergebnisse (1916)287) have retained *Desfontainia* in the Loganiaceae. Airy Shaw, however, continues to assign the genus to the Potaliaceae (in Willis, Dict. Fl. Pl. Ferns, Ed. 8(1973)350). At the present time, I prefer to accept the monotypic family Desfontainiaceae.

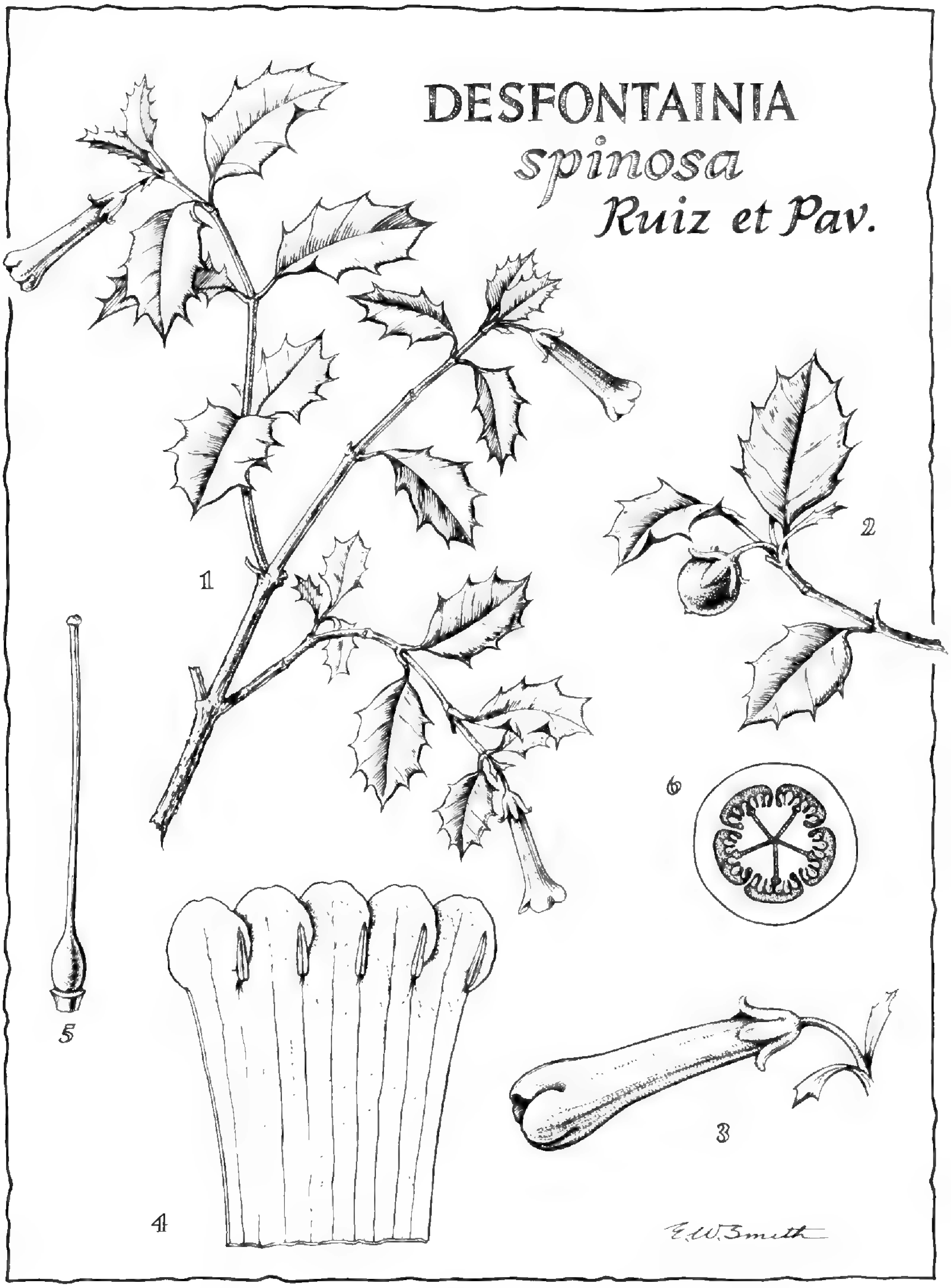
Although the genus *Desfontania* is regarded usually as comprising but two or three species, some eleven binomials have been described. All are Andean. The type species, *D. spinosa*, was collected near Churupallano, Tarma, or between Mũna and Pozuzo, Peru. It seems probable that some of the binomials proposed do represent synonyms of *D. spinosa*. Leeuwenberg has reduced all eleven species to synonymy under a highly variable *D. spinosa*, attributing the variability to altitudinal and ecological factors. He enumerated informally six "forms" (not recognizing them with Latin epithets) and a number of intermediates between the "forms," noting in summary that "the complexity of the variation is not yet completely described" by his enumeration. A preliminary survey of herbarium material of *Desfontainia* and familiarity with the variation in highland Andean floras combine to make me extremely dubious that such extraordinary variability can be treated simply as environmentally induced responses in a single species. Further taxonomic studies are needed to clarify this long standing enigma.

The two concepts upon which the reports of narcotic use are based are:

Desfontainia spinosa *Ruíz et Pavón* Fl. Peruv. Chile 2(1799)47, t. 186.

Desfontainia spinosa *Ruíz et Pavón* var. **Hookeri** *(Dun.) Voss ex Vilmorin* Blumengärtn, Ed. 3,1(1894)669.

PLATE 15



EXPLANATION OF THE ILLUSTRATION

Plate 15. *Desfontainia spinosa* Ruíz et Pavón. 1) Flowering branch, x ½. 2) Fruiting branch, x ½. 3) Flower in bud, approximately, x 1. 4) Corolla, cut and unrolled, x approximately 1¼ x. 5) Pistil, x approximately 1½. 6) Cross section of ovary, x approximately 7.

Drawn by E. W. Smith

PLATE 16

CLXXXVI

DESFONTAINIA

EXPLANATION OF THE ILLUSTRATION

Plate 16. The original illustration of the type species, *Desfontainia spinosa* Ruíz et Pavón, published with the description of the species.

THE IDENTIFICATION OF AN ARGENTINIAN NARCOTIC

ELSA M. ZARDINI*

There are few narcotic plants known to have been used by the Indians of Argentina, tobacco and cebil are almost the only examples.

The identification of another, however, remained uncertain: the root of a plant called *coro*. It was early mentioned by Padre Pedro Lozano, a Jesuit who lived and worked in Argentina in the 18th century, but whose writings were published much later. The plant was employed as a narcotic by the Calchaqui Indians as an additive to their alcoholic beverage *chicha:* "... mando echar en la chicha ciertas raices molidas que llaman coro y son muy eficaces para embriagar..."

More recently, there are other references to the use of this root powdered and smoked either alone or mixed with tobacco among the Chaco Indians (Mocovies, Tobas and Matacos). The same common name was used among all these natives.

My recent studies have disclosed that several species of the genus *Trichocline (Compositae: Mutisieae)* bear the same common name in Argentina—*coro*—as well as the ethnopharmacologically significant name *contrayerba*.

The rhizome is today employed extensively alone or mixed with tobacco as a fumitory. This use is very widespread, occurring in almost all areas where the Argentinian species are represented in the flora. The species most frequently utilized is *T. reptans* (Wedd.) Rob., the commonest in the Chaco region. In the Andean regions, *T. exscapa* Griseb. and *T. dealbata* (Hook. et Arn.) Griseb. are the species employed.

The rhizome of all the species is thick and woody. The leaves are borne in rosettes. The scapes have beautiful yellow inflorescences.

One use of the rhizome in folk medicine is reported to be smoking as an effective cure for "stomach ache".

Chemical studies of this genus have apparently not been car-

*Honorary Research Fellow in Ethnobotany; Guggenheim Fellow from Museo de La Plata, Argentina.

ried out, but the role that *Trichocline* plays in Argentinian folk medicine and in Indian customs would seem to justify analysis for active constituents.

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PLATE 17

Plate 17. *Trichocline reptans* (Wedd.) Rob. — Photographed in situ, Chaco, Argentina. — Photograph by Elsa Zardini.

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DE PLANTIS TOXICARIIS E MUNDO NOVO TROPICALE COMMENTATIONES XVI

Miscellaneous notes on biodynamic plants of South America

RICHARD EVANS SCHULTES

The many plants with toxic or otherwise biodynamic properties in the South American flora are surprisingly interesting in their botanical diversity. Knowledge and occasional use of these properties appear to be unusually extensive amongst the natives of the northwesternmost part of the Amazon Valley, especially in that sector lying within the boundaries of Colombia. Ethnotoxicological reports in the literature have not been so extensive for this area as they have been for some of the other better known sectors of this great basin.

Many of the species mentioned in the following pages belong to families and genera hitherto not known to possess active organic constituents. Consequently, their ethnotoxicological study frequently may yield chemotaxonomically or even pharmacologically significant information. Often this kind of information may indicate the advisability of critical phytochemical investigation.

Earlier contributions in this series have provided ethnobotanical observations designed to encourage medically oriented examination of chosen elements of the tropical American flora. Many of the notes cited below are taken from my own field observations during plant exploration in the Amazon Valley from 1941 through 1953 and on many subsequent short trips to the southeastern part of the Republic of Colombia. Other observations are extracted from the labels of herbarium collections and are here published either because of their own intrinsic significance or because they outline uses similar to those which I have encountered for the same or related species.

Voucher specimens are deposited in the Economic Herbarium of Oakes Ames, the Gray Herbarium (both at Harvard University) or the Herbario Nacional de Colombia in Bogotá—or in several of these institutions.

The families are arranged in accord with the system of Engler & Prantl; the genera are arranged alphabetically under the families.

GRAMINEAE

Hierochloe redolens *R. Brown,* Prodr. (1810) 209.

COLOMBIA: Departamento de Santander, vicinity of La Baja, alt. 2200–2600 m. January 14–28, 1927. *E. P. Killip et A. C. Smith 18395.*

Departamento del Norte de Santander, vicinity of Mutiscua, alt. 4000 m. February 20–22, 1927. *E. P. Killip et A. C. Smith 19678.*

According to Killip and Smith, the *itamo real* is a valuable remedy in Santander, "much used by aged people" and "one of the most valuable of medicinal plants, used for many diseases."

Coumarin has been reported from the genus Hierochloe (Gibbs, R. D.: Chemotaxonomy of Flowering Plants 3 (1974) 1899) and many species, including *H. redolens,* have a strong odour of coumarin.

PALMAE

Jessenia polycarpa *Karsten* in Linnaea 28 (1856) 388.

Throughout the Colombian area of the Llanos and the Colombian basin of the Amazon, this palm has the reputation of yielding an oil valuable for treating pulmonary problems. The oil from the pericarp is an excellent edible oil, and progress is now being made towards the domestication of this wild palm. There have been studies on the bromatology of the oil, but investigations concerning the widely accepted belief in the efficacy of the oil to relieve pulmonary troubles have not yet been initiated. The Makú Indians of the Río Piraparaná in the Vaupés employ the oil as a vermifuge (García-Barriga, H. *Flora Medicinal de Colombia* 1(1974) 144–146)—a medicinal use still to be scientifically examined.

ORCHIDACEAE

Eriopsis sceptrum *Reichenbach fil. et Warscewicz* in Bonpl. 2 (1854) 98.

BRAZIL: Estados do Amazonas, basin of Río Negro, Río Dimití, May 11–19, 1948. *R. E. Schultes et F.* López 9947.

Estado do Amazonas, Río Negro, Cocuí. May 9, 1948. *R. E. Schultes et F. López 9997.*

COLOMBIA: Comisaría del Vaupés, Río Guainía, near Cerro Monachí. June 1948 *R. E. Schultes et F. López 10035a.*

Comisaría del Amazonas, Río Apaporis, Soratama, between Ríos Pacoa and Kananarí. June 17, 1951. *R. E. Schultes et I. Cabrera 12620.*

The basal stems of this clumped epiphyte are boiled in water to extract the copious mucilage which is applied to sores of the gums and mucous membranes of the mouth for relief from discomfort. The Makuna name of this orchid in the Apaporis is *wan-oo-ma-ka* ("mouth herb").

NYCTAGINACEAE

Neea parviflora *Poeppig et Endlicher,* Nov. Gen. ac Sp. Pl. 2 (1838) 46.

COLOMBIA: Comisaría del Putumayo, Umbría, Alt. 325, Forest. January–February 1931. *G. Klug, 1955.*

Called *yano muco* ("black chew") in the Colombian Putumayo, this species is valued by the natives who chew the leaves to stain the teeth black in the belief that this custom "strengthens" the teeth and gums.

PHYTOLACCACEAE

Phytolacca bogotensis *Humboldt, Bonpland et Kunth,* Nov. Gen. et Sp. Pl. 2 (1817) 183.

COLOMBIA: Departamento de Cundinamarca, Pantano Redondo, Zipaquirá. Altitude 3200–3250 m. July 13, 1960. *R. E. Schultes 22469.*

Native farmers assert that cattle eating the foliage and fruit of the *Phytolacca bogotensis* are poisoned.

Cyanogenic glycosides have been reported from some species of the genus (Gibbs, loc. cit. 2 (1974) 1227).

Phytolacca rivinoides *Kunth et Bouché* in Ind. Sem. Hort. Bot. Berol. (1848) 15.

COLOMBIA: Comisaría del Putumayo, Río Sucumbíos, Conejo and vicinity, at mouth of Quebrada Conejo. Altitude 300 m. April 2–5, 1942. *R. E. Schultes 3458*.—Same locality and date. *R. E. Schultes 3646*. — Río Sucumbíos, Santa Rosa and vicinity. Altitude 380 (?) m. April, 1942. *R. E. Schultes 3583*.

The Kofán Indians occasionally mix the leaves of *Phytolacca rivinoides*, which they call *un-shum-bey*, with the leaves of Phyllanthus for stupefying fish. It is also commonly used as a saponifier for washing clothes. The name in Spanish in the region is *altasa* or *altusa*.

RANUNCULACEAE

Ranunculus peruvianus *Persoon*, Syn. Re. 2 (1806) 103.

COLOMBIA: Departamento de Cundinamarca. Siberia, Páramo de Palacios, 9,000–10,000 feet. July 11, 1960. *R. E. Schultes 22474*.

The roots are boiled to prepare a tea which is considered to be a stimulant for the aged and weak. It is employed in folk-medicine in the hills near Bogotá.

MENISPERMACEAE

Abuta Imene *(Mart.) Eichler* in Flora 47 (1864) 389.

COLOMBIA: Comisaría del Vaupés, Río Apaporis, Raudal de Jirijirimo. January 21, 1952. *R. E. Schultes et I. Cabrera 14958a*.

Along the Río Kananarí, an affluent of the Apaporis, the Taiwano Indians indicate that they utilize the bark of the stem of *Abuta Imene* in preparing one kind of curare.

Abuta splendida *Krukoff et Moldenke* in Bull. Torr. Bot. Club 68 (1941) 251.

COLOMBIA: Comisaría del Putumayo, Río Sucumbíos (San Miguel) Conejo and vicinity, near Quebrada Conejo. April 2–5, 1942. *R. E. Schultes 3235*.

The bark of this species of Abuta is employed by the Kofán Indians in the preparation of one of their strongest curares. The type of *Abuta splendida* was collected in Bolivia, far from this Colombian locality. The Kofán name of this liana is *sa-pe-pa*.

Abuta yaupesensis *Krukoff et Barneby* in Mem. N.Y. Bot. Gard. 20 No. 2 (1970) 19.

COLOMBIA: Comisaría del Vaupés, Río Piraparaná, Caño Teemeeña (Lobo Igarapé). September 10, 1952. *R. E. Schultes et I. Cabrera 17344.*

This collection is the type of the species. The bark of the lower stem is the principal ingredient of one of the curares prepared by the nomadic Makú Indians of the lower Piraparaná. The Barasana Indians of the Río Piraparaná formerly employed this species as their main curare plant.

Anomospermum reticulatum *(Mart.) Eichler* in Flora 47 (1864) 388.

COLOMBIA: Comisaría del Amazonas, Trapecio Amazónico, Río Loretoyacu. Alt. 100 m. September 28, 1946. *R. E. Schultes et al. 8287.*

The Tikuna Indians of the Trapecio Amazónico of Colombia formerly utilized the bark of this species in preparation of one of their arrow poisons.

Andontocarya tripetala *Diels* in Notizbl. Bot. Gart. Berlin 13 (1936) 28.

COLOMBIA: Comisaría del Amazonas, Trapecio Amazónico, Río Loretoyacu, Lago Socó. Alt. 100 m. November, 1946. *R. E. Schultes et G. A. Black 8623.*

A brew made by boiling together the bark of *Adontocarya tripetala*, the *zapote*, *Matisia cordada* H. et B., and fruits of *Capsicum annum L.* is commonly taken in the Leticia area of Colombia and in adjacent Peru and Brazil to expel intestinal parasites.

Orthomene Schomburgkii *(Miers) Barneby et Krukoff* in Mem. N.Y. Bot. Gard. 22 (1971) 80.

COLOMBIA: Comisaría del Vaupés, Río Apaporis, Jinogojé, mouth of Río Piraparaná. Alt. 200 m. June 5, 1952. *R. E. Schultes et I. Cabrera 16602.* Same locality. August 25, 1952. *R. E. Schultes et I. Cabrera 17026.*

The Makú name of this scandent shrub, said to be toxic, is *chawm-aat´*.

Telitoxicum peruvianum *Moldenke* in Britt. 3 (1938) 45.

COLOMBIA: Comisaría del Vaupés, Río Piraparaná, Caño Teemeeña (Lobo Igarapé). "Small tree. Fruit dark green, Barasana name = *bo-de'-mee-see.*" September 10, 1952. *R. E. Schultes et I. Cabrera 17340.*

The bark of this treelet is the main ingredient in one of the Barasana curares.

This species was described from Amazonian Peru.

ANNONACEAE

Guatteria calva *R. E. Fried* in Svensk. Vet. Akad. Handl., ser. 3, 24, No. 10 (1948) 9.

COLOMBIA: Comisaría del Vaupés, Río Vaupés, Mitú and vicinity, Urania. On granite slope. "Small tree, 20 feet. Flowers green, petals leathery. Leaves, bark, flowers very alkaloid-positive. Fruit slightly positive." September 27–October 20, 1966. *R. E. Schultes, R. F. Raffauf et D. Soejarto 24323.*

The Kubeo Indians indicate that the bark of the stem or trunk of this small tree is an ingredient of a type of curare which they prepared in former years. There were three ingredients, according to informants, but the identity of the other two plants have not yet been established beyond the statement that they are "leaves of trees."

Unonopsis veneficiorum *(Mart.) R. E. Fries* in Acta Hort. Berg. 12 (1937) 238.

COLOMBIA: Comisaría del Vaupés, Río Apaporis basin, Río Pacoa. "Puinave name = *choon.*" February 7–12, 1952. *R. E. Schultes et I. Cabrera 15269.*

The Barasana Indians, native to the lower Apaporis basin, employ the root and the bark of the lower stem of this tree in the preparation of an arrow poison. This report represents apparently the third concerning the role of this plant in curare. The Puinave Indians, some of whom have migrated recently into the Apaporis basin, are not aware of this use of *Unonopsis veneficiorum,* although they know the plant and recognize it as "dangerous."

This annonaceous species is apparently rather widely utilized. in the Colombian Amazonia as the basis of an arrow poison. The first report was published by von Martius (Spix, J. B. and K. F.

D. von Martius "Reise in Brasilien" [1831] 1237), who stated that the Indians in the Rio Japurá (Río Caquetá) and Rio Negro of Colombia and Brazil valued it *(Guatteria veneficiorum)* for this purpose. It has generally been overlooked in the literature, although Claude Bernard, in his classic *Leçons sur les effets des substances toxiques et médicamenteuses* (1867) 245 mentioned Martius' report. A recent report by Pinkley (in Schultes, R. E. in Bot. Mus. Leafl. Harvard Univ. 22 [1969] 134–136) has placed its use amongst the Kofán Indians of the Colombo-Ecuadorian border *(H. V. Pinkley 558)*.

LEGUMINOSAE

Entada polyphylla *Bentham* in Hooker, Journ. Bot. 2 (1840) 133.

COLOMBIA: Comisaría del Amazonas, Tropecio Amazónico, Río Loretoyacu. Alt. 100 m. September 28, 1946. *R. E. Schultes 8400c*.

A warm decoction of the seeds of this species is valued among the Tikunas of the Trapecio Amazónico as a gargle in cases of extreme nasal and pulmonary congestion as a result of severe catarrhal attacks to which they are prone in the cooler and wetter parts of the year.

Monopteryx angustifolia *Spruce ex Bentham* in Martius, Fl. Bras. 15, Pt. 1 (1862) 307.

COLOMBIA: Comisaría del Vaupés, Río Naquieni, Cerro Monachí. June 1948. *R. E. Schultes et F. López 10125*.

A bitter tea prepared from the bark of this tree is valued in the Río Guainía basin as a vermifuge.

Monopteryx Uaucu *Spruce ex Bentham* in Martius, Fl. Bras. 15, Pt. 1. (1862) 308.

COLOMBIA: Comisaría del Vaupés, Río Guainía, Caño del Caribe and vicinity. November 2, 1952. *R. E. Schultes, R. E. D. Baker et I. Cabrera 18270*.

The seeds of *Monopteryx Uaucu* are very oily but, boiled and toasted, they serve the natives of the upper Rio Negro of Brazil and the Colombian Vaupés as food. The tree, which is very tall with enormous buttress roots, has extremely important mythological significance to the Kuripakos of the Río Guainía.

The bark, scraped from the buttress roots and boiled, provides a tea which is often employed, as in the case of *Monopteryx angustifolia*, to expel intestinal worms. The Kuripako name of the tree is *ow-wei'-na*.

MALPIGHIACEAE

Banisteriopsis Cabrerana *Cuatrecasas* in Webbia 23, Pt. 1 (1958) 493.

COLOMBIA: Comisaría del Vaupés, Río Piraparaná, Caño Teemeeña. September 9, 1952. *R. E. Schultes et. I. Cabrera 17297.* Same locality. *H. García-Barriga 14321a.*

García-Barriga (loc. cit., 2 (1975) 54) reports that the Indians of the lower Piraparaná (the Barasana tribe) make their hallucinogenic drink from the stems of this vine. It is known locally as *yagé*.

VOCHYSIACEAE

Vochysia columbiensis *Marcano-Berti* in Pittieria, No. 1 (1967) 8.

COLOMBIA: Comisería del Vaupés, Río Kananarí, Cerro Isibukuri. "Small tree, 30 feet tall. Flowers yellow." December 4, 1951. *R. E. Schultes et I. Cabrera 14704a.*

The Kabuyarí Indians call this tree *ka-hó-gaw*. The bark is said to be an ingredient of one type of arrow poison prepared by the nomadic Makú Indians of the Río Piraparaná. The other two ingredients could not be ascertained beyond the fact that one was a leaf, the other a reddish berry. The arrow poison is made quickly by the Makú who use it for hunting small birds.

The chemistry of the Vochysiaceae has hardly been investigated. (Gibbs, loc. cit. 3 (1974) 1677).

Vochysia ferruginea *Martius*, Nov. Gen. et Sp. Pl. 1 (1826) 151, t. 92.

COLOMBIA: Comisaría del Vaupés, Río Apaporis, Raudal de Jirijirimo. Quartzitic base. April 1951. *R. E. Schultes et I. Cabrera 14538.*

The Kubeo Indians call this tree *too-á-ke*. They employ a decoction of the bark as a wash for ulcerating sores on the legs.

The dried and powdered leaves are occasionally added to coca in the belief that they are beneficial for sores of the mucous membrane of the mouth and gums.

Vochysia laxiflora *Stafleu* in Acta Bot. Neerl. 3 (1954) 407.

COLOMBIA: Comisaría del Vaupés; Río Apaporis, Raudal de Jirijirimo. "Flowers yellow. Large tree. Puinave: *po-ho-glo.*" November 25, 1951. *R. E. Schultes et I. Cabrera 14542.* Río Kananarí, Cerro Isibukuri. "Flowers yellow. Leaves erect. Tree 80 feet tall. Large crown. Bark grey-brown." September 29. 1951. *R. E. Schultes et I. Cabrera 14678.* — Same locality. "Medium sized tree. Flowers yellow. Leaves erect." December 4, 1951. *R. E. Schultes et I. Cabrera 14707.* — Río Apaporis, Jinogojé. "Flowers yellow. Small tree 35 feet tall." June 8, 1952. *R. E. Schultes et I. Cabrera 16676.*

Comisaría del Amazonas; Río Apaporis, Soratama. "Flowers yellow. Height 90 feet." February 4, 1952. *R. E. Schultes et I. Cabrera 15146.* — Same locality and date. *R. E. Schultes et I. Cabrera 15149.*

The Puinave Indians call *Vochysia laxiflora* by the same name that they use for *V. ferruginea,* although they easily recognize the two as different. They do not use it medicinally.

The several Indian tribes (Taiwanos, Barasanas, Makunas) resident in the middle Apaporis, on the contrary, value this tree for several therapeutic purposes. Its leaves are boiled with the leaves of coca *(Erythroxylon Coca* Lam.) to prepare a tea "when urination is painful or impossible." The bark, dried and finely powdered, is rubbed into skin sores which will not react to more usual treatments with various washes. The bark is likewise thrown on fires, and the acrid smoke thus produced is vigorously inhaled to relieve asthmatic and other respiratory ailments.

Vochysia lomatophylla *Standley* in Publ. Field Mus. Nat. Hist. Bot. Ser. 22 (1940) 150.

COLOMBIA: Comisaría del Vaupés, Río Pacoa. "Gigantic tree. Flowers yellow. Barasana: *ka-kwee-gaw-ya.*" February 7–12, 1952. *R. E. Schultes et I. Cabrera 15234.*

PERU: Departamento de Junín, Mazamari to Satipo. "*Sacha-alfaro.* Tree 25 m. high; fruit green; bark like 'capirona' — paler (beige). Perhaps used by the Campa tribe as contraceptive." September 14, 1960. *F. Woytkowski 6021.*

The Barasana Indians indicate that, when pulverized leaves and bark of *Vochysia lomatophylla* are given to pregnant women in warm chicha, the effect is abortifacient and that is "was formerly used for this purpose." In view of this report, the indecisive annotation on the Peruvian collection cited above may assume added significance.

Euphorbiaceae

Nealchornea yapurensis *Huber* in Bol. Mus. Goeldi 7 (1913) 297.

COLOMBIA: Comisaría del Amazonas, Río Loretoyacu, October 31, 1946. *G. Black et R. E. Schultes 46-257.*

Comisaría del Amazonas, Río Apaporis, Soratama. Flowers yellowish green. Flowers fragrant of lemon. Latex sparse, white. Flood-bank. Taiwano = *bo-to-ka.* July 31, 1951. *R. E. Schultes et I. Cabrera 13228.*

Comisaría del Vaupés, Río lPapurí. Teresita. May 28, 1953. *R. E. Schultes et I. Cabrera 19469.*

The Taiwano Indians occasionally crush the leaves of this small tree for use as a fish poison. It is said to be very efficaceous and that it would be more extensively employed but for the scarcity of trees in the area.

Phyllanthus piscatorum *Humboldt, Bonpland et Kunth,* Nov. Gen. et Sp. Pl. 2 (1817) 113.

COLOMBIA: Comisaría del Putumayo, Río Putumayo and vicinity. Kofán Indian name: "*dzin-zi-a-pa*". March 23–25, 1942.

Comisaría del Amazonas, Río Igaraparaná, La Chorrera. June 6, 1942. *R. E. Schultes 3898.*

This shrub is widely cultivated as a fish poison, for which use the leaves and branches are crushed and thrown into the water. The Witoto Indians of La Chorrera, however, employ a powder prepared from the dried leaves as an insect repellant, dusting it over the body at night before sleeping.

Icacinaceae

Calatola columbiana *Sleumer* in Notizbl. Bot. Gart. Berlin 15 (1940) 247.

ECUADOR: Napo, Río Aguarico, Durena. June 24, 1966. *H. V. Pinkley 318.*

The leaves of *Calatola columbiana* are chewed by the Kofán Indians to blacken the teeth and lips. The Kofán name of this tree is *ishoan-zi-hĕ.* (Pinkley, H. V. *The Ethnoecology of the Kofán Indians* (1973) 240 Unpubl. Ph.D. Thesis, Harvard University, Cambridge, Mass.).

SAPINDACEAE

Paullinia emetica *R. E. Schultes* in Caldasia 2 (1944) 419.

COLOMBIA: Comisaría del Vaupés, Upper Río Apaporis basin, Río Macaya, Cachivera del Diablo. Alt. 350 m. "Vine on riverside vegetation. Used by Karijonas (former inhabitants) as an emetic: an infusion of the leaves." May 22, 1943. *R. E. Schultes 5511.*

The Karijona Indians, who formerly lived in the headwaters of the Apaporis but remnants of whom now live in Miraflores on the Río Vaupés, state that the leaves of this vine were formerly made into a tea for use as a strong emetic.

CARYOCARACEAE

Anthodiscus obovatus *Bentham ex Wittmack* in Martius, Fl. Bras. 12, Pt. 1 (1886) 358.

BRAZIL: Estado do Amazonas, Upper Rio Negro basin, Rio Xié, Cachoeira Cumatí. "Small tree. Flowers yellow." November 29 — December 7, 1947. *R. E. Schultes et F. López 9226.*

The leaves of this small tree are often employed, crushed and thrown into still water, as a minor fish poison.

Anthodiscus peruanus *Baillon* in Adansonia 10 (1872) 241.

COLOMBIA: Comisaría del Vaupés, Río Negro, at confluence of Ríos Guainía and Casiquiare, Caño Ducuruapo (Igarapé Rana). In caatinga. "Tree about 35–40 feet high; diameter 18 inches. Wood hard, white. Bark shaggy, dark brown. Flowers bright yellow. Leaves very glossy, light green." December 13–17, 1947. *R. E. Schultes et F. López 9387.* Río Apaporis, Jinogojé (at mouth of Río Piraparaná) and vicinity. Alt. about 700 feet. "On high knoll. Enormous tree, 90 ft. tall. Flowers yellow. Bark white. Tanimuka = *tee-fe-roó-ka;* Makuna = ko-men-tań-go; Makú = chee-aẃ". June 8, 1952. *R. E. Schultes et I. Cabrera 16623.*

In both the Río Guainía and the Río Apaporis, this tree is valued as a minor fish poison. The Kuripako Indians of the Guainía and the Makunas of the middle Apaporis crush the leaves and young branches with a rather liquid clay-mud to cast into still water. Its action is fast but not long-lasting. Nothing is known of the possible chemical constituents responsible for the piscicidal activities of *Anthodiscus obovatus* and *A. peruanus*.

QUIINACEAE

Quiina leptoclade *Tulasne* in Ann. Sci. Nat., ser. 3, 11 (1849) 159.

COLOMBIA: Comisaría del Vaupés, Río Apaporis, Jinogojé. "Small tree. Fruit orange. Makuna name = *na-mor-so-roo*. Makú name = *teg-ee-doo*." June 15, 1952. *R. E. Schultes et I. Cabrera 16730.*

A snuff of the dried leaves of this tree is employed to stop recurrent nose bleeds, apparently a common ailment amongst the Makú Indians. Little is known of the chemistry of the genus Quiina (Gibbs loc. cit. 3 (1974) 1371, 1388).

MARCGRAVIACEAE

Souroubea crassipetala *de Roon* in Acta Bot. Neerl. 18 (1969) 701.

COLOMBIA: Comisaría del Vaupés, Río Apaporis, Raudal Yayacopi (La Playa) and vicinity. "Epiphytic vine. Flowers dark red, yellow at centres." February 16, 1952. *R. E. Schultes et I. Cabrera 15401.* — Same locality. "Epiphytic vine. Flowers maroon and orange; fruit red-orange." August 18, 1952. *R. E. Schultes et I. Cabrera 16912.*

A mouth wash of the leaves of this vine is prepared for treating "sores of the mouth" — various irritations of the mucous membrane which may have a variety of causes.

Little is known of the chemistry of the Marcgraviaceae. Tannins are high in some species (Gibbs, loc. cit. 3 (1974) 1371), explaining possibly this native use which may be based on astringency. The presence of resin cells in some species of Souroubea might likewise justify this use.

Souroubea guianensis *Aublet* var. **cylindrica** *Wittmack* in Martius, Fl. Bras. 12, Pt. 1 (1878) 253.

COLOMBIA: Comisaría del Vaupés, Río Piraparaná, Caño Teemeeña, Savannah O-kee-me-gaw. "Bush. Growing from sand. Flowers green-yellow." September 6, 1952. *R. E. Schultes et I. Cabrera 17238* — Río Piraparaná, Caño E-ree-ee-ko-mee-o-kee. September 18, 1952, *R. E. Schultes et I. Cabrera 17510.*

This plant is known only from British Guiana and Colombia. The collections cited above are the first from Colombia.

Mayna amazonica *(Mart.) Macbride* in Field Mus. Bot. 13 (1941) 16.

COLOMBIA: Comisaría del Putumayo, Río Sucumbíos, Conejo y los alrededores, en frente a la Quebrada Conejo. "Kofán: *tza-he-vee-ko*. Tree. Medicinal bath for cramps." April 2–5, 1942. *R. E. Schultes 3515*. — Buena Vista. October 13, 1972. *F. Piaguaje* for *J. Langdon s.n.*

In view of the use by Kofán Indians of a warm bath made of the leaves of *Mayna amazonica* to relieve cramps, the recent note by the anthropologist Langdon, who was working among the neighboring Sionas, on the use of the wood and leaves of this plant is noteworthy. Langdon reports that the wood and leaves are heated in water to prepare a decoction employed as a bath to relieve a condition causing aching of the legs and a feeling as though small ants were biting the legs.

Mayna linguifolia *R. E. Schultes* in Caldasia 3 (1945) 439.

COLOMBIA: Comisaría del Amazonas; Trapecio Amazónico, Río Loretoyacu. Alt. 100 m. Oct. 20–30, 1945. *R. E. Schultes 6593*.

Witoto Indians, originally from the Río Igaraparaná but now residing in the region of Leticia, report that formerly an oil from the seeds of this treelet was used to cure "sores of the skin." The Witoto name of the plant is *we-pe´-te-ka*.

Mayna longifolia *Poeppig et Endlicher,* Nov. Gen. ac Sp. Pl. 3 (1845) 64, t. 271.

COLOMBIA: Comisaría del Amazonas, Río Miritiparaná, Caño Guacayá. "Fruit cauline, greenish white." April 24, 1952. *R. E. Schultes et I. Cabrera 16285*.
ECUADOR: Napo, Río Aguarico, Dureno. "Primary forest. Aril around seed edible. Tree. Kofán: *itetsi pandiri cho*." December 21, 1965. *H. V. Pinkley 28*.

The seeds of this shrub are often kept in Indian houses for medicinal use: crushed and boiled in water, they are employed as an emetic, especially in cases of serious food poisoning. This tea must, however, be used with extreme caution, since it is itself toxic if vomiting is not provoked, causing dizziness, excessive sweating and uncontrollable trembling.

The plant and this use are well known among all of the Indians of the area. The Makuna call it *oo-too-mee-ko;* the Miraña, *do-ro-hĕ;* the Tanimuka, *ya-poo-moo-ho;* the Yukuna, *ka-sa-ra* ("tree of the beetle").

It is probably significant that, according to Pinkley, the Kofán Indians consider the aril edible.

Mayna toxica *R. E. Schultes* in Rhodora 65 (1973) 16, t. 10.

COLOMBIA: Comisaría del Amazonas, Río Caquetá, La Pedrera and vicinity, Quebrada Tonina. On high land. "Small tree, 20 feet tall. Flowers white." October 5, 1952. *R. E. Schultes et I. Cabrera 17731.*

The Miraña Indians of the region of La Pedrera assert that the ground up bark and seeds of this species are given to dogs in food as a poison. The same use has previously been reported (Schultes in Rhodora, loc. cit.) from other Indian tribes living in the Colombia Vaupés. At that time, it was indicated that: "The fact that at least two species — *Mayna muricida* R. E. Schultes and *M. toxica* — are similarly employed by Indians for their toxic properties and in far-separated parts of the Colombian Amazonia suggests that an investigation into the chemical constituents of this genus might be of interest."

VIOLACEAE

Corynostylis volubilis *L. B. Smith et Fernández* in Caldasia 6 (1954) 143.

COLOMBIA: Comisaría del Amazonas-Vaupés, Río Apaporis, Randal Yayacopi (La Playa) and vicinity. Alt. about 800 ft. "Flowers white. Vine." August 18, 1952. *R. E. Schultes et I. Cabrera 16972.*

Comisaría del Vaupés, Río Piraparaná, Caño Oo-moo-na. September 3, 1952. *R. E. Schultes et I. Cabrera 17155, 17158.*

A tea made by boiling the bark of *Corynostylis volubilis* for three hours is taken over a period of three days to expel intestinal parasites. That this plant has potent physiologically active principles which go beyond the expulsion of intestinal parasites is evidenced by the peculiar behavior which I have seen of men taking this tea as a cure: they are, for two or three days, nearly sleepless; they are nervous and irritable during the treatments; they occasionally are subject to violent vomiting. The medicine is employed especially amongst the Makuna Indians. This use of the plant is apparently unknown elsewhere in the Colombian Amazonia (e.g., in the Leticia region, where the species is very common.)

COMBRETACEAE

Combretum Cacoucia *(Aubl.) Exell* in Kew Bull. (1931) 469.

BRAZIL: Estado do Pará, Utinga, Belém. "*Rabo de arara*. Extensive liana. Acrid water in stem. Flowers red, said to be toxic." September 1947. *R. E. Schultes 8668*.

There are numerous reports in the literature which, like the report cited above, claim that the flowers of *Combretum Cacoucia* are poisonous. There seems to be no chemical evidence to sustain such an assertion, yet the number of folk reports would appear to justify serious investigation.

Caffeine and tannins have been reported from Combretum (Gibbs, loc. cit. 3 (1974) 1478).

ERICACEAE

Befaria congesta *Fedtschenko et Basilevskaja* in Not. Syst. Herb. Hort. U.S.S.R. 6 (1926) 42; Bot. Gaz. 85 (1928) 319.

COLOMBIA: Departamento de Cundinamarca, Macizo de Bogotá, above La Cita. May 10, 1946. *R. E. Schultes 7192*.

Peasants in the vicinity of La Cita report that a thick syrup made by boiling the bark of this plant in a sugar-water solution acts to relieve severe coughing.

Befaria resinosa *Mutis ex Linnaeus filius*, Suppl. Pl. (1781) 246.

COLOMBIA: Departamento de Cundinamarca, Macizo de Bogotá, El Retiro, Bogotá. Altitude 2600–2700 m. May 7, 1946. *R. E. Schultes 7204a* — Represa de Sisga. Altitude about 9000 feet. "Large bush. Flowers bright red, sticky." March 2, 1953. *R. E. Schultes 18799*.

The flowers of this shrub are often prepared in tea form as an expectorant. García-Barriga likewise reports this use (loc. cit., 2 1975) 346) as well as its employment as an antitusant.

SOLANACEAE

Brugmansia x **insignis** *(Barb. Rodr.) Lockwood ex R. E. Schultes, comb. nov.*

Datura insignis Barbosa Rodrigues in Vellosia, Ed. 1, 1(1888); Ed. 2, 1 (1891) 62.

Dr. Tom E. Lockwood monographed the genus *Brugmansia* for his Ph.D. thesis at Harvard University — *A Taxonomic Revision of Brugmansia, Solanaceae,* Unpubl., Cambridge, Mass. (1973) — but was prevented from publishing his nomenclatorial conclusions by his untimely death. That he fully intended to do so is indicated in his article in the *Botanical Museum Leaflets, Harvard University* 23 (1973) 281. In the meantime, he prepared the treatment of the genus *Brugmansia* for *Hortus Third* [Bailey, L.H. and E.Z. Bailey, (1976) 184, Macmillan, New York] in which "*B* x *insignis* (Barb. Rodr.) Lockwood" is given. Since no basionym was cited, the new combination was not validly made. Lockwood considered *Brugmansia* x *insignis* to be a hybrid between *B. suavelolens* x *B. versicolor.*

Inasmuch as there is a need for this binomial in connection with phytochemical publications, the above new combination is proposed.

APOCYNACEAE

Malouetia Duckei *Markgraf* in Notizbl. Bot. Gart. Berlin 9 (1926) 962.

COLOMBIA: Comisaría del Vaupés, Río Kuduyarí, Cerro Yapobodá. At base of mountain. "Small tree. Latex white. Puinave name = *pom-ka;* Kubeo name = *yau-wa-hau-ka-hee.*" October 1, 1951. *R. E. Schultes et I. Cabrera 14170.*

This collection extends *Malouetia Duckei* into Colombian territory. According to Kubeo informants along the Río Kuduyarí, crushed leaves and stems are employed as a fish poison.

Malouetia nitida *Spruce ex Mueller-Argoviensis* in Martius, Fl. Bras. 6, Pt. 1 (1860) 94.

García-Barriga (loc. cit., 2 (1975) 434) reports that *Malouetia nitida* is said to be "very poisonous." Several leaves, mixed with meat, were sufficient to kill a dog in a few minutes. In the Llanos of eastern Colombia, peasants are said to crush the leaves and apply them as a cure for gangrenous ulcers. An infusion of the leaves is likewise taken for "heart disease." The Saliva Indians of the Colombian Llanos are reported to prepare a very active poison from the leaves.

Steroid alkaloids have been isolated from an African species of Malouetia (Gibbs, loc. cit. (1974) 346), but chemical studies on South American species appear not to have been carried out on any systematic basis.

RUBIACEAE

Calycophyllum Spruceanum *(Benth.) Hooker filius ex K. Schumann* in Martius, Fl. Bras. 6, Pt. 6 (1889) 191.

PERU: Departamento de Loreto, Río Amazonas, Iquitos. "*Capirona*. Tree 20 m. Decoction of the bark is used for *sarna negra* (an arachnid that lives under the skin.) Dry pulverized bark applied for fungus infections." June 26, 1966. *R. T. Martin et C. A. Lau-Cam 1346*.

Chemical studies of this conspicuous tree of the Amazon have apparently never been conducted. Its characteristic bark is widely used for a variety of medicinal purposes in the upper Amazon region. In Peru, a decoction of the bark is used against "sarna negra", an arachnid that lives under the skin; the dried, powdered bark is also applied for fungus infections.

The interesting folk uses of the bark of this conspicuous tree strongly suggest the need for phytochemical and pharmacological studies. Nothing apparently is known of the chemical constituents. Its characteristic bark has a variety of other less specific medicinal uses in the indigenous populations of the upper Amazon.

Isertia hypoleuca *Bentham* in Hooker, Journ. Bot. 3 (1841) 220.

COLOMBIA: Comisaría del Amazonas, Río Amazonas, Leticia. Altitude about 100 m. "Flowers scarlet within, fringes yellow. Leaf pale beneath." September, 1946. *R. E. Schultes 8207*.

The non-indigenous population in Leticia administers a tea made from the leaves of *Isertia hypoleuca* and the crushed seeds of the papaya *(Carica Papaya L.)* in cases of menstrual irregularity, a use said to have been imported from the region of Iquitos in adjacent Peru.

Examination of the leaves of *Isertia hypoleuca* from the same population from which *Schultes 8207* was taken indicate the presence of sitosterin, *d*-amyrin and taraxasterol (Lau-Cam, C.A. in Phytochem. 12 (1973) 475).

CUCURBITACEAE

There is increasing evidence that this family has members which are toxic and which may contain highly interesting biodynamic principles as yet uninvestigated.

Anguria umbrosa *Humboldt, Bonpland et Kunth*, Nov. Gen. et Sp. Pl. 2 (1817) 121.

VENEZUELA: Estado de Carabobo, Hacienda de Cura, near San Joaquín. Alt. 480–1200 m.

"Rhizome said to be poisonous. Common name: *pasana*." July 5–8, 1918. *H. Pittier 7931*.

This collection indicates, with no explanatory detail, that the "rhizome" is considered to be toxic in Venezuela. The vernacular name in Venezuela is *pasana*.

Cayaponia racemosa *Cogniaux* in De Candolle, Monogr. Phan. 3 (1881) 768.

EL SALVADOR: Departamento de Ahuachapan. Vicinity of Ahuachapan. Alt. 800–1000 m. "Said to be poisonous, especially for cattle. *Sandía de culebra, hierba coral, camara, taranta*. Jan. 9–27, 1922. *P. C. Standley 19724*.

As yet, no important constituents have been reported from Cayaponia, except fatty oils from the seeds (Hegnauer 3 (1964) 619). This report from El Salvador (Altschul, S. von R. "Drugs and Foods from Little Known Plants — Notes in Harvard University Herbaria" 1973, 293), however, bears chemical investigation, especially in view of the interesting use in the Colombian Amazonia of *C. ophthalmica* R. E. Schultes in treating conjunctivitis (Schultes, R. E. in Bot. Mus. Leafl. Harvard Univ. 20 (1964) 324). A spot test for alkaloids indicated a negative result for *Cayaponia ophthalmica*.

Gurania rufipila *Cogniaux* in Bull. Soc. Bot. Belg. 14 (1875) 30.

COLOMBIA: Comisaría del Amazonas, Río Miritiparaná, Caño Guacaya. "Vine. Flower vermillion. Tanimuka name: *mee-ree-fee-ka-mó-ma-ka*. Flood banks. Stem reputedly poisonous." *March 5, 1952. R. E. Schultes and I. Cabrera 15809.*

Schultes and Cabrera 15809 represents the second collection of *Gurania rufpila*. The type was collected in Leticia, Colombia by E. Ule in 1902. A third collection, *F. Woytkowski, 5851,* has recently been made in the Departamento de Junín in Peru.

Although the Tanimuka Indians apparently make no use of this species, its stem is considered to be toxic when eaten.

PLATE 18

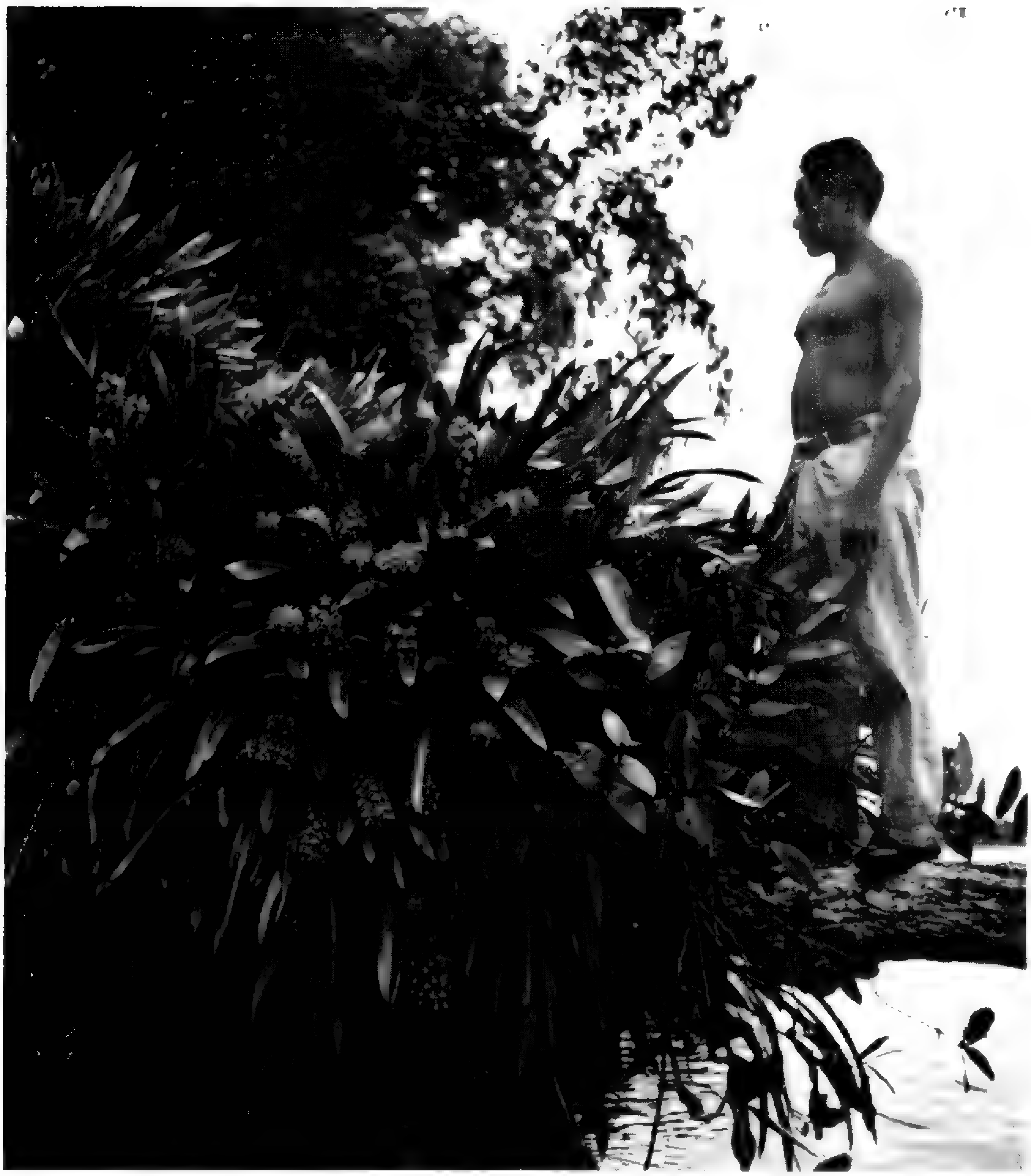


Plate 18. A clump of *Eriopsis sceptrum* (from which the collection *Schultes et Cabrera 12610* was made). Río Apaporis, Colombia. Photo, R. E. Schultes.

PLATE 19

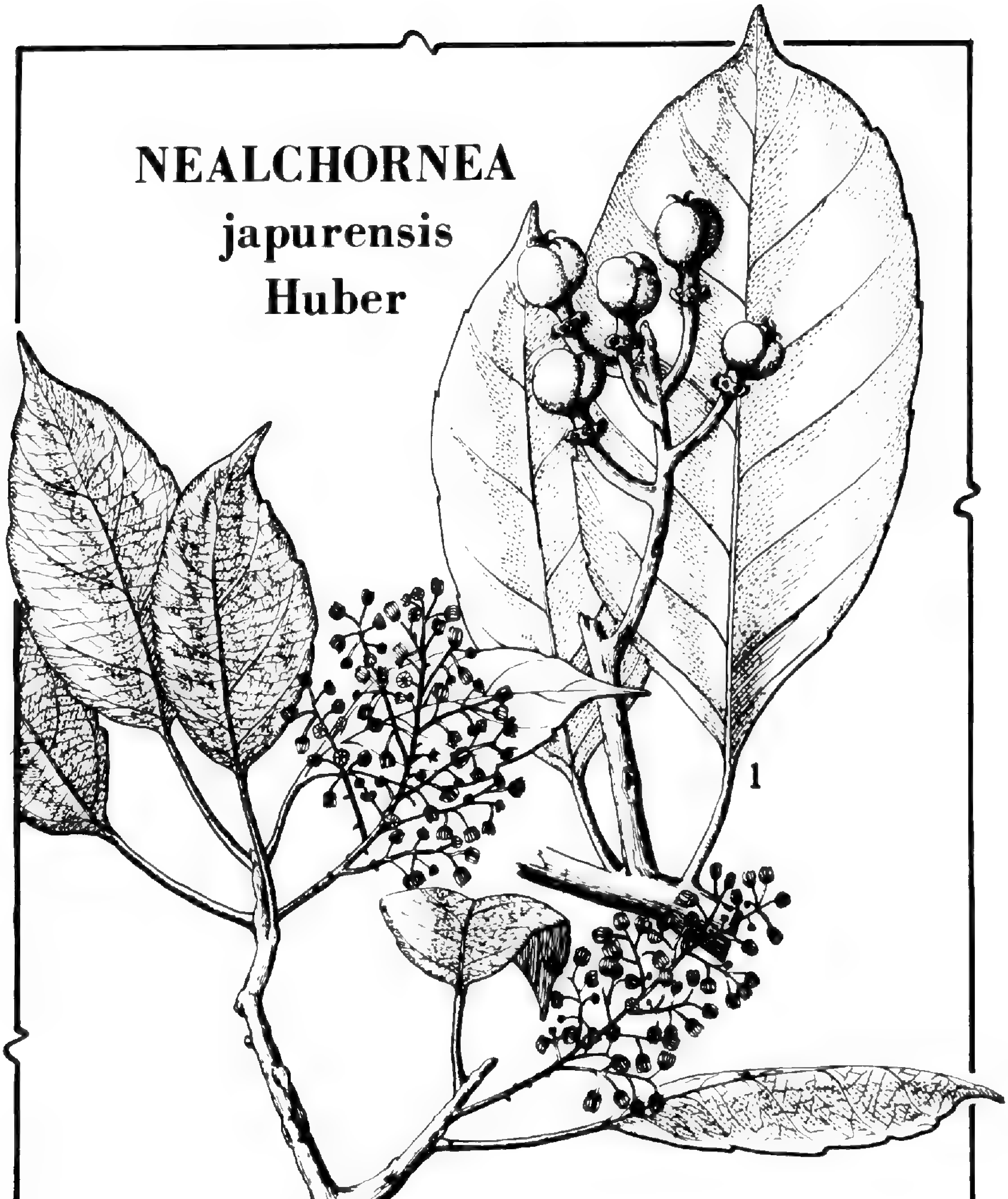
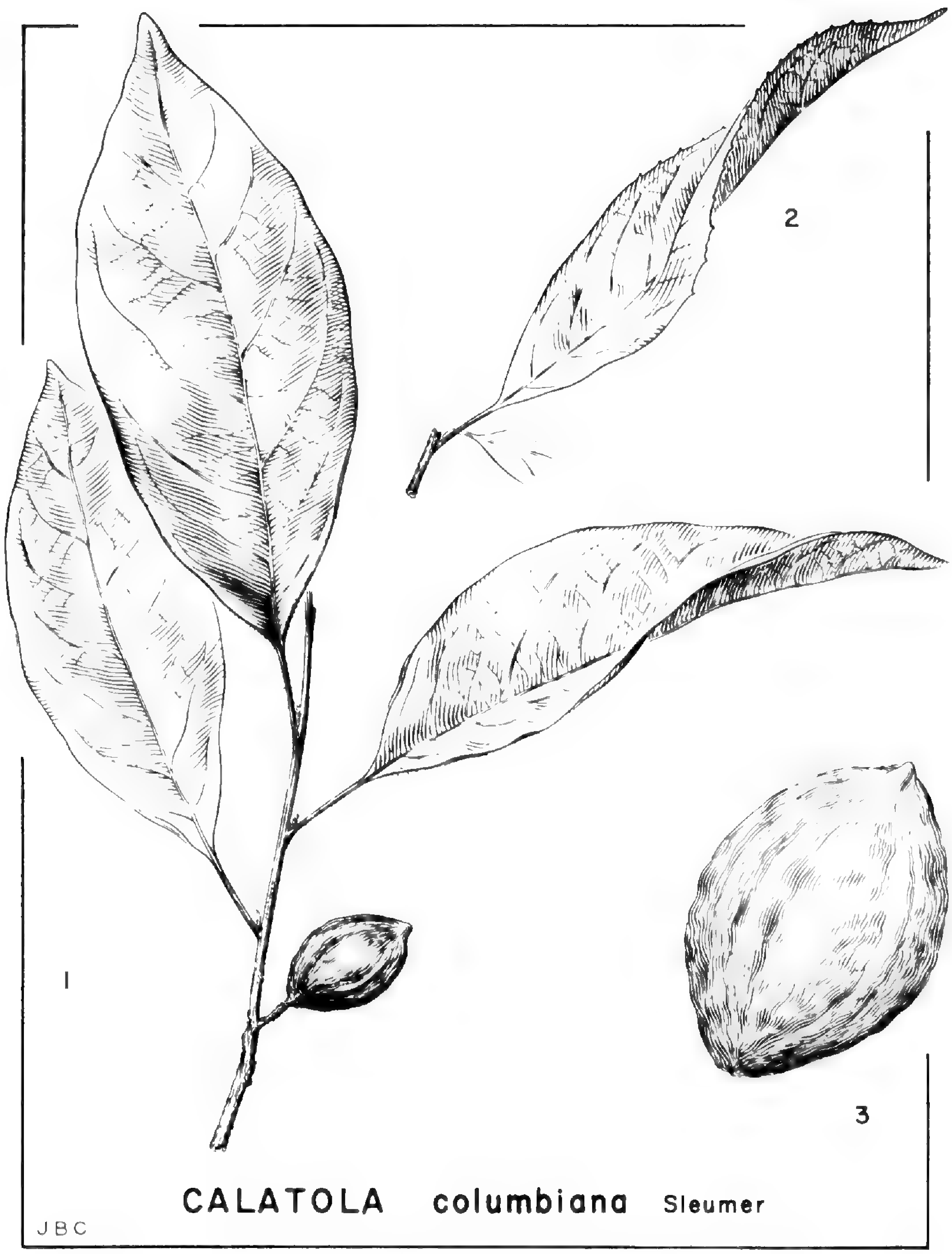


PLATE 20



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THE USE OF PSYCHOACTIVE MUSHROOMS IN THE PACIFIC NORTHWEST: AN ETHNOPHARMACOLOGIC REPORT

ANDREW T. WEIL, M.D.

I.

More than two centuries have passed since westerners first learned of a traditional Old World use of mushrooms to produce intoxication. In 1730, a Swedish army officer published an account of the cult of the fly agaric, *Amanita muscaria* (L. ex Fr.) Hooker, among primitive tribesmen of Siberia (1). Only forty years have passed since the rediscovery of the ceremonial use of hallucinogenic mushrooms in the Mexican state of Oaxaca (2). Today, ritual *Amanita*-eating in Siberia apparently is a thing of the past, and the mushroom ceremonies of Oaxaca are in great disarray as a result of the tremendous publicity accorded them.

Yet more people than ever may be eating mushrooms to bring on unusual states of consciousness. The bright red fly agaric is now in widespread use in the Rocky Mountains, California, and the Pacific Northwest. In Oregon and Washington, some people are using its close relative, the more potent, tan-capped panther fungus, *Amanita pantherina* (DC. ex Fr.) Krombh. Psilocybin-containing mushrooms, originally known from Oaxaca, are turning up in many localities and coming into more general use as people discover their properties. For example, *Stropharia cubensis* Earle, the "San Isidro" mushroom of Oaxaca, is now well known in Colombia, Costa Rica, Florida, along the entire Gulf Coast of the United States, in Texas, southeast Asia, and, probably, elsewhere (3).

To be sure, the use of psychoactive mushrooms outside of

Siberia and Mexico is not traditional. There is little doubt that most of it dates back only so far as the earliest modern publicity about mushroom rituals — that is, to the late 1950's. A great many articles about hallucinogenic mushrooms appeared in popular journals in that period (4). One result was an influx of thousands of young people from Europe and North America to the centers of mushroom use in Oaxaca (5). On leaving Mexico, these people, many of them members of subcultural groups valuing the alteration of consciousness by pharmacologic means, carried the search for suitable fungi to other lands; in many cases their diligence was rewarded.

Information about the recent use of psychoactive mushrooms outside of Mexico has been scanty. A few subjective reports have appeared (6), and several field guides in pamphlet form are best sellers in book stores near university campuses in the United States (7). These materials contain much misinformation and leave us mostly uninformed about the extent of use in different regions, the species in use, the methods of preparation and ingestion, and the nature of the effects.

The present paper attempts to clarify information about the use of psychoactive mushrooms in one area of North America: the Pacific Northwest, including western Oregon and Washington and British Columbia. The Pacific Northwest was selected for these investigations for several reasons. First, it is an outstanding area for the collection of many types of fungi. Even casual visitors in the fall fruiting season are struck by the exuberance of fungal growth from the crest of the Cascades to the sea. As one might expect, mushroom hunting is a popular activity in the area, and many residents involve themselves in the search for edible species. In this, they follow in the tradition of the native Americans who occupied the same territory. Moreover, because of its pioneer spirit and long tradition of tolerating individuality and independent life styles, the region has a strong counterculture and a large population of young people who experiment actively with natural methods of changing awareness. One example of the influence of this group is that in 1973, Oregon became the first state in the United States to decriminalize the possession of *Cannabis* for personal use. Many stories in circulation throughout the American subculture point to the Pacific Northwest as the source of several kinds of mushrooms that trigger high states of consciousness. Finally, laboratory analyses of mushroom samples sold on the black market occasionally demonstrate the presence of psilocybin; Oregon, Washington, and British Columbia have been the sources of much of the material giving positive tests (8).

Between 1973 and 1976 I made a number of visits to the Pacific Northwest in order to find and identify psychoactive mushrooms and learn something of their use. I had the good fortune to find four species containing psilocybin and to meet and interview a number of users of these species. I also talked with users of species in the genus *Amanita*, commonly regarded as the most dangerous group of all mushrooms. In this paper, I shall report observations and experiences with these psychoactive fungi and their users (9).

II.

Psilocybin is a strong hallucinogen that occurs in species of *Psilocybe*, *Stropharia*, *Conocybe*, and *Panaeolus*, and, so far as known, nowhere else in the Plant Kingdom. It may occur in combination with psilocin, a closely related compound with equivalent effects. Psilocybin is the phosphate ester of psilocin and the only known natural indole with a phosphoric acid radical. Psilocin is 1.4 times as potent as psilocybin, and, presumably, when psilocybin is ingested, it is first converted to psilocin in the body. Many texts give the mean oral dose of psilocybin as 4 to 8 mg., equivalent to about 2 gm. of the dried mushroom *Psilocybe mexicana* Heim (10). I think this figure is low, since experienced users of hallucinogens report 10-20 mg. to be a moderate dose.

In doses of 10-20 mg., psilocybin produces a distinctive intoxication marked by visual hallucinations. In certain settings, with proper expectation, it may induce mystical or religious feelings (11). Its effects wear off in four to six hours, and even high doses commonly leave no after-effects.

In the North American drug subculture, psilocybin is held in high esteem. Its duration of action, only half as long as that of LSD and mescaline, recommends it for convenience. Its power to induce visions is great. It is gentler on the body than other hallucinogens. And it comes from mushrooms, which, for many persons, are fascinating symbols of the unconscious or "night" side of human experience (12). For all these reasons, there is a great demand for psilocybin on the black market.

Psilocybin is much more expensive to synthesize than LSD, and nearly everything sold in the illicit trade as psilocybin turns out to be LSD mixed with filler and coloring or LSD combined with other drugs to modify its effects (13). In the past few years, various forms of alleged psilocybin mushrooms have also turned up on the black market; these often turn out to be ordinary cultivated mushrooms, *Agaricus bisporus* (Lange) Imbach, treated with LSD (14).

I had no difficulty locating some of these false psilocybin mushrooms in the university community of Eugene, Oregon, in the fall of 1973. The particular ones that I obtained were frozen, sold for $15 an ounce, and were said to be cultivated in Washington. A teaspoonful of the coarsely chopped material was one dose. Of course, there is no way to identify mushrooms that are chopped and frozen, but the flavor and texture were consistent with canned *Agaricus bisporus*. On analysis (15), these mushrooms contained LSD and phencyclidine (PCP), a depressant drug that produces variable mental symptoms and a peculiar type of muscular incoordination. Apparently, PCP effectively disguises the actions of LSD; even experienced users of hallucinogens have refused to believe that these adulterated mushrooms could owe most of their properties to LSD. PCP is a clever choice as an additive, because real psilocybin-containing mushrooms sometimes cause motor restlessness or weakness, possibly on account of secondary constituents.

False psilocybin mushrooms turn up in many guises, from dried mushroom chips to brown powders, often selling for $50 an ounce or more. In every instance that I have had them analyzed they have turned out to contain LSD or LSD mixed with PCP. An amusing variety, manufactured in Austin, Texas, is a light brown powder sold as "psilocybin mushroom spores." The spores are probably the least active parts of hallucinogenic mushrooms.

In the American South, where *Stropharia cubensis* is the principal active species, it is possible for people to collect sufficient quantities of this large, easily recognized, fleshy mushroom to enable them to sell it. But the active species of the Pacific Northwest are tiny and thin fleshed, gatherable only with some difficulty. Until the fall of 1975, I did not succeed in buying genuine psilocybin mushrooms here. The only real ones that I came across were those I collected myself in the field or obtained from other collectors.

In interviewing persons who have ingested hallucinogenic mushrooms, it is important, therefore, to determine the source of the material. Was it collected in the field or obtained from someone who collected it? If not, it may not contain psilocybin. A useful question to ask is how long the effects lasted. If symptoms were felt beyond six hours, the active compound was almost certainly LSD. If symptoms dissipated by six hours, psilocybin is a possibility, but low doses of LSD may also fade early, especially if the user expects the effects of mushrooms to be short. In studying psychoactive drugs, we see repeatedly that psychological expectation (set) may be the single most important factor determining individual reactions, even over-riding direct pharmacological action. (A spectacular example is variation in response to *Amanita pantherina*, to be discussed below). This fact may explain why many persons who ingest false psilocybin mushrooms feel that their experiences are qualitatively different from anything that they have felt on LSD.

In the Pacific Northwest, genuine psilocybin mushrooms are small and inconspicuous, typically growing in open, grassy places, such as lawns and fields, often in association with cow manure. A few woodland species also occur. These mushrooms do not call attention to themselves by their size, colors, or growth habits, and, as their caps are quite thin, they have never been pursued by hunters of edible mushrooms. The two genera in use are *Psilocybe* and *Panaeolus*. Until the discoveries in Oaxaca, no one cared much about these fungal groups, and, consequently, relatively little information is to be found on them in the scientific literature. And because they have been of so little interest to collectors, there is no good body of data on their field characteristics.

Many amateur mushroom hunters read descriptions of *Psilocybe* and *Panaeolus* in guide books, then attempt to find them in cow pastures. Anyone who has hunted in this way knows how frustrating it is to meet the bewildering array of little brown mushrooms that come up in pastures in the fall. It is quite possible that some of them are undescribed species, because, until recently, experts often ignored these groups of inconspicuous mushrooms.

Psilocybe, the genus with the greatest number of active species, has purple-brown spores and a number of characteristic anatomical features visible under the microscope. Not all species of *Psilocybe* contain psilocybin, but those that do seem to make up a section of the genus called the *Caerulescentes* (from Latin, "becoming blue"), defined by the appearance of blue stains after injury or under certain conditions of growth (16). Many seekers of hallucinogenic mushrooms believe that any mushroom showing blue stains on bruising is a psilocybin-containing species, but blueing also occurs in genera unrelated to *Psilocybe*; consequently, it has nothing to do with the presence of the active principle. For example, some of the poisonous boletes stain blue on bruising. Moreover, blueing is not necessarily a reliable character within the genus. One of the most active Pacific Northwest species, to be described below, shows it only irregularly, even when treated with *p*-methylaminophenol sulfate (Metol), a chemical that is supposed to accelerate the color change (17).

Before describing the species in use, I must emphasize the difficulty of giving exact identifications. In general, the taxonomy of dark-spored agarics leaves much to be desired. In particular, the species of *Psilocybe* do not separate easily. Some work has been done on the genus, but little of it pertains to the species of the Pacific Northwest (18). In the absence of a definitive monograph for this region, all identifications should be regarded as tentative, including those stated with authority in some of the literature.

III.

One of the most desirable species in terms of hallucinogenic power and freedom from unwanted effects is a small *Psilocybe* that grows near the Pacific coast in the fall. Specimens which I collected in 1974 have been identified by Guzmán as *P. semilanceata* (Fr.) Kummer, which is possibly synonymous with *P. pelliculosa* (Smith) Sing. & Smith, *P. Cookei* Sing., and *P. semilanceata* var. *caerulescens* Cooke (19). *Psilocybe semilanceata* is a European species, known in England and Wales as the "Pixie Cap" or "Liberty Cap." Devotees in Oregon also call it the Liberty Cap. Several informants told me that the name indicates its resemblance to the Liberty Bell in Philadelphia, but, in fact, it derives from a French Revolutionary emblem, the Cap of Liberty, which, in turn, comes from an ancient symbol, the Phrygian bonnet. Especially after drying, the mushroom resembles this peaked, conical hat with its point bent over.

The Liberty Cap is distributed from southern Oregon north to British Columbia in the territory enclosed by the mountains of the Coast Range and the ocean. I have found it occasionally on the eastern side of the coastal mountains, and it may be moving into that region. It grows after rains in open, recently used cow pastures between the Autumn Equinox and Winter Solstice, sometimes fruiting into early January. In some locations, a second fruiting may occur in the spring. I have collected this mushroom as late as mid-June in the Oregon Coast Range.

The Liberty Cap grows out of the ground near cow manure, often in or near tall clumps of sedge, and its habit of growth is solitary or grouped. The cap is conical, 0.3-3.0 cm. in diameter, with a distinct umbo or "nipple" at the apex. As the mushroom ages, the nipple becomes more distinct due to settling of the cap on the stipe. The cap has a viscid pellicle when wet and is variable in color, ranging from a dingy gray-brown when fresh to deep golden brown and light yellow-tan when bleached by the sun. The margin of the cap is inrolled when young and shows faint striations. The flesh is very thin and translucent to light near the margin.

The gills are attached to the stipe, appearing light to chocolate brown when young, becoming dark purple-brown as the spores mature. The stipe is 2-13 cm. long, 1-3 mm. wide, with a characteristic elastic pliancy. It may show blueing at the base, especially at the point of junction with the underground mycelium. Otherwise, blueing is not an obvious field character.

Eaters of the Liberty Cap are not prone to divulge locations of favorite collecting grounds; in this habit, they resemble hunters of prized edible species, such as morels (*Morchella spp.*). If one knows where and how to look, large collections are possible. Good hunters may get a pound of Liberty Cap in an hour or ten pounds in a day — respectable quantities when one considers that a pound represents many hundreds of these delicate little mushrooms. In the fall of 1975, extremely heavy fruitings of this species in Oregon permitted collectors to gather enough mushrooms to sell them. In Eugene, Liberty Caps sold for $75 to $100 a pound, wet weight.

An average dose of this species is 20 whole mushrooms, often eaten just as they are picked. I have met persons who prefer the effects of two or three mushrooms and others who like to eat up to a hundred at a time. Several informants told me that one good collection provides enough material to intoxicate at least a hundred people. Properly dried, Liberty Caps retain their potency for at least a year and may be brewed into a powerful tea.

Almost all of the users of Liberty Caps whom I met were young people who referred to themselves as "freaks" — mostly long-haired members of the Pacific Northwest counterculture, many of whom lived communally in rural areas. All of them had extensive experience with *Cannabis* and hallucinogens, and most preferred natural drugs to synthetic ones. In almost every case, they had first learned of the activity of these mushrooms from university students with mycological training, usually from Oregon State University at Corvallis. I met two individuals who chanced upon the Liberty Cap by eating small brown mushrooms growing in cow fields without any special knowledge. There are persistent stories in western Oregon of older, local people who have used these mushrooms for more than 20 years. I have been unable to verify these tales. If true, they suggest an independent route to knowledge of local psilocybin-containing species, possibly going back to accidental discoveries of early settlers or even to Indians. Coastal tribes in the Pacific Northwest gathered mushrooms as food, but there is no evidence that they used any psychoactive fungi, unless, as in Mexico, they concealed such practices from most of the invading Europeans.

The next most prized species in Oregon is a much larger mushroom that grows throughout western Oregon and Washington in scattered locations through the fall. It grows often in groups on greenhouse mulch and on lawns. In Eugene, Oregon it fruits regularly on a bark mulch around rhododendron bushes in municipal parks and is avidly collected by local residents. The cap is dull brown, bluntly cone-shaped when young, expanding to convex or flat with age. It may be 4 cm. wide at greatest expansion. The mushroom has a viscid pellicle when fresh and wet; on drying, the color fades leaving an area of copper brown in the center. It shows blueing on injury more consistently than the Liberty Cap. The stipe is whitish, the spores purple-brown. Four carpophores make up an average dose.

Mycology students at Oregon State University call this mushroom *Psilocybe baeocystis* Smith, as do many users in Eugene. *Psilocybe baeocystis* has a reputation as an especially powerful species, probably because it was implicated in the death of a 6-year-old child in Milwaukie, Oregon, near Portland, in 1960 (20). Two unusual alkaloids, baeocystin and *nor*-baeocystin, have been isolated from this species in addition to psilocybin and psilocin. They may occur in other *Psilocybe* species as well, and their pharmacology has not been studied.

I have been unable to send voucher specimens of the Eugene mushroom to Mexico City for formal identification, and, though I believe it to be *P. baeocystis*, I will report it here simply as *Psilocybe sp*. It has no common name. I will refer to it here as the "Eugene *Psilocybe*." Because it grows inland in scattered locations, not many Liberty Cap eaters have tried it. I have talked with only a few persons who have ingested both species. They report that the two mushrooms are roughly equivalent in psychoactive power but that the Liberty Cap produces more prominent visual displays, whereas the "Eugene *Psilocybe*" causes more physical changes in the body.

A third *Psilocybe* is known to many collectors in western Washington. Commonly called the "Washington Blue Veil," it is distinguished from the other species by the persistence of an annulus on the stipe, an unusual character in this genus. The mushroom blues quite readily, even without injury, and the annulus appears often as a thin ring of bluish or bluish black tissue, hence the common name. The mushroom has a fleshy cap up to 5 cm. wide, of an even chestnut brown color with striate margin and viscid pellicle. The veil is white and fleshy when young. Stipes are up to 5 mm. wide and 8 cm. long; they are fleshy, often convoluted, and often showing blue at the base. Habit of growth is grouped to cespitose, often with five or six carpophores in a cluster, and the mushroom is abundant on manured lawns and bark mulch in the fall after rains.

Originally thought to be a variety of *Psilocybe caerulescens* Murrill, a species known from Oaxaca, this mushroom first appeared on the campus of the University of Washington in Seattle in the fall of 1973. It seemed to spread by way of a bark mulch in use by the university grounds crew, and enquiring graduate students quickly discovered its psychoactivity. It is strongly hallucinogenic, producing a typical psilocybin-psilocin intoxication in doses of about 20 carpophores. Specimens collected in 1974 near Olympia, Washington, and sent to Mexico City have now been shown not to be *P. caerulescens*.

ERRATUM: For Panaeolus subalteatus read Panaeolus subbalteatus throughout.

The Washington Blue Veil is now considered a new species, hitherto undescribed, and has recently been named *P. Stuntzii* Guzmán and Ott (21).

The Washington Blue Veil fruited heavily in the region around Olympia in the fall of 1974. Again, greenhouse bark mulches seemed responsible for transmitting it to new locations. College students in the area use it frequently. As yet, the mushroom is not reported from Oregon, but it has been collected in Vancouver, British Columbia (22). On a weight basis the Washington Blue Veil is less potent than the Eugene *Psilocybe*. Washington collectors who have tried both it and the Liberty Cap rate those two species as equally desirable.

One more psilocybin-containing species is in widespread use in the Pacific Northwest. It is in the genus *Panaeolus*, a black-spored group of coprophilic mushrooms. Hallucinogenic species of *Panaeolus* have been reported in such diverse places as Oaxaca, Maine, Hawaii, (23), and Colombia (24), but there is considerable taxonomic uncertainty about their identity. A number of inactive members of the genus also grow throughout North America.

The active *Panaeolus* of the Pacific Northwest has a cap 0.5 to 4.0 cm. broad, hemispherical when young, becoming broadly expanded with characteristic cracks. It is tan to reddish brown, often with a distinctive dark zone around the margin. A veil is absent. The gills are reddish brown or reddish gray when young, becoming mottled with gray or black, eventually black. The stipe is 1-5 mm. thick, hollow, stringy, vertically grooved at the top, covered with a whitish deposit when young. This mushroom occurs in groups or clusters in open grassy places with cow manure, on compost, and on rotting hay. It is found throughout the Willamette Valley in western Oregon and in western Washington from early spring through fall, after rains. I have never seen this species exhibit blueing, but experienced collectors say that one in a hundred specimens may show blue at the base of the stipe; this coloration is not a response to injury. Specimens which I collected near Albany, Oregon in April of 1974 have been identified by Ola'h as *Panaeolus subalteatus* Berk. & Br. (25).

Many Oregonians have tried *Panaeolus subalteatus* because this mushroom grows plentifully in the most populated areas of the state, especially in the vicinity of Oregon State University at Corvallis, and because it grows throughout more of the year than any of the *Psilocybe* species. It is collected in large quantities for use during spring and summer, when other varieties are not available, although it is distinctly less potent and more toxic than the others. In doses of about 20 carpophores, it produces an intoxication of rapid onset, marked by initial restlessness and possible nausea, prostration, and various physical symptoms, succeeded by dreamy feelings and visual hallucinations. On a weight basis, *Panaeolus subalteatus* is about half as potent as *Psilocybe semilanceata*.

The toxicity of this *Panaeolus* does not deter people from frequently eating it. Possibly, the physical symptoms are due to unidentified compounds other than psilocybin and psilocin. These symptoms are more pronounced after ingestion of fresh mushrooms, less after ingestion of dried ones. Many users like to brew a tea from the dried mushrooms. Screening of this species for other alkaloids would be a profitable line of chemical investigation.

The above four species are the psilocybin-containing mushrooms in widespread use in the Pacific Northwest. A number of other species are reported here, including *Psilocybe strictipes* Sing. & Smith (18) and several unnamed *Psilocybe* species, but definitive identifications are lacking, and they are used only by rare individuals, usually those with some mycological expertise.

IV.

Use of *Amanita* mushrooms as recreational drugs in North America dates back only to the recent identification of the ancient Aryan intoxicant *soma* with the fly agaric (26) and to numerous popular accounts of the psychoactivity of this species (27). Not long ago, many books called this famous mushroom deadly, and standard toxicological works listed its active principle as muscarine. (The alkaloid muscarine was named for *A. muscaria*, when it was first isolated in the mid-19th Century.) We now know that very few people die from eating the fly agaric and that it usually contains clinically insignificant amounts of muscarine (28).

The psychoactive principles in *Amanita muscaria* are ibotenic acid and its decarboxylation product, muscimol, which is five to ten times more potent. Muscimol is a structural analog of GABA (gamma-aminobutyric acid), and like GABA inhibits neurotransmission in the central nervous system (29). These compounds also occur in *Amanita pantherina* (30), *A. cothurnata* Atkinson (31), as well as in hybrids of *A. gemmata* (Fr.) Gill and *A. pantherina*.

Amanita cothurnata, which does not occur in the Pacific Northwest, is not used as a recreational intoxicant, but both the fly and panther Amanitas are so used. In North America, the panther fungus contains higher concentrations of ibotenic acid and muscimol than the fly agaric (30) and is preferred by users in the Pacific Northwest who have tried both species. Many mushroom books still call *A. pantherina* a deadly species, and most mycologists are horrified to hear of people eating it deliberately for enjoyment. *Amanita gemmata*, with a yellow cap, is an inactive species but is said to hybridize readily with *A. pantherina*, producing mushrooms of intermediate color and activity. Doubtless many persons who have learned to eat the panther fungus unknowingly collect and eat these hybrids as well, which may account for some of the variation of response to ingestion of this mushroom.

Little sophistication is necessary to recognize fly agarics. They are striking mushrooms of the Pacific Northwest in the fall, often one of the largest and brightest colored species in conifer forests. Truly giant forms occur in southwestern Oregon near the coast, in Coos and Curry Counties. The ease of collecting fly agarics is in sharp contrast to the difficulty of learning to recognize the unspectacular psilocybin-containing species in this region of North America. Consequently, many users of *Amarita muscaria* are unfamiliar with *Psilocybe* and *Panaeolus* and have never tried them. In fact, none of the *Amanita* eaters whom I interviewed in Oregon and Washington in 1973 had ever eaten local psilocybin mushrooms.

Psilocybin mushroom hunters, on the other hand, are often familiar with the fly and panther Amanitas but tend to regard them as toxic and dangerous. This belief may reflect the fact that psilocybin mushroom hunters in the Pacific Northwest have usually learned to collect from mycologically trained persons, such as university graduate students, and these people tend to be biased against experimentation with Amanitas. In any case, I have noted repeatedly that *Amanita* eaters are a distinct group from psilocybin eaters. For example, they are often older and less directly affiliated with the counterculture. Curiously enough, the *Amanita* eaters tend to be more knowledgeable about food mushrooms than psilocybin eaters. I have met many collectors of Liberty Caps, for instance, who have never eaten a meadow mushroom (*Agaricus campestris* L. ex Fr.), even though meadow mushrooms often grow in different parts of the same fields.

It is extremely difficult to sort out the clinical pharmacology of the fly and panther Amanitas. Some persons eat these mushrooms and experience no effects whatever. Others become very sick for a number of hours, and others have ecstatic experiences. A variety of factors may contribute to this inconsistency, among them: individual idiosyncracy in response to the active compounds; geographic and seasonal variation in the chemistry of the mushrooms; differences in ways of preparing the mushrooms for use; and, finally, differences in set or expectation of the results of ingestion.

Individual differences in susceptibility to mushroom toxins is well known to all collectors. Species considered choice edibles by some may be poisonous to others. The few deaths reported following ingestion of fly and panther Amanitas by persons other than children or the elderly may be due to allergic or other idiosyncratic reactions. Some of those who get very sick after eating these mushrooms may also be especially sensitive to ibotenic acid and muscimol.

In addition, the activity of the mushrooms probably varies from location to location and from time to time in the same location. European species of *Amanita* may be more toxic than American ones, but the American species may contain more muscarine than the European ones. *Amanita muscaria* in eastern North America is yellow-capped and frequently inactive. *Amanita pantherina* may be less potent in the early spring in the Pacific Northwest than in the late spring. We know little about these natural variations in the activity of Amanitas except that they occur. Persons who wish to try these mushrooms cannot assume that they are the same from place to place and time to time.

I have recorded many different methods of preparing *Amanita*. Some people eat whole, fresh mushrooms. Some eat only the colored peel, discarding the rest of the mushroom. Some discard the peel. Some dry the peel and smoke it. Some dry the whole mushroom and smoke it. Some dry the mushroom and make tea of it. Some steep the mushroom in milk and drink the milk. Some boil the mushroom. Some steep it in warm water acidulated with lemon juice. Some saute the mushroom in oil. No doubt, these different methods result in preparations of different compositions and strengths. We know that the greatest concentration of active compounds occurs in and just under the colored peel. I have smoked the dried peel of *A. muscaria* and found it mildly psychoactive, akin to *Cannabis*. Infusions of the mushroom produce more powerful effects.

Expectation plays a major role in shaping responses to all psychoactive drugs. Differences in response to the panther *Amanita* illustrate this principle well. Persons who eat this fungus accidentally while collecting food mushrooms often become violently ill and sometimes require hospitalization. Typically, they recover in 24 hours. Quite frequently, these victims receive incorrect medical treatment, because most emergency medical manuals and poison information centers continue to recommend injections of atropine as the antidote for poisoning by *A. muscaria* and *A. pantherina* in the erroneous belief that the toxin is muscarine. (Atropine and muscarine are classical pharmacologic antagonists.) In fact, atropine may potentiate the effects of ibotenic acid and muscimol and is contraindicated in these cases. Correct treatment includes gastric lavage, if there is a possibility of removing any ingested material, observation, reassurance, and general supportive measures, with mild sedation if necessary. After recovery, victims of accidental panther fungus poisoning cannot imagine why anyone would deliberately eat the mushroom.

By contrast, persons who eat *Amanita pantherina* for the purpose of changing their consciousness usually do not experience sickness and often have positive experiences, which they like to repeat. In a recent survey in the Olympia, Washington area, nine victims of accidental poisoning were interviewed along with nine deliberate users. The accident cases typically had no experience with psychoactive drugs other than alcohol, tobacco, and coffee and interpreted the symptoms as the onset of poisoning and, possibly, imminent death; some of them lost consciousness. The deliberate users all had extensive drug experience and welcomed the physical symptoms as the onset of a high. They did not lose consciousness, even though they ingested larger doses than the victims of accidental intoxication. The deliberate users had eaten *Amanita* an average of 30 times each (32).

In experienced users, *Amanita muscaria* and *Amanita pantherina* taken orally produce physical symptoms of rapid onset, usually in less than 30 minutes. These may include, nausea, drowsiness, muscle spasms and weakness, loss of balance and coordination, and a laxative effect, although some users report no unpleasant symptoms. As the intoxication progresses, a state of great relaxation and dreamy stupor develops, akin to hypnotic trance. Dream images may be prominent. Some users liken this state to the combined effects of psilocybin and opium. The pull in the direction of sleep is distinct from psilocybin intoxication, and although *Amanita* eaters sometimes report visual hallucinations they seem to mean enhanced mental imagery rather than the visual changes induced by psilocybin and other indole hallucinogens. Effects of *Amanita* may last from four to 12 or more hours, depending on dose and individual sensitivity.

The popularity of *Amanita*, especially the panther fungus, is definitely on the increase in the Pacific Northwest, and there is much active experimentation to find out how best to prepare and use these mushrooms.

V.

The consequences of the explosion of use of psychoactive mushrooms in the Pacific Northwest and other parts of North America remain to be seen. Mycologists express great concern about the possibility of epidemics of mushroom poisoning with so many untrained persons combing the fields and forests in search of new highs, but it may be that mycologists tend to be overcautious. Certainly there are dangers in eating wild mushrooms, chiefly from the deadly species of *Amanita*, such as *A. verna* (Bull. ex Fr.) Pers. ex Vitt. and *A. phalloides* (Vaill. ex Fr.) Secr., and from several small mushrooms in the genus *Galerina* that contain the same toxins as the deadly Amanitas.

It is unfortunate that some mycologists continue to call the panther fungus a deadly species: this misinformation may encourage some panther eaters to sample the really deadly ones. So far this has not happened. Species of *Galerina* present some danger to people looking for psilocybin mushrooms in woods, because they are inconspicuous, brown mushrooms that grow on wood or buried wood. People who confine their collecting of psilocybin mushrooms to open fields do not seem to run great risks of encountering really dangerous fungi, except, possibly, some poisonous *Inocybe* species around the edges of fields. These mushrooms contain toxic amounts of muscarine, but cases of poisoning by them are rare in the Pacific Northwest, although thousands of people are picking small mushrooms. So far, the psychoactive mushroom craze has not resulted in any great increase in the incidence of mushroom poisoning.

The legal status of psychoactive mushrooms is unclear. Although United States Federal law controls any "material" containing psilocybin, mushrooms are not specifically mentioned. The laws of most states are similar to the Federal law in this respect. No laws, Federal or state, apply to *Amanita*. In the American South, where large numbers of young people hunt the conspicuous psilocybin mushroom, *Stropharia cubensis*, prosecutions for trespassing have occurred but not for possession of mushrooms. In 1976, two young hunters of *S. cubensis* were shot to death by a policeman in a Florida field; the policeman was subsequently indicted by a grand jury (33). In the Pacific Northwest, law enforcement officers do not pay much attention to collectors of psychoactive mushrooms. This situation will change if the number of hunters increases greatly, if newspapers publicize the use of the mushrooms, or if the behavior of users draws attention. Large numbers of Oregonians went after Liberty Caps in the fall of 1976, with much attendant publicity, and increasing complaints from property owners.

Use of psychoactive mushrooms in the Pacific Northwest and elsewhere will almost certainly continue to grow. Psychoactivity appears to be distributed more widely in the fungal kingdom than anyone has imagined. Consequently, more species may come into use, including others previously considered poisonous. There is little chance that these mushrooms will disappear or lend themselves to eradication by zealous opponents of psychoactive drugs. If anything, the mushrooms are swiftly invading new territories, as in the case of the Washington Blue Veil that seemed to appear out of nowhere on the University of Washington campus. Doubtless human involvement with these species is one factor helping to spread them. We need much more information on psychoactive mushrooms, on their taxonomy, chemistry, pharmacology, and potential usefulness. Growing awareness of them in rich collecting grounds such as the Pacific Northwest will possibly inspire the necessary research.

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A NATIVE DRAWING OF AN HALLUCINOGENIC PLANT FROM COLOMBIA

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and
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There has recently been discovered an interesting and undoubtedly very significant drawing of an hallucinogenic plant made by an Indian artist in southern Colombia. We have been able to identify this plant as *Brugmansia vulcanicola* a species only recently described as *Datura vulcanicola* A. S. Barclay, from the Andes of southern Colombia (Barclay, 1959).

The drawing, reproduced here, shows a shrub or small tree with tubular flowers and an Indian woman sitting beneath its branches. It is entitled "Mujer al pie de borrachero" (Woman at the foot of a borrachero tree). The name of the plant in the Indian dialect is given as *yas*. Drawn a quarter of a century ago in Popayán, Colombia, by a Guambiano Indian from the region of Silvia — Francisco Tumiña Pillimue — it has been published in a book of many interesting drawings by the same native artist entitled *Nuestra Gente – Namuy Misag*, with a text by Dr. Gregorio Hernández de Alba (Tumiña P., 1949).

The drawing has all of the characteristics of indigenous art, especially as to lack of detail and disregard of relative size. Yet we believe that it is possible to identify this drawing with certainty as representative of the solanaceous *Brugmansia vulcanicola*. The leaves match in shape those of this species. The flowers — with a dentate calyx, almost regularly tubular corolla with a slightly flaring dentate lip — match the characters of this plant. Furthermore, the shape and surface texture of the fruit are the same. The name *borrachero* is applied to all of

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Application to mail at Second-Class Postage Rates is pending in Boston, Mass.

the *Brugmansias* in southern Colombia. *Brugmansia vulcanicola,* moreover, is endemic to the highlands of southern Colombia, being especially abundant and possibly having originated in the region of the Volcán de Puracé, not far from the location of Silvia in the Departamento del Cauca.

We believed at first that the drawing might possibly represent another solanaceous hallucinogen of southern Colombia: *Iochroma fuchsioides* (HBK.) Miers. Careful study, however, indicates that, even though this species is likewise called *borrachero,* such an identification would be extremely tenuous and open to grave doubt. The flowers, for example, are drawn as though borne singly, while in *Iochroma fuchsioides* they occur in multiflorous clusters. Furthermore, the shape and texture of the fruits are so far from the condition of the bacca of *Iochroma fuchsioides* with its enlarged, persistent calyx as to present serious problems in attributing the differences to artistic license.

Brugmansia vulcanicola was described in 1959 on the basis of material collected on the northern slopes of the Volcán de Puracé in Cauca, Colombia, between 7000 and 8400 feet. This locality is not far from Silvia. In this region, the plant is extremely abundant. Natives of the region indicated that it was used "in olden times" as an hallucinogenic narcotic by Indians, but the acculturated peasants now living in the type locality do not utilize it. Ten or twelve years later, however, when additional botanical collections were made in the type locality, botanists found that local residents were assiduously destroying the population because of the initiation of a new industry, bee-keeping, and the fear that the presence of these toxic flowers could damage the honey produced in the region.

It has been thought that *Brugmansia vulcanicola* might represent an endemic of the region of Puracé, but collections have also been made near the Laguna La Cocha, above El Encanto, between 9000 and 11,000 feet, in the Departamento de Nariño, east of the city of Pasto in southern Colombia. Whether or not the plants growing in this more southern locality, which is a tourist centre, are the result of introductions from the localities near Puracé cannot be ascertained. It is our suspicion that perhaps they may have been introduced because of their horticultural attraction, since the species has never been found in the area between Puracé and the region of La Cocha, and the occurrence of the plants near La Cocha is sporadic and along roadsides, where it appears to have been planted.

There have been several different botanical interpretations of the concept which we here call *Brugmansia vulcanicola*.

Lockwood, in his revision of *Brugmansia* (Lockwood, 1973) considered the concept described as *Datura vulcanicola* to represent a subspecies of *Brugmansia sanguinea*, but he did not have an opportunity to make the indicated nomenclatural change before his untimely death. It can be differentiated from *Brugmansia sanguinea*, with which it is obviously allied, on the basis of corolla colour and shape; the pericarp which is woody and externally provided with a warty, corky reticulum; an extremely stout, woody peduncle; very hard wood; the calyx which is conspicuously not persistent on the fruit; the usually smooth surface of the seed; and leaf shape and size. Although Lockwood argued that ". . . the hard wood, the thick, woody peduncle; and hard, woody pericarp of the fruit may all represent the pleitropic effects of one mutant gene that controls lignification", it seems that there are sufficient characters on which to accept specific status.

Bristol (Bristol, 1966) studied a number of species of *Brugmansia* employed for hallucinogenic purposes by medicine-men in the Valle de Sibundoy in the southern Colombian Andes and recognized it as a distinct species. He (Bristol, 1969) suggested that this concept might represent an incipient species, especially in view of its limited range in the Andean highlands of southern Colombia between about 9,000 and 11,000 feet. Consideration of its very marked differences from its nearest ally, *Brugmansia sanguinea*, however, would tend to indicate that it is far from incipient and that it is already a well established species.

It would seem advisable, in view of the numerous and stable characters, to continue recognizing it as a distinct species. Consequently, the necessary nomenclatural transfer to *Brugmansia* is here made.

Brugmansia vulcanicola *(A.S. Barclay) R.E. Schultes comb. nov.*

Datura vulcanicola A. S. Barclay in Bot. Mus. Leafl., Harvard Univ. 18 (1959) 260.

All parts of the plant of *Brugmansia vulcanicola* give very positive spot tests for alkaloids with Dragendorff reagent. Although further chemical studies have not yet been carried out on this species, it seems logical to presume that it contains the same tropane alkaloids found in all other species of the genus.

Some six species of *Brugmansia* are recognized, all native to South America and all but two native to relatively high parts of the Andes. All have been employed by native peoples as hallucinogens (Schultes, 1976; Schultes and Hofmann, 1973). In prehispanic times the Chibcha-speaking Muisca people of the high plateau of Bogotá used *Brugmansia aurea* Lagerheim to drug the women and slaves who were to be buried with a dead chief. Juan de Castellanos described this custom four centuries ago (de Castellanos, 1589): "At Tunja, in the land of the Chibcha-speaking Muiscas, the dead chief was accompanied to the tomb by his women and slaves, who were buried in different layers of earth . . . of which none was without gold. And so that the women and poor slaves should not fear their death before they saw the awful tomb, the nobles gave them things to drink of inebriating tobacco and other leaves of the tree we call borrachero ('intoxicator'), all mixed in their usual drink, so that of their senses none is left to foresee the harm soon to befall them."

The depiction of the tree — which the Chibcha-speaking Guambianos call *yas* — as the only plant and its association with the name *borrachero* lead us to suspect strongly that it was chosen and drawn because of its importance as an hallucinogen in indigenous life. This suspicion is heightened by the very conspicuous association of the large bird with the tree: the bird is a symbol of evil and sorcery amongst these Indians.

A translation of Hernández de Alba's text which accompanied the Indian drawing follows.

"A WOMAN AT THE FOOT OF A *BORRACHERO* (The Intoxicator). ISUG *YAS* GYETA

"How pleasant is the perfume of the long, bell-like flowers of the Yas, as one inhales it in the afternoon, following the rural paths.

"But the tree has a spirit in the form of an eagle which has been seen to come flying through the air, and then to disappear; it vanishes completely in the leaves, between the branches, between the flowers.

"The spirit is so evil that if a weak person stations himself at the foot of the tree, he will forget everything and stay in that state, feeling up in the air as if on the wings of the spirit of the Yas. This happens to men and women alike, but if a *girl who has evil within her, something dirty** sits resting in the tree's shade, she will dream about men of the Páez tribe, about those men who never stop chewing coca, and later, a figure will be left in her womb which will be born six months later in the form of pips or seeds of the tree.

"Spirit which evilly impregnates women. Spirit which punishes Indians if they uproot all the plants where they live in order to make fields, when at least one plant should be left just for seed.

"A spirit so evil, our grandparents tell us, was in these trees with flowers like long bells, which give off their sweet perfume in the afternoon, that they were the food of those Indians at whose name people tremble: the fierce Pijaos."

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*This is a literal translation, but it all means "a menstruating girl".

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PLATE 21

Plate 21. *Brugmansia vulcanicola* (Barclay) R.E. Schultes. Photograph of the plant from which the type-specimen was collected. Photograph by Richard Evans Schultes.

PLATE 22

Plate 22. *Brugmansia vulcanicola* (Barclay) R.E. Schultes. Drawn by Lynda Bates and taken from the unpublished Ph.D. Thesis: A Taxonomic Revision of *Brugmansia* (Solanaceae) by Tommie Earle Lockwood.

PLATE 23

Plate 23. *Brugmansia vulcanicola* (Barclay) R.E. Schultes. Native drawing of an Indian woman under a *borrachero* tree.

HALLUCINOGENIC PLANTS IN CHINESE HERBALS

HUI-LIN LI*

The Chinese literature contains an extensive series of works on pharmaceutical botany, composed mainly of pharmacopoeias or materia medicas known as *pên-t'sao* or herbals. These works deal with drugs of all origins, mineral, animal, but mainly vegetable, hence the name. Then there are also many other treatises on plants and natural products from various parts of the country or neighboring states. All these works, accumulated in the last two thousand years, provide us with a vast store of knowledge on medicinal and economic plants and their uses, as well as on natural history in general, origin and distribution of plants, ethnobotany, agricultural history, and other related subjects. Plants with hallucinogenic properties are the subject of the present study.

Since very early times, the Chinese, like many other peoples, have discovered plants with hallucinogenic properties in their native flora, finding them perhaps along with their search for plants for medicinal uses. Plants with hallucinogenic effects were recorded in the earliest herbals nearly two thousand years ago. The special significance of these hallucinogenic plants was, however, not specifically discussed until the sixteenth century, when Li Shih-chên, the greatest authority on Chinese medicinal plants, in his magnus opus *Pên-ts'ao kang-mu* (first published in 1596 after his death) recorded along with details of a criminalistic episode involving the possible use of some hallucinogenic drugs. So far as I know, there has been no report of any use of hallucinogenic plants in China in more modern times. We do not know whether the practice of using some such plants by "sorcerers" or some other peoples as mentioned in earlier works occurred also in recent ages or not. It is not impossible that some use of hallucinogens may be found among the aborigines or other non-Han tribesmen along

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the remote borderlands in the southwest or elsewhere. There seems to be no such ethnobotanical study or survey ever having been made. We do come across, however, some records indicating that *Cannabis* was being used by the Uigurs along the Sinkiang (Chinese Turkestan) border in the remote northwest as late as the early twentieth century (Li 1974b).

Li Shih-chên's encyclopedic work, the *Pên-ts'ao kang-mu*, upon its publication, became the standard treatise on materia medica in China. Later authors, dealing with medicinal plants, nearly all derive their information from his work. This paper is also largely based on it as a primary source. In this work, he gave the details of an event in connection with a note on the general use of hallucinogens. This episode occurred in the year 1561 A.D. Apparently it was a news event of great nation-wide interest, as afterwards, because of this, the Emperor especially proclaimed an edict of warning throughout the whole country. His account is translated below.

"Lang-tang *(Hyoscyamus niger),* Yün-shih *(Caesalpinia sepiaria),* Fang-k'uei *(Peucedanum japonica)* and Red Shang-lu *(Phytolacca acinosa)* all can cause hallucination in peoples. In the past, this significance has not been fully divulged. Plants of this kind are all toxic, which can obscure the mind, alter one's consciousness, and confuse one's perception of sight and sound. In the T'ang times, An Lu-shan [a foreign warlord in the Chinese army service] once enticed the Kitan [tribesmen surrendered to his command] to drink Lang-tang wine and buried them alive while they were unconscious. Again in the second month of the 43rd year of the Chia-ch'in period (1561 A.D.), a wandering monk, Wu Ju-hsiang of Shensi province, who possessed wizardry, arrived at Ch'ang-li and stopped over at the house of a resident, Chang Shu. Upon finding the latter's wife being very beautiful, he asked that the entire family sit together at the table with him when he was being offered a meal. He put some reddish potion in the rice and after a while the whole family became unconscious and submitted to his assault. He then blew a magic spell into the ears of Chang Shu and the latter turned crazy and violent. Chang visualized his entire family as all devils and thereby killed them all, sixteen altogether, without any blood shed. The local authorities captured Chang Shu and kept him in prison. After ten days, he spat out nearly two spittoonsful of phlegm, became conscious, and found out himself that those he killed were his parents, brothers, sisters-in-law, his wife, sons, sisters, nephews. Both Chang and Wu were committed to the death sentence. The Emperor, Shih-tsung, proclaimed throughout the country about the case. The particular magic potion must be of the kind of Lang-tang or similar drugs. When the man was under the spell, he saw everyone else as a devil. It is thus very important to find out the remedy that counteracts such a thing."

The four plants mentioned by Li Shih-chên above, as well as other hallucinogenic plants from Chinese works, are given below, in the order of their relative importance.

It may be mentioned that the botanical identity of some of these plants are not positive, and others may also be subject to questioning. Among the Chinese drug plants in these old herbals, certain items appearing under one name may actually involve several different species of the same genus or even several species belonging to different genera. In other instances, a Chinese drug under one name may involve several species of the same genus as occurring in different geographical areas. However, in many cases, a plant drug may be positively determined as representing a certain species. It is not the aim of this paper to ascertain the definitive botanical identity of all the plants herein discussed, nor the chemical nature of the alleged hallucinogenic agents involved. These plants are being given here on the basis of their records as such as found in the literature. In some cases, as can be seen, an older record was not being further substantiated by later authors or may be even questioned or disputed.

Many attempts have been made by modern authors for the botanical identification of Chinese medicinal plants in the old herbals. Among the chief sources available are the works of Matsumura (1915), Stuart (1911), and Read (1936). However, the botanical identifications as well as the nomenclature in these works are, in some cases, subject to further more critical verification or modification.

The Chinese herbals and other related works cited here are given below with the author's name first and arranged chronologically to give a historical perspective to this record. References to these old works are given by the number in the following text. A Bibliography to modern works is given at the end of the paper with citations to the author and year of publication in the text. It has to be noted that most of the earlier herbals have been lost and existed only as quotations in subsequent works. A number of these items have been reconstituted by later workers.

The illustrations given here are from Chang Ts'un-hui (20), the 1249 A.D. edition of T'ang Shên-wei's *Chêng-lei pên-ts'ao* of 1108 A.D. (16), which is one of the earliest illustrated *pên-ts'ao* extant.

HAN DYNASTY (206 B.C.-220 A.D.)

1. Anonymous *Shen-nung pên-ts'ao ching* (Classical Pên-ts'ao of the Heavenly Husbandman). (Based on Chou and Ch'in, 1122-206 B.C., material reaching final form ca. 2nd cent. A.D.)
2. Chang Chung-ching *Chin-k'uei yao-lüeh* (Essentials of the Golden Cabinet). ca. 150-219 A.D.

CHIN DYNASTY (265-420 A.D.)

3. Chang Hua *Po-wu chih* (Record of the Investigation of Things). 290 A.D.
4. Ko Hung *Pao-p'u tzu* (Book of the Preservation-of-Solidarity Masters). ca. 320 A.D.
5. Ko Hung *Chou-hou pai-i fang* (Remedies for Emergencies). 340 A.D.

NORTHERN AND SOUTHERN DYNASTIES (386-589 A.D.)

6. Lei Hsiao *Lei-kung p'ao-chih lun* (Master Lei's Treatise on the Decoction and Preparation of Drugs). 470 A.D.
7. T'ao Hung-ching *Ming-i pieh-lu* (Records of Famous Physicians) ca. 510 A.D.
8. Ch'ên Yên-chih *Hsiao-p'ing fang* (Minor Prescriptions).

T'ANG DYNASTY (618-906 A.D.)

9. Chen Ch'üan *Pên-ts'ao yao-hsing* (Nature of Drugs in Pên-ts'ao). ca. 620 A.D.
10. Su Ching (=Su Kung) *T'ang pên-ts'ao* (Pên-ts'ao of the T'ang Dynasty). 659 A.D.
11. Mêng Shen *Shih-liao pên-ts'ao* (Nutritional Therapy Pên-ts'ao). ca. 670 A.D.
12. Ch'ên Ts'ang-ch'i *Pên-ts'ao shih-i* (A Supplement for the Pên-ts'ao). ca. 725 A.D.

FIVE DYNASTIES (907-960 A.D.)

13. Han Pao-shun *Shu pên-ts'ao* (Pên-ts'ao of Szechuan). ca. 934-965 A.D.
14. T'ao Ku *Ch'ing-i lu* (Records of Unworldly and Strange Things). 950 A.D.
15. Ta Ming (Jih Hua Tzu) *Jih-hua chu-chia pên-ts'ao* (The Sun-rays Master's Pên-ts'ao, Collected from Many Authors). ca. 972 A.D.

SUNG DYNASTY (960-1279 A.D.)

16. T'ang Shên-wei *Chêng-lei pên-ts'ao* (Reorganized Pên-ts'ao). 1108 A.D.
17. Su Sung *et al.* *Pên-ts'ao t'u-ching* (Illustrated Pên-ts'ao). 1061 A.D.
18. Fan Ch'êng-ta *K'uei-hai yü-hêng chih* (Guide to the Southernmost Region [of China]). 1175 A.D.
19. Ch'ên Jên-yü *Chün p'u* (A Treatise on Fungi). 1245 A.D.

YUAN DYNASTY (1206-1367 A.D.)

20. Chang Ts'un-hui *Ch'ung-hsiu Chêng-ho ching-shih chêng-lei pei-yung pên-ts'ao* (Revision of the Pên-ts'ao of the Chêng-ho reign-period). 1249 A.D.

MING DYNASTY (1368-1644 A.D.)

21. Liu Wên-tai *et al.* *Pên-ts'ao p'in-hui ching-yao* (Essentials of the Pên-ts'ao Ranked According to Nature and Efficacy) 1505 A.D.
22. Li Shih-chên *Pên-t'sao kang-mu* (The Great Pên-ts'ao). 1596 A.D.

Lang-tang — **Hyoscyamus niger** L. — Plate 24

This Solanaceous plant is the most famous hallucinogenic drug in the Chinese herbals. The very name, meaning violent delirium, implies its physiological effect. The hallucinogenic property is from the seeds, while the root is used as a medicine in pernicious malaria and in parasitic skin diseases.

Lang-tang was identified at first with *Scopolia japonica* L. by Japanese authors. But this is a species of Japan and the Chinese plant, as noted by Read and Liu (1925) and later followed by Chinese as well as Japanese (Matsumura 1915) authors, should be *Hyoscyamus niger* L. There is also a species of *Scopolia* in China, *S. sinensis* Hemsl., which is confined only to western China in Hupei and Szechuan provinces and only the root is used in medicine (Bot. Inst. 1972).

Hyoscyamus niger L. is long known as a hallucinogenic drug as given in Schultes and Hoffman (1973), who locate it in western Asia and Europe. The plant is also native to northern and southwestern parts of China, as well as in Russia and India (Bot. Inst. 1972). Makino (1921) considers the Chinese plant as representing a variety as var. *chinensis* Makino.

The seed is long known in the Chinese herbals to be very poisonous and when taken will produce madness. For use in medicine, the seeds should be properly treated to reduce their toxic properties. It is under this drug that Li Shih-chên (22), mentioning it along with three other plants following this item in this paper, discussed the hallucinogenic plants in detail as translated above. The hallucinogenic nature of this drug is noted in the earliest herbal, the *Pên-ts'ao ching* (1), which states "[The seeds] when taken [when properly prepared] for a prolonged period enable one to walk for long distances, benefiting to the mind and adding to the strength . . . and to communicate with spirits and seeing devils. When taken in excess, it causes one to stagger madly."

In using the seeds as a medicine, the preparation consists of soaking in vinegar and then in milk and afterwards drying in air in the shade. As a drug, it is considered to be tonic and constructive, and is prescribed in dysentery, mania, toothache and other ailments.

In the herbals, it is repeatedly mentioned that the seed should not be broken in its use as a medicine. One early reference to this very fact is Ch'ên Ts'ang-ch'i (12), which states "Do not let the seeds become broken. Broken seeds [when taken] produce madness." Lei Hsiao (6) states that "[The seed] is extremely poisonous, and when accidentally taken, it causes delirium and seeing sparks and flashes." Another author (9) states that "[The seed] should not be taken raw as it hurts people, causing them to see devils, acting madly like picking needles." Li Shi-chên's (22) statement about the seeds is that they produce madness and delirium when taken.

Yün-shih — **Caesalpinia sepiaria** Roxb. — Plate 25

This is a drug plant in the Chinese pharmacopeia from early times. It is a shrubby vine of the Legume family widely distributed in China among the provinces south of the Yangtse River and in other warmer countries of Asia. The stem is hollow and densely beset with backwardly hooked spines. The leaves are doubly pinnate-compound with 6-16 pinnae each with 12-14 elliptical pinnules. The flowers are yellow and arranged in racemes. The flat pods are about 3 inches long, each containing 5 or 6 dark seeds, with a somewhat unpleasant odor.

The root, flowers, and seeds are all used in medicine. According to Li Shih-chên (22), the root is used to assist removal of a bone in the throat. The seeds are attributed to have astringent, anthelmintic, antipyretic and antimalarial properties. The flowers are attributed in the early herbals as having certain occult properties, and in at least one instance, the seed is similarly attributed. The first herbal, *Pên-ts'ao ching* (1) thus says, "[The flowers] could enable one to see spirits, and when taken in excess, cause one to stagger madly. If taken over a prolonged period, they produce somatic levitation and effect communication with spirits." Tao Hung-ching (7) states that "[The flowers] will drive away evil spirits. When put in water and burned, spirits can be summoned." The same author, in another instance, says that "The seeds are like Lang-tang *(Hyoscyamus niger)*, if burned, spirits can be summoned; but this [sorcery] method has not been observed."

Li Shih-chên (22) admits the occult properties attributed to the flowers of these early records but expresses doubts about their beneficial effect on prolonged use. Remarking on the statement given above by the *Pên-ts'ao ching*, he says that "As the flowers of Yün-shih enable one to see spirits and drive one to madness, how can it be possible to gain somatic levitation by taking it over a long time? This shows that this is an error in these old works."

Caesalpinia sepiaria has not been noted as a hallucinogenic plant in modern works. In fact, as far as I am aware, it has not been investigated medicinally or chemically.

Fang-k'uei — **Peucedanum japonica** Thunb. — Plate 26

This Umbelliferous plant has also not been noted as a hallucinogenic plant in modern works. The root is used in Chinese medicine. It is considered by most authors as an eliminative, diuretic, tussic and sedative, and regarded as a tonic with prolonged use. Some, however, believe it slightly deleterious in nature.

Thus, Tao Hung-ching (7) says that "Feverish people should not take it, because it causes one to be delirious and see spirits." Ch'ên Yên-chih (8) says that "Fang-k'uei, if taken in excess, makes one become delirious and act somewhat like mad."

One of the noted characters of this drug is that it decays readily. Li Shih-chên (22), who cites the above quotation, is of the opinion that the hallucinogenic effects attributed to this drug are due to adulteration by Lang-tu. Lang-tu is generally referred to some species of the genus *Aconitum*, a genus with a large number of species widely distributed in China, many of which enter into the pharmacopeia and all are highly poisonous (Stuart 1911, Read 1936). In the *Chinese Materia Medica* (Pharm. Inst. 1960), however, Lang-tu is referred to a species of *Euphorbia*, *E. fischeriana* Steud. (*E. pallasi* Turcz.). Both *Aconitum* and *Euphorbia* species are poisonous in nature, but in the Chinese herbals, although drugs belonging to these genera are noted for their high toxicity, hallucinogenic properties do not seem to have been attributed to them.

Shang-lu — **Phytolacca acinosa** Roxb. — Plate 27

The species of *Phytolacca* are widely distributed in warm to tropical regions in the northern hemisphere, especially in America, and several species are noted for their edible leaves and poisonous roots. The species *Phytolacca acinosa* Roxb., extensively distributed in China, also in Japan and India, is a well-known drug plant in China. The leaves are known to be edible.

According to the old herbals, there are two kinds of Shang-lu; white with white flowers and white root, and red with red flowers and purplish root. The white root is edible when cooked and that kind is cultivated in some parts of the country for the edible root. The red root is considered to be extremely poisonous. *Phytolacca acinosa* Roxb. var. *esculenta* Maxim. (*Phytolacca esculenta* Van Houtte) is apparently referred to the edible kind which is generally referred to as a synonym.

The old herbals named both the flowers and roots as useful for medicinal purposes. The flowers, called Ch'ang-hau, are prescribed in apoplexy. The very poisonous root is, when used as a medicine, generally applied only in external application for inflammation. It is also prescribed in dropsy and as a remedy for abdominal parasites.

The deadly poisonous nature and the hallucinogenic effect of this drug was noted in many herbals and apparently it must have been quite commonly used by sorcerers in former times. T'ao Hung-ching (7) says that "The T'aoists used it. By boiling or brewing and then taken, it can be used for abdominal parasitic worms and for seeing spirits."

Su Sung (17) says "It was much used by sorcerers in ancient times." The two kinds were carefully differentiated. Han Pao-shun (13) thus states, "The red-flowered kind has reddish roots; the white-flowered kind has white roots." As to the white-flowered kind, which is considered as not poisonous and used as a drug, Ta Ming (15) states that "The white root has a very cooling effect; it is better taken with garlic."

Su Ching (10) summarizes in more detail the pharmaceutics of this plant. "This drug has two kinds, red and white. The white kind is used in medicine. The red kind can be used to summon spirits; it is very poisonous. It can be only used as external application for inflammation. When ingested, it is extremely harmful, causing unceasing bloody stool. It may be fatal. It causes one to see spirits."

Ta-ma — **Cannabis sativa** L.

The hemp, *Cannabis sativa* L., was the chief textile plant in northern China, and the seed was a leading grain. It was also an important drug plant. There are archaeological and historical records to indicate that it has been found in China since Neolithic times (Li 1974a).

The early Chinese records clearly differentiate the male and female plants. The male plants produce better fibers. The edible seeds are enclosed in fruit coverings which contain the toxic substance. The *Pên-ts'ao ching* (1) states that "Ma-fên (the fruits of hemp) . . . if taken in excess will produce hallucinations (literally 'seeing devils'). If taken over a long time, it makes one communicate with spirits and lightens one's body." T'ao Hung-ching (7) says that at his time "Ma-fên is not much used in prescriptions. Necromancers use it in combination with ginseng to set forward time in order to reveal future events." As a drug plant, *Cannabis* was used for various purposes but primarily for its anesthetic effect.

The hallucinogenic effect caused by *Cannabis*, especially the effect of temporal distortion, is mentioned in other later works. T'ang Shên-wei (16) gives a more complete account on the pharmaceutics use of the plant: "Ma-fên has a spicy taste; it is toxic; it is used for waste diseases and injuries; it clears blood and cools temperature; it relieves fluxes; it undoes rheumatism; it discharges pus. If taken in excess, it produces hallucinations and a staggering gait. If taken over a long term, it causes one to communicate with spirits and lightens one's body."

The stupefying effect of the hemp plant, commonly known from extremely early times, was indicated linguistically as the character *ma* assumed also a connotation of numbness and senselessness, apparently derived from the medicinal characters of the leaves and fruits. *Ma* as a radical combines with many other radicals to form characters with such meaning as demon, grinding, waste, rubbing, porridge, etc.; or as a character it is used in combination with other characters to form bisyllabic words meaning narcotic, numbness, paralysis, etc. (Li 1974b).

In a discussion on the possible use of hallucinogenic plants by ancient Taoist practitioners in their search of elixir for immortality, Needham (1974) notes a record of the addition of *Cannabis* to the contents of incense-burners to generate hallucinogenic smokes. This record is found in a Taoist collection *Wu-shang pi-yao* (Essentials of Matchless Books), a work appeared between 561 to 578 A.D. He also quotes the statement of the hallucinogenic properties of Ma-fên in the *Pên-ts'ao ching* mentioned above.

The use of the plant as a hallucinogen persisted for some time before it gradually declined. Mêng Shen (11) says that "Those people who want to see spirits use raw *ma* fruits, Ch'ang-p'u *(Acorus graminea)*, and K'uei-chiu *(Podophyllum pleianthum)* in equal parts, pound them into pills of the size of marbles and take one facing the sun every day. After one hundred days, one can see spirits." It is suggested that in ancient China the use of *Cannabis* as a hallucinogen was probably associated with Shamanism. The later belief became more and more restricted in China since the Han dynasty but its extensive practice among the nomad tribes north of China perhaps carried its use westward to central and western Asia and to India (Li 1974b).

Man t'o-lo — **Datura alba** Nees

This name is generally identified as the Jimson weed, *Datura alba* Nees, although the Sanskrit equivalent of the Chinese Man-t'o-lo, *Madara*, refers to *Erythrina indica* Lam. Several species of *Datura* have been introduced into China from India and they were not clearly differentiated from each other in the former literature. These species were introduced to China probably in the Sung to Ming times and thus they were not recorded in the earlier herbals. Only in Li Shih-chên's *Pên-ts'ao kang-mu* (22) that the medicinal uses of the Man-t'o-lo began to be given. The flowers and seeds are used externally for infections and eruptions on the face and internally they are prescribed for colds, nervous disorders and others. Notable is the fact that the drug is used in combination with *Cannabis sativa* and taken with wine as an anesthesia for small operations and cauterizations. *Cannabis* was among the earliest plants used in China for its anesthetic effect.

The delirious action produced by the Jimson weed seeds was also known to the Chinese along with its introduction. Li Shih-chên himself experimented with this and recorded his actual experience as follows: "According to traditions, it is alleged that when the flowers are picked for use with wine while one is laughing, the wine will cause one to produce laughing movements; and when the flowers are picked while one is dancing, the wine will cause one to produce dancing movements. [I have found out] that such movements will be produced when one becomes half drunk with the wine and someone else laughs or dances to induce these actions."

Mao-kên — **Ranunculus acris** L.?

The identity of this plant is uncertain. Mao-kên is the name generally referred to species of the genus *Ranunculus*. A species or a variety of a species of the genus, growing along the waters edge, is alleged, in some earlier works, to have delirious effects on man. The whole plant is considered poisonous and it is not used as medicine internally but applied only externally for irritation and inflammation. The delirious action, however, noted in earlier works, is not mentioned in later herbals.

Li Shih-chên cites Ko Hung (4), an author of the 4th century, in the following account: "Among the herbs there is the Shui Lang (water Lang, a kind of Mao-kên) a plant with rounded leaves which grows along water courses and is eaten by crabs. It is poisonous to man and when eaten by mistake, it produces a maniacal delirium, appearing like a stroke and sometimes with blood-spitting. The remedy is to use licorice."

There is the possibility that there is some mistaken identity about the plant in question as a *Ranunculus*. A quotation similar to the one given above appears also in Li Shih-chên separately under Lang-tang *(Hyoscyamus niger* L.*)*. This quotation is credited to Chang Chung-ching (2) which names the plant Shui Lang-tang (water Lang-tang). The two quotations are so similar that they are clearly referable to the same plant and perhaps derived from the same source. As it is described as a semi-aquatic species with shiny leaves, the plant in question is more likely a species of *Ranunculus* rather than a Solanaceous plant related to *Hyoscyamus*. Read (1936) gives *Ranunculus acris* L. var. *japonicum* Maxim. as a deliration.

Fang-fêng — **Siler divaricatum** Benth. & Hook.?

Fang-fêng is a drug generally identified as an Umbelliferous plant, *Siler divaricatum* Benth. & Hooker. However, it could be possibly referable to some species of *Peucedanum*. The root of the plant is regarded in herbals as an antidote for aconite poisoning and as a remedy for curing many types of rheumatism and debility. The leaves, flowers, and seeds are also used for some purposes.

It is not certain whether the drug actually causes hallucinogenic effects or not as there is only one sketchy reference referring to this. T'ao Hung-ching (5) was purported to say that "The root is spicy and non-poisonous. The kind that bifurcates at top produces madness. The kind that bifurcates at the bottom causes reversion of old ailments." This quotation was given in Li Shih-chên (22) without any substantiation or additional explanation.

Lung-li — **Nephelium topengii** (Merr.)Lo?

There is only one reference to the plant Lung-li having hallucinogenic effects. This is in Fang Chêng-ta (18) of the Southern Sung dynasty, subsequently cited in the imperial commissioned pharmacopeia by Liu Wên-tai *et al.* (21) and by Li Shih-chên (22). "Lung-li grows in Ling-nan (Kwangtung province). The shape [of the fruit] is like a small Lychee with the flesh tasting like Longan. The body and foliage of the tree are also similar to these two fruit trees so it is called Lung-li. It blossoms in the third month with small white flowers. The fruit ripens at the same time with Lychee which cannot be eaten raw but only after steaming. The taste is sweet and the nature hot. When eaten raw, it causes one to go mad or see devils."

The botanical identity of this plant has never been positively made. The description is too meager for a definitive determination. Judging from the reference given to its characters as intermediate between Lychee, *Litchi chinensis* Sonn. and Longan, *Euphoria longan* (Lour.) Steud. and its geographical occurrence, the plant in question must be a variation of either one of these two species or a species of one closely related genus in the Sapindaceae that grows in the southernmost part of China.

Euphoria longan and *Litchi chinensis*, two well-known fruits of southern China, are unique fruits in that the edible part is the fleshy aril of the single seed. They are the only species of their respective genus that are native to China. *Euphoria* contains about 10 species distributed in southern Asia and *Litchi* two species, the other being known to the Philippines only.

In all probability, the plant in question is a species of the genus *Nephelium*, which is closely related to these two genera, especially in having arillate seeds. Some botanists regard *Euphoria* and *Litchi* as congeneric with *Nephelium*. Stuart (1911), who considers *Nephelium* in this broad sense, regards Lung-li as *Nephelium sp. Nephelium sens. str.* differs from the other two primarily in the aril being united with the seed coat while it is distinct in *Euphoria* and *Litchi*. There are two species in southern China; *N. lappaceum* L., a species of tropical Asia that is cultivated in the southernmost part of Kwangtung and the Hainan Island as a fruit tree, and *N. topengii* (Merr.) H.S. Lo (*N. lappaceum* L. var. *topengii* (Merr.) How et Ho) (Kwangtung Bot. Inst. 1974) native to Hainan, Kwangtung, Kwangsi and Yunnan. The tree, growing in the forests, has a fruit that is edible but the seed is known to be poisonous (Kwangtung Bot. Inst. 1974). Thus it is quite possible that this is the species in question, especially as the unripened fruit is mentioned as being toxic. However, among the several vernacular names of the species known locally, there is no record of the name Lung-li.

Hsiao-ch'ün — **Panaeolus papilionaceus** Fr.

The earliest record of a Laughing Mushroom appears to be in the early account of natural history by Chang Hua (3) in the Chin dynasty. "In the mountains south of the Yangtze River, on tall trees, there are mushrooms growing from spring through summer . . . which are tasty to eat but often prove fatal. It is said that these mushrooms are mostly poisonous . . . . Those growing on the Fêng tree *(Liquidambar)*, when ingested, cause people to laugh unceasingly. The method for treating this is to use soil infusion, which cures it readily."

Subsequent authors give many similar records. In the Sung dynasty, T'ao Ku (14) states that "there is a kind of mushroom which causes one to suffer from a dry-laughing disease . . . ." In the early *Treatise on Fungi* by Ch'ên Jên-yü (19), the mushroom is named Tu-hsin "which grows in the ground. People believe it to be formed by the air from poisonous vermins, and kills people if taken . . . . Those poisoned by it will laugh. As an antidote, use strong tea, mixed with alum and fresh clear water. Upon swallowing this, it will cure immediately." Ch'ên treated 27 species of mushrooms from Taichow, Chekiang province.

The mushroom is often identified as growing on *Liquidambar* trees. Ch'ên Ts'ang-ch'i (12) states that "mushrooms that have poisonous snakes and vermins passing beneath them are all poisonous. Those that grow on Fêng trees *(Liquidambar)* produce an unceasing laughing delirium."

This laughing mushroom was also recorded in old Japanese works, which is called Waraitake or Laughing Mushroom. Kawamura (1918) identified this as *Panaeolus papilionaceus*. Yü (1959) notes that this mushroom is found not only in Japan and China but also in the United States and that the "soil infusion" described in early Chinese works is the clear liquid after soil is mixed with water and allowed to settle, an effective antidote for poisons.

Sanford (1972), in discussing the laughing mushrooms of Japan, records and translates two accounts from Chinese notebooks or *pi-chi*, one in Yeh Mêng-tê's *Pi-shu lu-hua* (early 12th cent.) of the Sung Dynasty, and one from Hsieh Chao-shua's

Wu tsa-tsu (1619) of the Ming Dynasty which are not repeated here. There may be other mentions of this mushroom in the numerous *pi-chi* of all dynasties. It may be noted that in Sanford's translation of the former, the term "Wen-tai" receives a footnote explaining that it is possibly not a place name and is meant for "warm spots." Actually it is an abbreviation for Wenchow and Taichow, two districts in the eastern part of Chekiang province, the same area where Ch'ên Jên-yü prepared his treastise on the fungi (19).

In a study on the search of elixir for immortality by Taoist practitioners in ancient China, Needham (1974) mentions the possible use of hallucinogenic plants, which may include the fly agaric, *Amanita muscaria*. He quotes Watson that this fungus was known in China, as in several other cultures, by the name of toad mushroom, Ha-ma-ch'ün, now often Tu-ying-hsin or fly-killing fungus. The laughing mushroom, Hsiao-ch'ün, is identified by him as *Panaeolus* or *Pholiota*. Needham remarks that "the further exploration of hallucinogenic fungi and other plants in Taoism and in Chinese culture in general will be an exciting task."

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PLATE 24

Plate 24. Lang-tang, *Hyoscyamus niger* (From *Chêng-lei pên-ts'ao*, 1249 ed.)

PLATE 25

Plate 25. Yün-shih, *Caesalpinia sepiaria* (From *Chêng-lei pên-ts'ao*, 1249 ed.)

PLATE 26

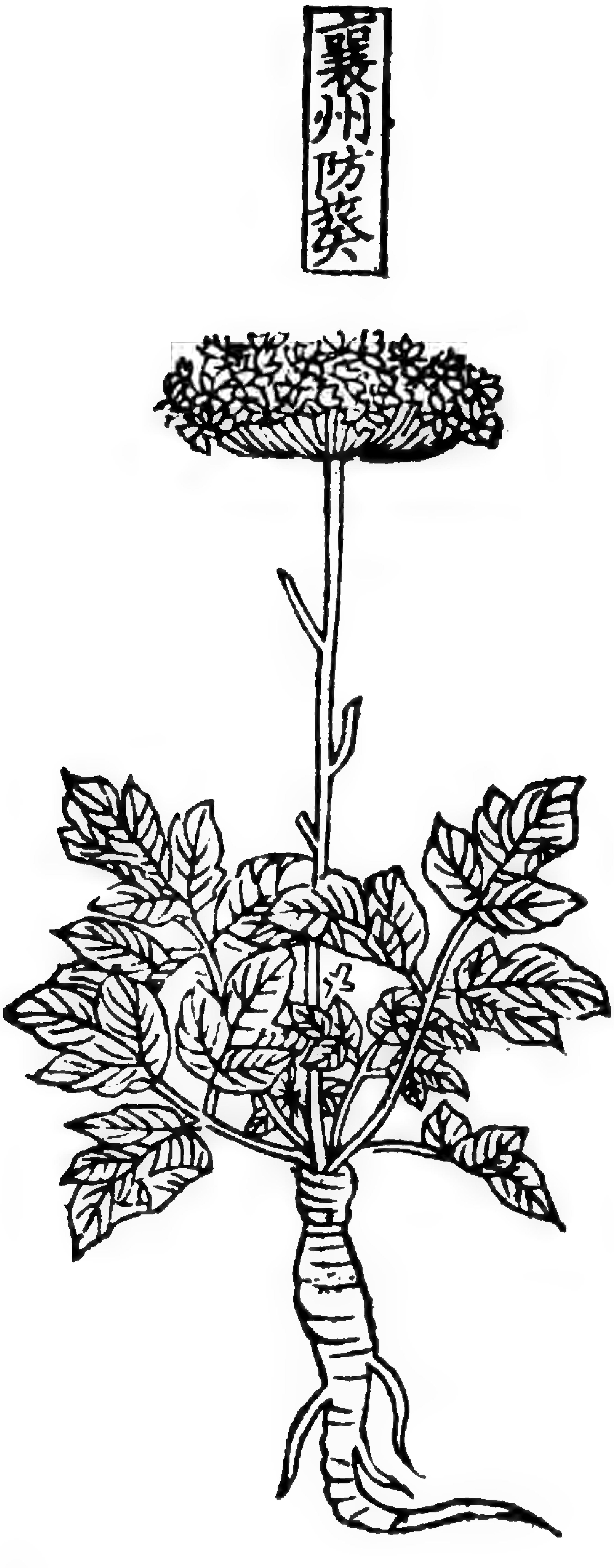

Plate 26. Fang-k'uei, *Peucedanum japonica* (From *Chêng-lei pên-ts'ao,* 1249 ed.)

PLATE 27

Plate 27. Shang-lu, *Phytolacca acinosa* (From *Chêng-lei pên-ts'ao*, 1249 ed.)

BOTANICAL MUSEUM LEAFLETS
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AN UNUSUAL SPICE FROM OAXACA: THE FLOWERS OF *QUARARIBEA FUNEBRIS*

FREDERIC ROSENGARTEN, JR.*

Most spices are to be found in the seeds, buds, fruits, leaves, roots or bark of the spice-producing plant. An extraordinary exception to this rule is the small, white flower (Plate 28) of *Quararibea funebris* (La Llave) Vischer, a majestic, evergreen tree (Plate 29) of the Bombacaceae (Silk-cotton family), indigenous to southeastern Mexico and Guatemala. The dried flowers of *Q. funebris* provide a highly pungent spice, suggestive in aroma of Slippery Elm (*Ulmus rubra* Muhl.), Fenugreek (*Trigonella foenumgraecum* L.) or curry powder. This strong fragrance is found also in the fruits and even in the wood of *Q. funebris*.

The genus *Quararibea* includes about twenty-nine species (Schultes, 1957), all of which are characterized to a greater or lesser degree by this peculiar aroma. The genus is widespread in the neotropics, comprising shrubs and trees occurring in Middle America, the West Indies and northern South America. The odor is so persistent that botanical specimens of *Q. funebris* collected in 1841 by Liebmann were highly aromatic when examined over a century later (Schultes, 1972).

For many centuries, the principal use of the spicy white flower of *Q. funebris* has been to add pungency to various chocolate-flavored beverages in southeastern Mexico. In Oaxaca, the drink is called "tejate"; elsewhere it is known as "pozonque," "pozonqui," or "pozol." *Quararibea funebris* itself has various local names in Mexico: in Oaxaca I found it is called "rosita de cacao," or in the Zapotec tongue "yieb-díe."

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In Chiapas it is known as "flor de cacao" or "molinillo"; in Puebla and Veracruz, "palo copado" or "madre de cacao"; in the Nahuatl dialect, "cacahoaxochitl" (Pennington & Sarukhán, 1968).

When the Spanish came to Mexico in the sixteenth century, they found three important spices indigenous to that country: the chili peppers (*Capsicum annum* L. and *C. frutescens* L.), vanilla (*Vanilla planifolia* Andr.), and allspice (*Pimenta dioica* L.). These flavoring agents were destined to become highly popular condiments throughout the world (Rosengarten, 1973). Yet *Q. funebris*, for some puzzling reason, never became popular or even known outside of a limited region in Middle America. This minor spice had been mentioned, to be sure, by the renowned Spanish chronicler, Sahagún, during his sixteenth-century travels in Mexico: "There are also other trees called *cacauaxochitl* which bear flowers . . . like jasmine and have a very delicate but pungent fragance."

While the world-wide consumption of vanilla in 1976 was more than 3,000,000 pounds, of allspice over 5,000,000 pounds, and of chili peppers more than 150,000,000 pounds, the total consumption of the highly aromatic flowers of *Q. funebris* was insignificant, probably less than 20,000 pounds, and this use was for the most part limited to southeastern Mexico (Plates 30 and 31).

In the pleasant Zapotec valley of Oaxaca, 10 kilometers northeast of Oaxaca City, there lies a sleepy village called San Andrés Huayapan. Ordinarily Huayapan, elevation 5,900 ft., consisting of a church and a few scattered adobe homes, would not be especially worthy of note. The village is unusual, however, in that some two dozen trees of *Q. funebris* may be found growing in and around it. The largest is about 50 feet tall, with the lowest branches spreading to a diameter roughly equal to its height (Plate 29). This magnificent tree, said to be 120 years old, characterized by its conical symmetry and dense foliage, is growing in the back yard of a local, indigenous family. Its abundant flowers provide most of this humble family's annual income. The flowering takes place all year long, although it is especially prevalent during the rainy season, between May and August. The flowers, having been dried on mats in the sun

(Plate 32), are sold in small lots every Saturday throughout the year as "rosita de cacao" in the market at Oaxaca City (Plate 33). The local price, although somewhat difficult to calculate, comes out roughly to U.S. $1.50 a pound. The volume of sales is small. There are no commercial plantings of *Q. funebris* trees in the Oaxaca region. When a young tree is planted, it requires at least five or six years before any noticeable flowering occurs.

The popular chocolate-flavored beverage called "tejate" is produced in Huayapan in the following manner: first, the necessary ingredients are collected, starting with corn which has been boiled with firewood ashes and which is known as "conesli." Dried flowers of *Q. funebris* are required, as well as cocoa seeds and a few mamey nuts (Plate 34). These ingredients are roasted separately on a "comal", or flat earthenware pan (Plate 35). The ingredients are then ground up separately on a primitive "piedra moler" or grindstone (Plate 36). In the case of the cocoa beans, the aromatic outer skin (the part utilized) is carefully peeled off prior to grinding. A doughy mass is now formed by kneading and mixing together the four ground-up ingredients. Cold water and sugar are added, as the light brown liquid is vigorously stirred until a froth is developed (Plates 37, 38 and 40). It is said that this sticky foam, which floats on top of the "tejate" (a cold, cocoa-like drink), is due to the presence of the *Q. funebris* flowers — hence the name "rosita de cacao" or "flor de cacao." "Tejate" is indeed a refreshing, invigorating beverage, popular with field workers during the harvest of the corn crop.

In Mexican herbal medicine, various therapeutic uses are attributed to *Q. funebris* (Monografias Científicas II, 1976): (1) the fruits may be used as an antipyretic to control and allay fevers; (2) the flowers may be used in the treatment of psychopathic fears; and (3) the flowers may be utilized to regulate menstruation.

In the Oaxaca region, a popular Zapotec cough remedy is prepared by adding 5 "rosita de cacao" flowers and 1 cinnamon stick to ½ liter of boiling water.

The following chemical analysis of approximately 7 ounces of flowers of *Q. funebris* from Oaxaca, was reported by Strasburger & Siegel, Inc., chemists and food technologists of Baltimore, Maryland, on January 20, 1977:

REPORT

pH of 10% Suspension	——	6.2%	
Moisture Content (at 70°C in vacuo)	——	8.57%	
Steam Distillable Volatile Oil	——	0.57%	
Total Oils (Ether Extract)	——	2.16%	2.16%
Volatile Oils (Ether Extract)	——	0.13%	
Fixed Oils (Ether Extract)	——	2.03%	
ANALYSIS OF ETHER EXTRACTS			
Glucosides (Acid Ether Extract)	——	0.03%	
Fats and Waxes (Acid Ether Extract)	——	0.02%	
Principle Aromatics (Aroma and Oils) (Acid Ether Extract)	——	0.59%	
Alkaloidal Compounds (Basic Ether Extract)	——	0.95%	
Oils and Resins (Basic Ether Extract)	——	0.23%	
Resins Insoluble in Acid and Basic Ether Extract	——	0.09%	
		Total Recovery —	1.91%

The botanical history of this plant is simple, with apparently only three binomials ever having been applied to the concept.

The combination under *Quararibea* is sometimes attributed to Standley [Rivera M. in An. Inst. Biol. (Mexico) 13 (1942) 502], who actually did indicate this as a new combination in 1923. Vischer's publication of 1919, however, has priority.

Quararibea funebris (La Llave) Vischer in Bull. Soc. Bot. Genève, ser II, 11 (1919) 205, t.p. 205 *(fl.)*.

Lexarza funebris. La Llave ex La Llave et Lexarza, Nov. Veg. Desc., fasc. 2 (1825) 7.

Myrodia funebris (La Llave) Bentham in Journ. Linn. Soc. 6 (1862) 115.

"Tree, often 20 meters high, with broad dense crown; leaves oval or elliptic, short-petiolate, 13 to 40 cm. long, obtuse to acuminate, rounded at base, glabrous except for the tufts of hairs in the axils of the veins beneath; flowers short-pedicellate; calyx bracteolate, tomentulose; petals pure white, linear oblong, the slender claws as long as the calyx; stamen tube twice as long as the calyx; fruit subglobose''. (Standley, 1923).

According to Standley, this species is reported from Oaxaca and Veracruz, Mexico, and occurs also in Guatemala and El Salvador. A map presented by Pennington and Sarukhán (1968) indicates that the tree ranges disjuctively in northern Veracruz, northeastern Oaxaca, northern Chiapas into Guatemala along the Pacific coast of Chiapas. None of these sources indicates that the type locality is in Puebla, although Izúcar de Matamoros, the type locality, is in the State of Puebla. The locality of my collection from Huayapan, near Oaxaca City, also appears to be outside of the ranges noted by the above authorities. Consequently, we must presume that the distribution of the tree is wider than hitherto indicated in the literature. We must remember, however, that the trees in Izúcar and Huayapan were cultivated. Therefore, these and trees reported from other localities outside of the natural range of the species, may have been taken by man from the areas where it is wild and planted for their usefulness and beauty elsewhere.

The collection upon which this article is based *(Frederic Rosengarten, Jr. s. n., July 16, 1977, Huayapan, Oaxaca, Mexico)* has been deposited in the Botanical Museum of Harvard University.

An early and interesting illustration of *Q. funebris* is reproduced herein (Plate 39); this drawing was made by a primitive Mexican artist during the last quarter of the sixteenth century. The artist's intention was to portray the *cacahoaxochitl* tree with Indians gathering flowers. As sometimes occurs in primitive art, the relative proportions are not realistic in that the size of the flowers — the important part — is highly exaggerated. (Drawn as an illustration for the *Historia general de las cosas de Nueva España* of Bernardino de Sahagún and reproduced from the Paso y Troncoso edition, first published in 1905).

The curious specific name "funebris" was chosen by the Spanish botanist, Pablo de La Llave (1825), when he heard that the local inhabitants of the Mexican village of Izúcar, near Puebla, were accustomed to mourn their dead under the shelter of the thick foliage of the lower branches of a *cacahoaxochitl* tree. At the present time, however, the Zapotec Indians in the Oaxaca valley do not associate the tree, *Q. funebris* with mourning the deceased or with death. Possibly the folk connection of *Q. funebris* with the idea of life and death may be attributed to the fact that this vigorous tree is evergreen. It is not uncommon in primitive societies to associate trees which do not shed their leaves at one time with the concept of everlasting life.

With increasing emphasis on natural, rather than synthetic flavorings, the long-neglected, highly aromatic flowers of *Q. funebris* may some day become more important in the world spice trade.

Furthermore, the handsome, conical, evergreen tree, characterized by its symmetry and abundant foliage, might be of interest for planting in southern Florida, southern California and Hawaii — as an attractive, ornamental shade tree for parks, gardens and homes. Upon my return from Oaxaca in July 1977, seeds of *Q. funebris* were sent to the Fairchild Tropical Garden, Miami, Florida and to the Royal Botanic Gardens, Kew, England. These may represent the first introductions of *Q. funebris* to the horticultural world.

ACKNOWLEDGMENT

I wish to express my appreciation to Miss Bodil Christensen of Oaxaca, Mexico, for her helpful orientation in locating *Q. funebris* trees in Huayapan; and to Dr. Richard Evans Schultes for his thoughtful editorial guidance.

Illustrations: Plates 28, 29, 32, 33, 34, 35, 36, 37, 38 and 40 by Lynn Rosengarten; plates 30 and 31 by Elmer W. Smith.

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PLATE 28

Plate 28. White flower of *Quararibea funebris* approximately 1½ in. in length.

PLATE 29

Plate 29. 120-year old tree of *Quararibea funebris* growing at Huayapan, near Oaxaca, Mexico. Approximately 50 ft. tall.

PLATE 30

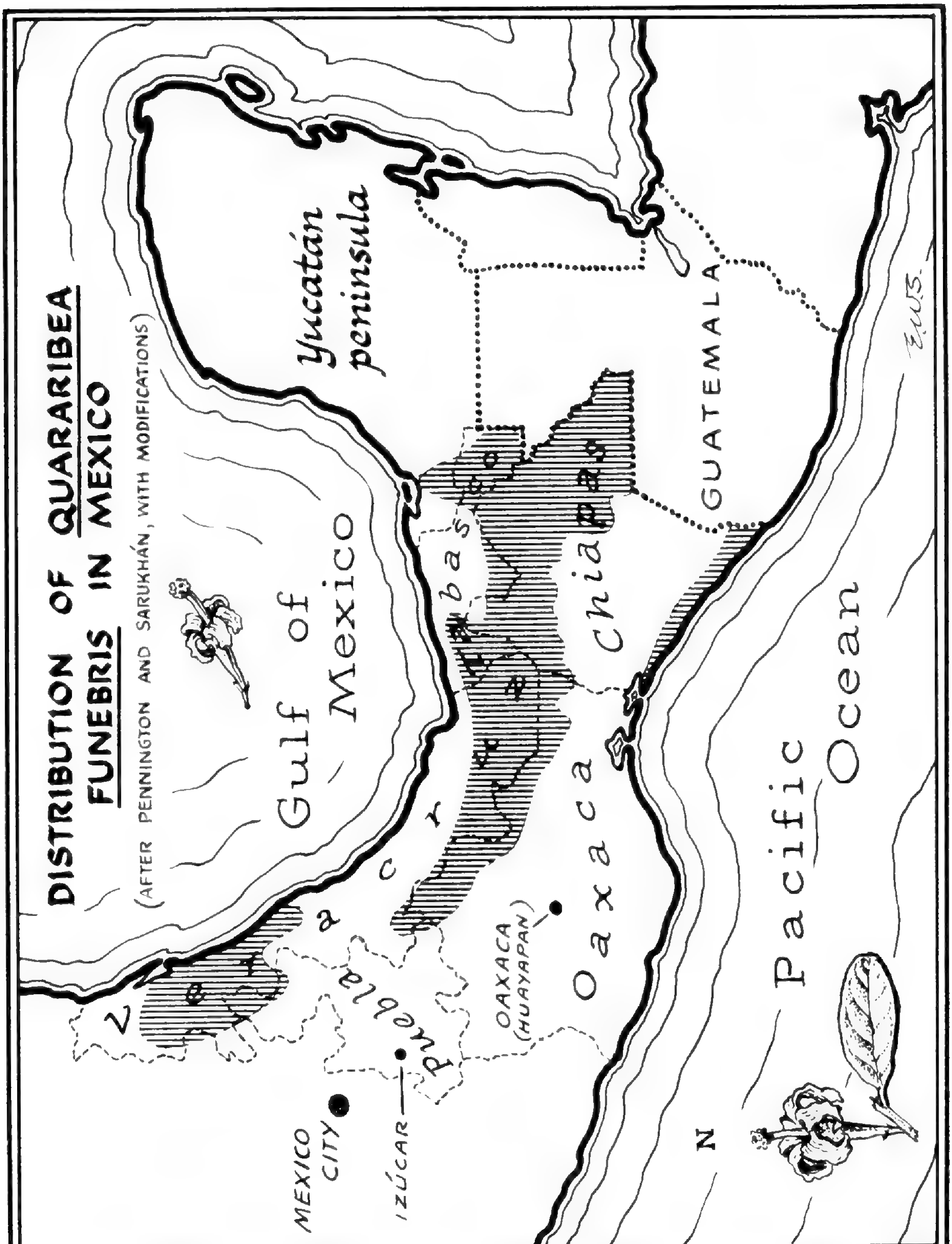
DISTRIBUTION OF QUARARIBEA FUNEBRIS IN MEXICO
(AFTER PENNINGTON AND SARUKHÁN, WITH MODIFICATIONS)
Gulf of Mexico
Yucatán peninsula
GUATEMALA
Puebla
Oaxaca
Pacific Ocean
MEXICO CITY
IZÚCAR
OAXACA (HUAYAPAN)
N
E.W.S.

PLATE 31

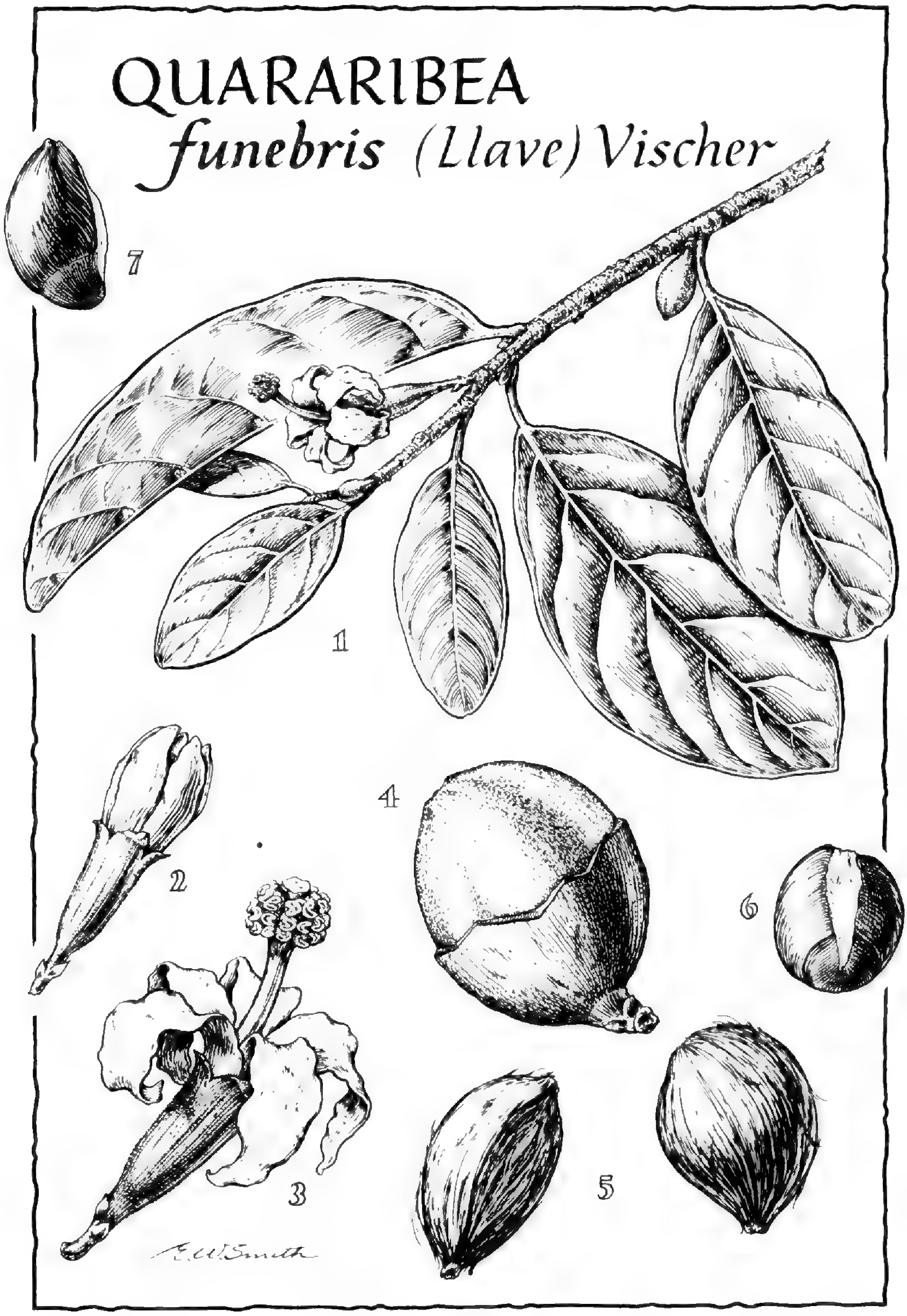

PLATE 32

Plate 32. Drying flowers of *Quararibea funebris* on a straw mat at Huayapan.

PLATE 33

Plate 33. Every Saturday throughout the year, the flowers of *Quararibea funebris* and the beverage "tejate" are sold in the market at Oaxaca (see woman at left).

PLATE 34

Plate 34. Ingredients used in the preparation of tejate at Huayapan: left, roasted mamey nuts; top, cocoa beans; foreground, corn; and on top of leaf, roasted flowers of *Quararibea funebris*.

PLATE 35

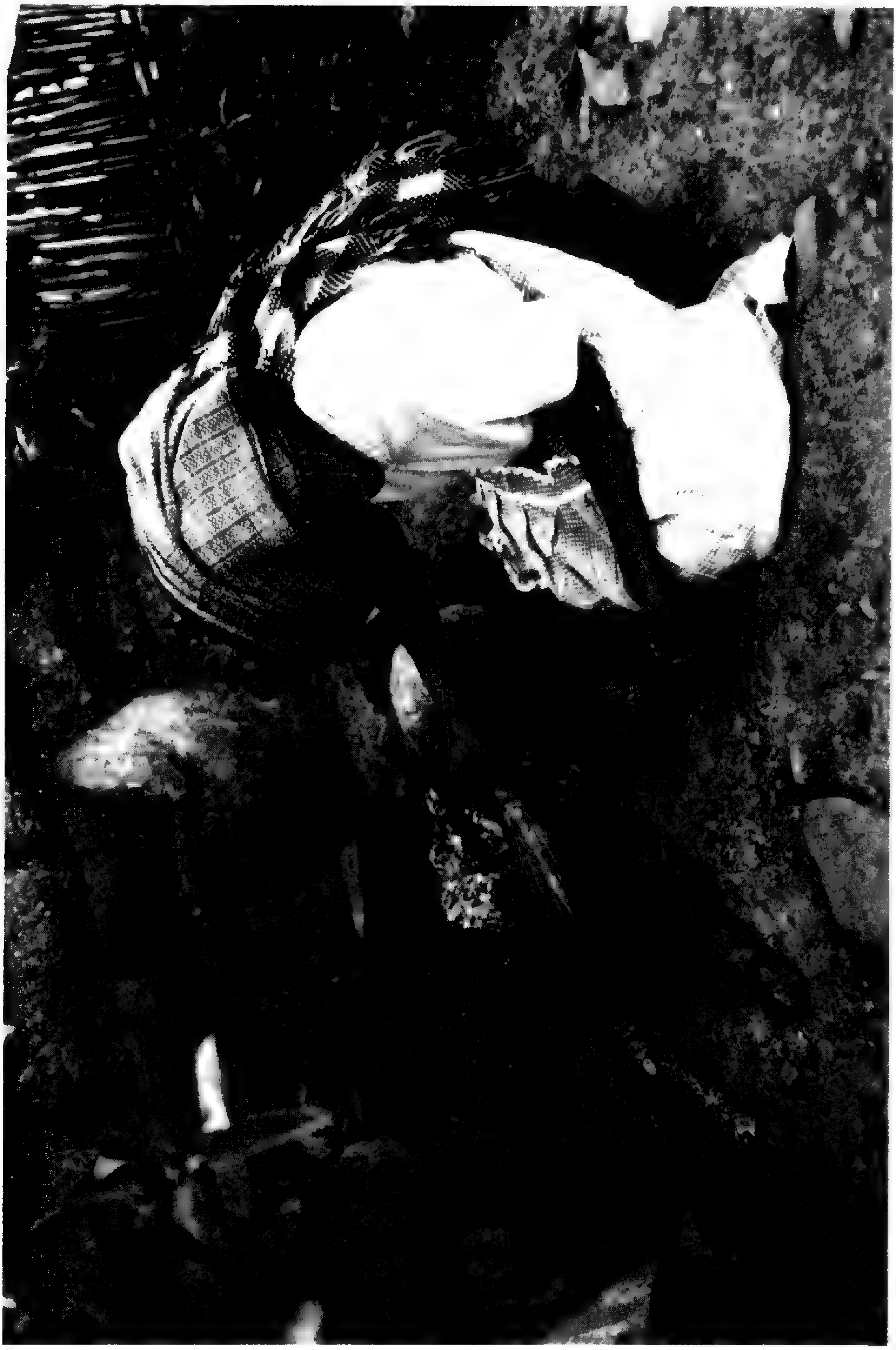

Plate 35. Roasting the ingredients for tejate.

PLATE 36

Plate 36. Grinding the ingredients for tejate.

PLATE 37

Plate 37. A bowl of fresh tejate, ready for drinking. The sticky froth on top of this chocolate-flavored beverage is due to the mucilage in the flowers of *Quararibea funebris*: hence the names "flor de cacao," or "rosita de cacao."

PLATE 38

Plate 38. In foreground, fruit, flowers and leaves of *Quararibea funebris:* in background, a bowl of tejate.

PLATE 39

Plate 39. *Quararibea funebris*, reproduced from the Paso y Troncoso edition of Bernardino de Sahagún: *Historia general de las cosas de Nueva España.*

PLATE 40

Plate 40. Bud, flower, fruit and seed (in husk) of *Quararibea funebris*.

CANNABIS FOLKLORE IN THE HIMALAYAS

G. K. Sharma*

Perhaps searching for truth and reality in folklore is well summarized by the Chinese proverb: "It is better to journey than to arrive". *Cannabis* folklore in the Himalayas is full of mystery and awe. To add further to the tangle, it is shrouded in the metaphysical outlook of the East. The Himalyas offer a great challenge to the ingenuity of the ethnobotanist, ecologist, biochemist, and anthropologist. The remoteness and inaccessibility of human populations, the confusing and long history of wild and cultivated *Cannabis* in the area, the antiquity of local culture, the mythological folklore of the area, and the stark immutability of the Himalayas make these mountains an ideal area for investigations such as those herein reported.

Cannabis is wild in the area, although cultivation is permitted in certain parts of the Himalayan arc, extending from Afghanistan to Burma — a distance of 1,500 miles. The use of *Cannabis* here was reported in some of the oldest Aryan scriptures, including the sacred *Vedas* (4,000-5,000 B.C.), where it has been called "joy-giver", "victory", and "liberator". The oldest known Vedic description of *Cannabis* is found in Book XI, 6, 15 of the *Atharva-Veda* (3,000-4,000 B.C.). In the translation (Whitney, 1905) of the original Sanskrit text, dedicated to many different gods for relief, the following is stated:

> "The five kingdoms of plants, having soma as their chief (crestha), we address; the darbha, hemp, barley, saha — let them free us from distress."

Other references alluding to the antiquity and the special niche of *Cannabis* in the ancient Indian culture can be found in classics such as *Rg-Veda*, *Susrita* and the *Mahabharata* (Majumdar, 1952; Watt, 1889). The *Susrita* (600 A.D.) offers hemp as an anti-phlegmatic. Nedkarni (1954) characterizes *Cannabis*

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as ". . . a source of great staying-power under severe exercise or fatigue." *Sarangadhara* (1,500 A.D.), describes *Cannabis* as an excitant; while in *Bhavapakash* (1,600 A.D.), the plant is known for its exhilarating properties and for curing leprosy. The Muslims regard bhang as a holy plant and in Tibbi (the Muslim system of medicine) it is used for treating numerous diseases: asthma, dandruff, and urinary disorders. In the Zoroasterian scriptures of ancient Persia (with close resemblance to *Rg-Veda*), references to bhang for producing miscarriage and for euphoria (Darmesteter, 1883) can be found. It would not be an exaggeration to call *Cannabis* the penicillin of Ayurvedic medicine — the indigenous medical system of India. Even the generally accepted findings of the Hemp Drugs Commission in India (1893-94) did not oppose the moderate use of *Cannabis* for social and medicinal practices in the Indian sub-continent, although excessive consumption was regarded as injurious.

Many methods of using *Cannabis* in these mountains have been deeply rooted in the cultural, social, and economic lives of the local peoples. A casual observer is not likely to see or hear much *Cannabis* folklore because of cultural and social differences. Furthermore, folklore is a way of life for some people in the area; hence one finds no glittering pronouncements or exaggerations typical of urban societies. Only a serious student of ethnobotany purposefully seeking it out could penetrate the mystery of *Cannabis* folklore in these mountain fastnesses.

The average inhabitant questioned about *Cannabis* use or folklore, expresses indifference or little interest in it, making research even more difficult. Near the India-Tibet border in the northern Himalayas in India, I met several Tibetan refugees (now Indian citizens), known for their frequent use of "momea" or "solaradsa" *(Cannabis)* for its medicinal, food and narcotic properties (Plate I). Mountain caravans travelling through narrow passes at 17,000 feet carry normal supplies of *Cannabis* preparations for their long and adventurous journeys. Even a discreet gesture to befriend them can, at times, arouse a bellicose response — adding to the difficulties of the probing ethnobotanist. Notwithstanding these difficulties, it must be done to preserve the folk medicine associated with *Cannabis*, else the onslaught of modern medicine and technology is sure to bury this fascinating heritage.

In 1973 and in 1976, I spent several months in the northern and central Himalayas, visiting towns, villages, hamlets and mud-huts to observe the preparation and folk use of *Cannabis*. I interviewed several local people, representing a variety of professions and social strata. This area of mountain peaks is covered with perpetual snow, ranging up to 29,000 feet or more, although my studies did not take me above 15,000 feet. Human populations are scattered and small. *Cannabis* grows up to 10,000 feet in a wide variety of microhabitats. The plant exhibits great phenotypic plasticity and, as suggested by folklore and my preliminary studies (Sharma, 1975), possibly corresponding narcotic strengths. Dry conditions of microhabitat have generally been considered more conducive to narcotic potency. There are areas at different elevations (but with a similar humidity range) known to have strongly narcotic *Cannabis*. I visited several of these places known to the local people for "strong" *Cannabis:* the folklore was confirmed by users and non-users alike. At certain localities, semi-religious gatherings or fairs are arranged, and the use of *Cannabis* products is common among the religious mendicants, the so-called ascetics, and fakirs. It is important to remember that, with some exceptions, the use of *Cannabis* is confined usually to the economically lower strata. *Cannabis* is not generally accepted in the educated society.

While narcotic use of *Cannabis* is more prevalent in the economically lower groups, its medicinal properties are valued throughout the area and in all segments of society. Cough, diarrhea, asthma, malaria, excessive bleeding, and high blood pressure are some of the ills for which preparations of *Cannabis* have been used in the past in the Indian sub-continent and in many other parts of the world (Bouquet, 1950; Chopra & Chopra, 1957); and these uses are still common in the Himalayas. Chopra (1933) and Chopra & Chopra (1957) outline some of the common modes of consumption of *Cannabis* in the Indian sub-continent:

MAJUM: A special type of confection, for the preparation of which bhang or ganja is either boiled in water or heated in clarified butter. The green resinous scum that appears on the surface is mixed with sugar and is then heated to form a paste, cut into small pieces. In some parts of the country, this preparation is slightly different.

HALWA: Bhang is boiled in a jaggery syrup. The filtrate is mixed with flour and clarified butter for making halwa. This preparation is common in the southern part of the Indian sub-continent.

CURRY: Bhang leaves are prepared in powdered form and then used for making curries, with the usual assortment of spices and vegetables.

BHANG BEVERAGES: Bhang leaves are pounded and mixed with sugar, black pepper, and diluted with water. Almonds, resins, and even curds are mixed with pounded bhang leaves in the well-to-do strata of society.

SMOKING OF CANNABIS: Ganja and charas are used for smoking in a wide variety of equipment in the sub-continent. "Chillam" or "hookah" (the water pipe) are the commonly employed paraphernalia.

Partly in view of the great significance given to *Cannabis* as a medicine in the *Susrita* (600 A.D.) — the Bible of the Indian system of medicine — there is a growing interest in revitalization of the indigenous Ayurvedic system of medicine in India. Government-supported clinics and research units exist where age-old treatments, making use of native herbs, are fully utilized and investigated. There is a tendency among the old societies to be influenced by modern civilization and technology. During this metamorphosis, their own cultural heritage is forgotten or denegated. Maintenance of fine cultural traits or the protection of the existing ones is a challenge, since they bespeak man's achievements in his climbing the evolutionary scale.

Nowhere does this fit more than in the case of *Cannabis* in the Himalayas. Such an investigation can discover new biodynamic principles associated with *Cannabis*. This paper is obviously a step in that direction. The Himalayas are extensive, and *Cannabis* folklore there needs further research and attention. I observed the following modes of *Cannabis* utilization in the

Himalayas during my ecological investigations in that area. It is quite possible to encounter variants of these in other parts of the world.

BHANG PAKORAS: This preparation is made by mixing fresh or dried *Cannabis* leaves (Plate II) with chick-pea flour. A kind of electuary is prepared by adding water and the desired condiments (black or red pepper, ginger, and cumin seeds). The resulting dough is salted. Small balls of the dough are fried in mustard oil. These fried 'pakoras', as they are called, are eaten as snacks with tea or beer. The strength of this preparation is controlled by the amount of *Cannabis* leaves at the time of making the dough. On festive occasions, these 'pakoras' are sought with great felicity.

BHANG PARANTHAS: For this extremely popular delicacy, crushed or powdered roasted seeds are stuffed in large, round wheat bread dough, either baked in an earthen oven or shallow-fried in a skillet. The resulting product is used like a regular bread by adults in a family. In some cases, *Cannabis* of desired quality is cultivated in private lots for this common preparation.

BHANG BALLS: Fresh, tender leaves of *Cannabis* are finely powdered or crushed and mixed with a small amount of water. Small (1" diameter) balls are prepared from the mixture. Poppy seeds are added at times. These *Cannabis* balls are used as snacks with tea or coffee and sold freely in markets, especially during the summer months. The educated people seem to pay no attention to this product, however, since it is an accepted custom in the area (Plate III).

BHANG AND HONEY: A widespread belief holds that a concoction of young *Cannabis* leaf powder and honey keeps youth, vitality, and virility. It is also used to maintain hair colour and texture. The preparation is made easily by the local inhabitants, since the ingredients are available on the spot.

"BHANG, HONEY, AND FULL MOON": According to folklore, if bhang is collected from the plant during a full moon, it yields enormous amounts of resin of high quality, which is mixed with honey before consumption. Folklore thus becomes practical on occasions during the spring and early summer, when *Cannabis* produces copious amounts of resin, a fairly well established phenomenon in that part of the world. Perhaps the full moon may have a validity in scientific significance — a point that should be investigated.

CANNABIS AND COBRA: This folklore belief is accepted throughout this area: the cobra is killed and buried; *Cannabis* seeds grown on this site are presumed to yield extremely potent forms of marihuana, which is used for medicinal purposes, especially for tuberculosis. Such sites are naturally not common, since such utilization would be limited to medicinal use. It demands, however, a scientific analysis of this folklore belief, since there may be other chemical substances of significance, in addition to tetrahydrocannabinol, which possess medicinal potentialities and which may be affected by this treatment of the soil.

BHANG CHEWING: It is a common practice among travellers — especially porters and caravans in the high Himalayan country — to chew bhang leaves during their journeys at high elevations. I came across a lonely traveller at about 10,000 feet, riding his mule (Plate IV) and fully equipped with *Cannabis* preparations to be used during his arduous journeys. The chewing of *Cannabis* leaves in the Himalayas may well be compared to the use of coca leaves in the Andes.

BHANG SMOKE AND CHILDBIRTH: In the mountains and in the plains of Panjab and adjoining Pakistan, smoke in the room or house at childbirth from burning bhang seeds is considered to be a ritual that drives off bad spirits and thus ensures health and luck to the new-born. Seeds are burned in an earthenware pot at regular intervals in the mornings and evenings. Again it seems obvious that this practice may have significance in suggesting the use of *Cannabis* seeds as a vermicide.

I visited a small, isolated village in the foothills of the Himalayas: a village with the reputation of *Cannabis* of great narcotic strength. An exotic, religious fair, well attended, is held annually in the nearby forested grove inhabited by a few religious mendicants. Bhang products are collected just before the onset of the Monsoons — a month earlier to be precise — since it is at this time of the year when the highest quality bhang is produced. After the rains, according to reports, the strength is diluted. There may be some logic to this folklore: tetrahydrocannabinol resin exudes in abundance in dry, hot weather, which is so typical of this area before the rains arrive. The practice of collecting the resinous secretion before the rains is common throughout the entire area.

Some of the other common uses of *Cannabis* in the Himalayan area are: oil extracted from the seeds is used for rheumatism; leaves boiled in milk and used for stomach upset; seeds mixed with barley are eaten by the common folks of these hills, perhaps an unconscious following of the hymn of *Atharva-Veda; Cannabis* mixed with *Datura Stramonium* seeds for intoxication.

During field investigations, I met several curious, helpful inhabitants of the hamlets. Practically everybody suggested a strong correlation between strong odour and narcotic potency of *Cannabis*. A biochemical analysis of various populations is planned to determine the validity of this folklore belief.

Finally, the uses of *Cannabis* drugs in the Indian sub-continent can be described under the following categories (Chopra & Chopra, 1957): 1) medical and quasi-medical use; 2) use in connection with religious and social customs; 3) euphoric purposes. Unfortunately, it is the use or abuse for euphoric purposes which causes public commotion, fear and indignation in the minds of many, sometimes obscuring the medicinal and religious significance of *Cannabis* in India. General belief holds that *Cannabis* is a means of escape from the realities of life. Dutt (1900) rightly summarizes the euphoric effect of *Cannabis* observed in Indian surroundings:

> Almost invariably the inebriation is of the most cheerful kind, causing the person to sing and dance, to eat food with great relish, and to seek aphrodisiac enjoyments. In persons of a quarrelsome disposition, it induces, as might be expected, an exasperation of their natural tendency.

There is some truth to this statement, as evident in the Himalayan areas and other parts of the world. However, caution and discretion must be exercised while trying to write a complete story of *Cannabis*, since its folklore may reveal new medicinal potentialities (as has been the case in the past with this and many other plants in the Himalayas). I hope, therefore, that this account may stimulate further research before the tide of modern civilization sweeps away all folklore. Many more isolated Himalayan niches remain to be visited for data. A combination of folklore and modern tools of research in biology, biochemistry, and anthropology will surely result in a wealth of information. Investigation on *Cannabis* and biological problems associated with it have not yet received the support and attention warranted by their immense potentialities for human welfare. International and national efforts must be made to understand basically this plant of such great significance. Further, the Himalayas are untapped, representing a relatively virgin field for folklore and scientific endeavors.

ACKNOWLEDGMENTS

I wish to thank Professor Richard Evans Schultes, Director, Botancial Museum, Harvard University, for his advice and encouragement during the course of my studies. Thanks are due the Government of India and the various State Governments in the Himalayan area for permitting me to conduct research on *Cannabis;* inhabitants of the area studied for their generous help; Abha Kapila and Naveen Kapila for acting as guides.

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PLATE 41

Plate. 41. A Tibetan refugee near the India-Tibet border holding a *Cannabis* plant growing in the area.

PLATE 42

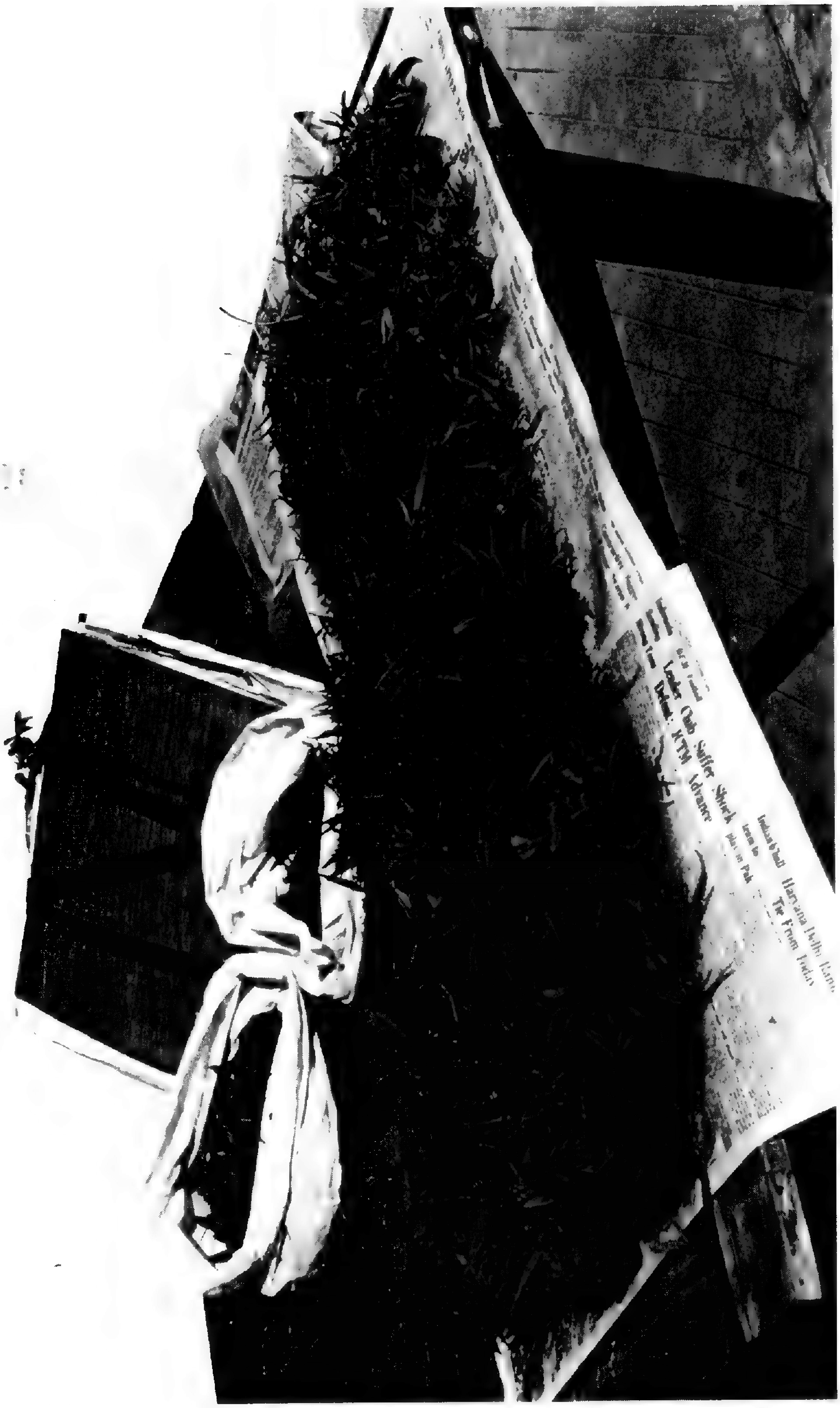

Plate 42. *Cannabis* plant material being dried in the sun.

PLATE 43

Plate 43. A shop in the area selling bhang balls.

PLATE 44

Plate 44. A mountain man chewing and smoking bhang during long mountainous journey.

CHEMICAL TEST FOR IDENTIFICATION OF COPROLITES

Elizabeth A. Coughlin

Archaeological identification of coprolites has, for the most part, been based on visual and microscopic evaluations of gross morphology and of dietary botanical inclusions. These, combined with the absence of any major skeletal network, but possibly with inclusions of small dietary skeletal remains, have served as indicators of coprolites.

Chemical analysis, however, of the suspected coprolite itself and of nearby associated material from the same stratum, level or feature offers further substantiation for identification.

Significantly high levels of nitrates (which are the final and most highly oxidized form of nitrogen in the nitrogen cycle of biologic oxidation of organic nitrogen compounds) indicate the final stages of biological degradation and are thus suitable for indentification of coprolites.

A colorimetric estimation of nitrates (NO_3) can be made by measuring the yellow color produced by the reaction of nitrates with brucine at a wave-length of 410 millimicrons.

PROCEDURE

1. Preparation of standards
   - A. *Stock Nitrate Solution:* dissolve 721.8 mg. anhydrous potassium nitrate, KNO_3, and dilute to 1,000 ml. with distilled water. (This solution contains 100 mg /1 N.)
   - B. *Standard Nitrate Solution:* dilute 10.00 ml. Stock Nitrate Solution to 1,000 ml. with distilled water. Prepare immediately before using.
   - C. *Nitrate Standards:* prepare standards in the range of 0.1 — 1 mg/1 N. by diluting 1.00, 2.00, 4.00, 7.00, and 10.00

ml. Standard Nitrate Solution to 10.00 ml. with distilled water. (1.00 ml. of Standard Nitrate Solution = 1.00 mg. N.)

2. PREPARATION OF SAMPLES
   A. Grind to a fine granular form a small amount of suspected coprolitic material.
   B. Add 10 ml. distilled water and shake thoroughly.
   C. Pass this mixture through a glass filter, separating out all loose particles.
   D. Collect the filtrate; this is the prepared sample.

3. PREPARATION OF REAGENTS
   A. *Sodium Chloride Solution:* dissolve 300 g. sodium chloride and dilute to 1,000 ml. with distilled water.
   B. *Sulfuric Acid Solution:* add 500 ml. concentrated sulfuric acid to 125 ml. distilled water. Cool to room temperature before using.
   C. *Brucine-Sulfanilic Acid Solution:* dissolve 1 g. brucine sulfate and 0.1 g. sulfanilic acid in 70 ml. hot distilled water. Add 3 ml. concentrated hydrochloric acid, cool, and make up to 100 ml. with distilled water.

4. PREPARATION OF BLANK
   A. Prepare reagent blank by measuring out 10 ml. distilled water.
   B. Run test procedure as in 5, including water baths and addition of reagents.

5. TEST[1]
   A. Place all standards, samples and blanks to be tested in test tubes in a cool water bath and add 2 ml. sodium chloride solution.

[1]This test eliminates interferences of nitrites (NO_2) and chlorides. Interferences due to excess organic material are removed by filtration through glass (See 2-C.).

B. Mix thoroughly by swirling by hand. Do not use mechanical or magnetic stirrers. Add 10 ml. sulfuric acid solution and swirl again. Replace in cool water bath.

C. Add 0.5 ml. brucine-sulfanilic acid reagent; swirl by hand and place in a well stirred boiling water bath that maintains a temperature of not less than 95°C.

D. After exactly 20 minutes, remove standards, samples and blanks and immerse in a cold water bath.

E. When thermal equilibrium is reached at room temperature, dry off the tubes, and read standards and samples against reagent blanks at 410 millimicrons in a spectrophotometer. Run at least two standards and two blanks with each batch of samples.

6. CALCULATIONS

A. Subtract reagent blanks from final absorbance readings of standards, and plot the resultant absorbance against mg. NO_3-N/1 (milligrams nitrate-nitrogen per liter).

B. Correct the absorbance readings of the samples by subtracting their sample blank values from their final absorbance values.

C. Read the concentrations of NO_3-N directly from the standard curve.

D.

$$\text{mg./1 } NO_3 - N = \frac{\text{mg. } NO_3\text{-N}}{\text{ml. sample}}$$

E. mg./1 NO_3 = mg./1 NO_3-N x 4.43

7. EVALUATION OF RESULTS

A. A high level of nitrate (NO_3) in the suspected coprolitic material combined with comparatively lower levels of NO_3 in associated accompanying material from the same level, stratum or feature would substantiate identification of coprolites.

This procedure was developed in the Ethnobotanical Laboratory of the Botanical Museum of Harvard University with the support and encouragement of Prof. Richard Evans Schultes, Director of the Museum. I thank Prof. Schultes and the museum staff for their contribution to this project. I also express my appreciation to Miss Virginia Popper for initially suggesting to me the application of chemical techniques to ethnobotanical and archaeological identifications.

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STUDY OF PRE-CERAMIC MAIZE FROM HUARMEY, NORTH CENTRAL COAST OF PERU

ALEXANDER GROBMAN, DUCCIO BONAVIA AND
DAVID H. KELLEY WITH PAUL C. MANGELSDORF
AND JULIÁN CÁMARA-HERNÁNDEZ[1] [2]

In 1960, Harvard University received a collection of maize samples from the Valley of Huarmey in the north central coast of Peru. These samples represented prehistoric specimens and were sent by David H. Kelley, who at the time was associated with West Texas State University, and by Duccio Bonavia, who then was an associate research worker at the Institute of Anthropological Investigations of Lima.

Although these samples were studied almost immediately, due to a series of circumstances the publication of the report has been delayed. We believe today, however, that this information is valuable for the knowledge of prehistoric cultigens, and it is, therefore, being published with slight modifications in the original manuscript, as a result of recent fundamental changes which have come about in our knowledge of the archaeology of the Peruvian Coast. With reference to the subject,

[1]Alexander Grobman, Associate Director General, Centro Internacional de Agricultura Tropical, Cali, Colombia.

Duccio Bonavia, Profesor Principal, Departamento de Biología, Universidad Peruana Cayetano Heredia, Lima, Perú.

David H. Kelley, Professor, Department of Archaeology, University of Calgary, Alberta, Canada.

Paul C. Mangelsdorf, Fisher Professor of Natural History, Emeritus, Harvard University.

Julián Cámara-Hernández, Professor Asociado, Facultad de Agronomia, Universidad de Buenos Aires, Buenos Aires, Argentina.

[2]The section on description of maize remains was worked and written by Paul C. Mangelsdorf and Julián Cámara-Hernández.

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only a few general notes were advanced (*vide* Kelley and Bonavia, 1963; Mangelsdorf and Cámara-Hernández, 1967), which are now being complemented with the present technical report on the botanical material.

The present report, nevertheless, is a preliminary one. The work at Huarmey has not been concluded, and a final and more thorough study is in preparation.

Up to this time, the site appears in the scientific literature with the denomination of Huarmey North 1, because a name was not known for that site. From now on we will call it Los Gavilanes, an old toponimic which the dwellers of the locality recall and its code will be PV35-1, according to Rowe's nomenclature.

The locality of Huarmey is in the Valley of Huarmey, which is in the Department of Ancash, Province of Casma, District of Huarmey in the North Central Coast of Peru. The archaeological site which is being described is located in the lower part of the Valley, exactly at 78°10'21" longitude West and 10°02'45" latitude South. The site, which was originally located by Edward Lanning, was a subject of interest of David H. Kelley, who made some test pits in the years 1957 and 1958. At the request of Paul C. Mangelsdorf, who at that time was Director of the Botanical Museum of Harvard University, in the year 1960 Duccio Bonavia excavated two stratigraphic cuts at the site and returned to it on numerous occasions in order to effect further observations. However, it is only in 1974 that Bonavia was able to make a more detailed and thorough work, still regarded as preliminary, on account of the size of the site and the complexity that it represents.

This site is located in a sandy area, removed from the cultivated area of the Valley, and a small range of hills separated it from the sea, while in its northern limit the remains of a fossil lagoon can be traced. This lagoon was formed on the bed of an ancient river, which is now dry and as a consequence of the conformation of ocean beach lines.

The site is totally covered by a layer of eolic sand and on its surface can be observed patterns of a series of structures, apparently circular, whose function is not yet clear. No ceramics are present on the surface, while lithic material is easily found. These are rough, simple tools, the majority with indefinite typology, made by percussion, and all of them on flakes. The only typical tools which characterize the site (and whose close counterparts are found only in the neighbouring Valley of Culebras and in a similar context), are some pebbles of various sizes, round or oval in shape, thin, and whose borders have been worked by unifacial percussion creating cutting edges.

When Kelley made the first preliminary excavation in the year 1967, he found one maize cob, peanut shells, abundant samples of cotton, fragments of gourds, and residues of sea shell and bones. It is presumed that one sample of lima bean was also present, although it was never identified by a specialist. Later on, Kelley himself in 1958 continued searching for more botanical evidence in the surroundings of his preliminary excavation site, having been able to find 10 maize cobs and a corn tassel. This material was shown to Mangelsdorf and because of its importance it was decided to go on with the search.

When Bonavia excavated the site in the year 1960, he was able to find abundant residues of corn (consisting not only of cobs and ears, but also leaves and plants) besides lithic residues (among which some disks which were mentioned before and one chipped stone point), textiles, mats and ropes. What called the attention most particularly was the finding of three pottery sherds during the excavations of the second stratigraphic cut. Two of them were at the base of the eolic sand, that is on the surface of the site, at a depth of 15 cms., while the third appeared without any control, because of the collapse of one of the walls of the cut; it could be presumed that this one was associated with the two previous ones.

The finding of these pottery sherds left some doubts about the possibility that the site could be pre-ceramic. However, in spite of many visits made by Bonavia to the site since 1960, he could never find on the surface other pottery fragments and during the excavations which took place in the season of 1974 nothing in the way of ceramic residues was found. Although the studies of the structures present a series of questions, in general terms all the cultural context which is associated with this corn belongs to the late pre-ceramic period of the Peruvian

Coast, what Lanning called Pre-ceramic VI (*vide* Lanning, 1967). Unfortunately, we are not in a position to analyze the three pottery fragments, a matter of controversy today, because they were delivered to Lanning for their study and have been lost. Judging, however, on the basis of the recollections of Bonavia who found them, because of their paste characteristic, they do not correspond to early pottery as known on the Peruvian Coast. Bonavia suggests that these fragments could well have been brought by fishermen who had a permanent transit route over the site or else they could have been deposited in the pre-hispanic period, long after the site was abandoned by its original dwellers. This statement is based on the fact that in the sandy areas surrounding the site, small surface sites have been found, which probably correspond to fishermen who came down from the Valley and stayed there for a short period of time, and they belong in time from the Middle Horizon up to the Late Horizon. The pottery found at Los Gavilanes should correspond to these occupations.

When the site was excavated in the year 1960 carbon samples were gathered in order to be utilized for dating through ^{14}C. Due, however, to an error, samples of corn were sent to laboratories for determinations. The results obtained were totally inconsistent since the date fluctations were between 200 and 800 years before the present era, with a margin of error varying between 70 and 95 years.

When this situation was investigated, we were informed that "corn cobs were particularly bad for use for ^{14}C dating, because growing corn had a most unusual rate of absorption of ^{14}C, giving a high content and indicating spuriously late dates" (Gary Vescelius, personal communication, 1970). Furthermore, there is a possibility of contamination of these samples, either through moisture in the deeper part of the site, in connection with the fossil lagoon, which is nearby, and which up to now maintains some vegetation through its humidity. Also the corn was subjected to multiple manipulations before it went through the ^{14}C process of dating.

Up to a few years ago the existence of pre-ceramic corn in Perú was not only doubted, its acceptance was even forthrightly refused by some archaeologists. Today the situation has changed and pre-ceramic corn is accepted by a number of specialists (*vide* Lanning, 1967 and Moseley, 1975).

The area of corn occurs through a coastal belt of approximately 150 kms. which extends from the famous site of Las Haldas (in the vicinity of Casma) to Aspero (near Supe) (*vide* Moseley, p. 89). Most of this corn belongs to the Late Preceramic that in terms of time means a period which extends from the year 2500 B.C. to the years 1800-1500 B.C. We think that in spite of existing doubts, the corn at Los Gavilanes is part of the same complex. New samples have been sent for new dating. At this time we have received two new datings, obtained on material excavated in the 1974 season, and which we believe form part of the same context to which plants excavated in 1960 belong.

The first dating was made by the method of thermoluminescence of burnt stones, at the Laboratoire de Cristallographie et de Physique Cristalline de la Faculté des Sciences of the University of Bordeaux, France. The result obtained is 4800±500 years BP (BOR 20). On the other hand, a sample of burnt wood from the same context was dated by the ^{14}C method at the Laboratoire du Radiocarbone du Comisariat à l'Energie Atomique et du Centre National de la Recherche Scientifique de Gif-sur-Yvette, France. The date obtained is 3750±110 years BP (GIF 3564).[1] Also, in an indirect form, the results of the work of the Ayacucho Archaeological-Botanical Project, directed by Richard MacNeish (*vide* MacNeish, Nelken-Terner and Garcia Cook, 1970) in some respects provides a logical explanation to the problem.

Though there are some questions, we believe that in the future these can be answered and that because of the dearth of botanical reports on the materials found at the pre-ceramic sites and because of the importance of the Huarmey corn, it is desirable that we publish the result of our studies, pointing out again that they are only of a preliminary nature.

Since this is a preliminary report, we have make no attempt to review the extensive literature that, in one way or another,

[1]Thanks are due to Claude Chauchat and Danièle Lavallée, for their help in securing the collaboration of this institution, and to Georgette Delibrias and Max Schvoerer of the two laboratories respectively, who made the actual datings.

has a bearing on our own findings. In a later, more complete report, we shall discuss some of the more recent contributions in South American archaeology that have come to our attention, notably an article by Zevallos *et al.*[2]

The Maize Remains

The prehistoric remains of maize from the Huarmey site comprised a total of 238 specimens including all parts of the plant from the roots to anthers in the spikelets of the tassels. Their description follows:

Cobs: Cobs, 61 specimens in all, were found at all levels in the pits. With respect to their size the cobs reveal an evolutionary sequence, those from the lower levels being generally shorter and more slender with fewer kernel rows and fewer spikelets per row. Since the majority of the cobs were not intact with respect to length and many of them were somewhat eroded, the only datum that could be obtained from all of the specimens was kernel-row number. The data for this characteristic are shown in Table 1, along with such other data as we

Table 1

Kernel-row numbers of the cobs from five stratigraphic levels. Level 1 is most superficial; level 5 is deepest.

Level	Kernel-row numbers				
	4	8	10	12	14
1			2	2	
2		4	8		1
3	1	15	5		
4		16	1		
5		2	1		

[2]Carlos Zevallos M., Walton C. Galinat, Donald W. Lathrap, Earl R. Leng, Jorge G. Marcos, Kathleen M. Klumpp. 1977. "The San Pablo corn kernel and its friends", *Science*, Vol. 196, pp. 385-389.

were able to obtain. The majority of the cobs from the three lowest levels were eight-rowed and none had more than ten rows. In contrast the majority of cobs in the two upper levels had more than eight rows and several had twelve or fourteen rows. One exceptional cob in level 3 (not included in Table 1) was distichous and had only four rows.

Accompanying an increase in kernel-row number was an increase in the diameter of the rachis and the total number of spikelets.

This conclusion is more a matter of observation than one of statistical averages since the number of intact cobs was limited. A trend can be illustrated, however, by comparing the intact cobs from levels 2, 3 and 4. The averages from these three levels are 133, 126 and 113 spikelets respectively.

The early cobs from this site appear to represent a weak form of pod corn. The glumes are quite long in relation to the diameter of the rachis and they are soft and fleshy; not like the indurated lower glumes of corn's relatives, teosinte or *Tripsacum*.

With respect to known races of maize of Peru, some of these cobs could be assigned to the Peruvian popcorn race Confite Morocho described by Grobman *et al.* (1961, Fig. 49). Like the slender cob illustrated by these authors the rachis is square in cross section and the cupules are shallow in outline. None of the cupules are as long as those of the unusually slender ear illustrated in Grobman *et al.* Cobs of this type are also quite fragile, breaking up easily into sections of one cupule each. Some of the smaller cobs have the stumps of terminal staminate spikes.

The early cobs, which comprise the majority of the collection may be related to the Peruvian race, Confite Morocho. This possibility is supported by cob morphology, number of kernel rows, which approaches an average of 8, kernel type, form and consistency of the glumes, etc. They bear also some resemblance to the Mexican race Chapalote, although they seem to be farther removed from it. Except for one cob, with four rows of spikelets and stiff lower glumes, which we would have classified as tripsacoid had we found it in the context of a Mexican ancient cob collection, all the others exhibited long, semi-tunicate, soft glumes. Tripsacoid cobs, such as those we would ascribe to the result of hybridization of corn with either teosinte or *Tripsacum*, simply do not appear in the Huarmey collection.

The Huarmey maize bears an interestingly close resemblance to the Confite Morocho maize obtained by MacNeish *et al.* (1970 p. 38), from the Ayacucho, Peru caves that he explored, and which was dated as circa 4300 to 2800 B.C. In all respects it also coincides with segregants described by Grobman *et al.* (1962) as Confite Morocho, from the Los Cerrillos site in Ica.

There are two exceptional cobs, one of which is illustrated in Plate 46A. This cob occurred in level 3. It is thick and tapering and has 14 kernel rows. It is quite similar to the predominating corn from the Huaca Prieta site described later.

Plates 45 and 46 illustrate the variation in the cobs from the lower to the upper levels of this site. The range in size is by no means as great as it is in the prehistoric cobs from the several caves in Mexico and the southwestern United States. This may indicate that a shorter span of time is involved or it may suggest that in the absence of contamination by teosinte or *Tripsacum* the rate of evolution is less rapid.

KERNELS: Only ten kernels were found. Several of these were immature and one was defective. The pericarp color in all kernels in which it could be determined was brown. The kernel shape, where it could be determined, was slightly pointed, (Fig. 1). Some ears of the Peruvian race Confite Morocho have kernels of this shape (Grobman *et al.*, 1961, Fig. 48).

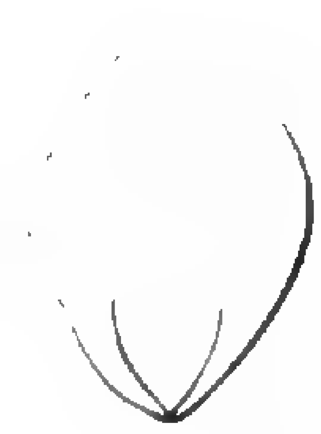

Fig. 1. Enlarged diagram (2X) showing the shape of a kernel found in level 2. The shape is typical of the kernels of some ears of the Peruvian popcorn race Confite Morocho. All of the kernels found in this site have a brown pericarp color.

ROOTS AND STALKS: Five pieces of stalks with attached roots show mainly that the root system of prehistoric maize is virtually identical with that of modern maize. Diameters of the first internode above the root in the five specimens were 10.6, 4.3, 9.1, 7.1, and 9.4 mm. These dimensions are much smaller than those of the modern race Confite Morocho which has an average stalk diameter at the first internode of 16.0 mm. One of the five specimens had a split area on one side showing that it either had a tiller attached to it or was itself a tiller. This is the first archaeological evidence of tillering that we have encountered. (Plate 47)

One of the pieces with roots attached had four internodes which, measured from the base upward, had lengths of 51, 93, 143, and 141 mm. respectively. There was an undeveloped ear attached to the third node above the ground and the remains of a husk system attached to the fourth node. An internode pattern plotted from the data (Fig. 2) is similar to that of the modern Confite Morocho (Grobman *et al.*, 1961).

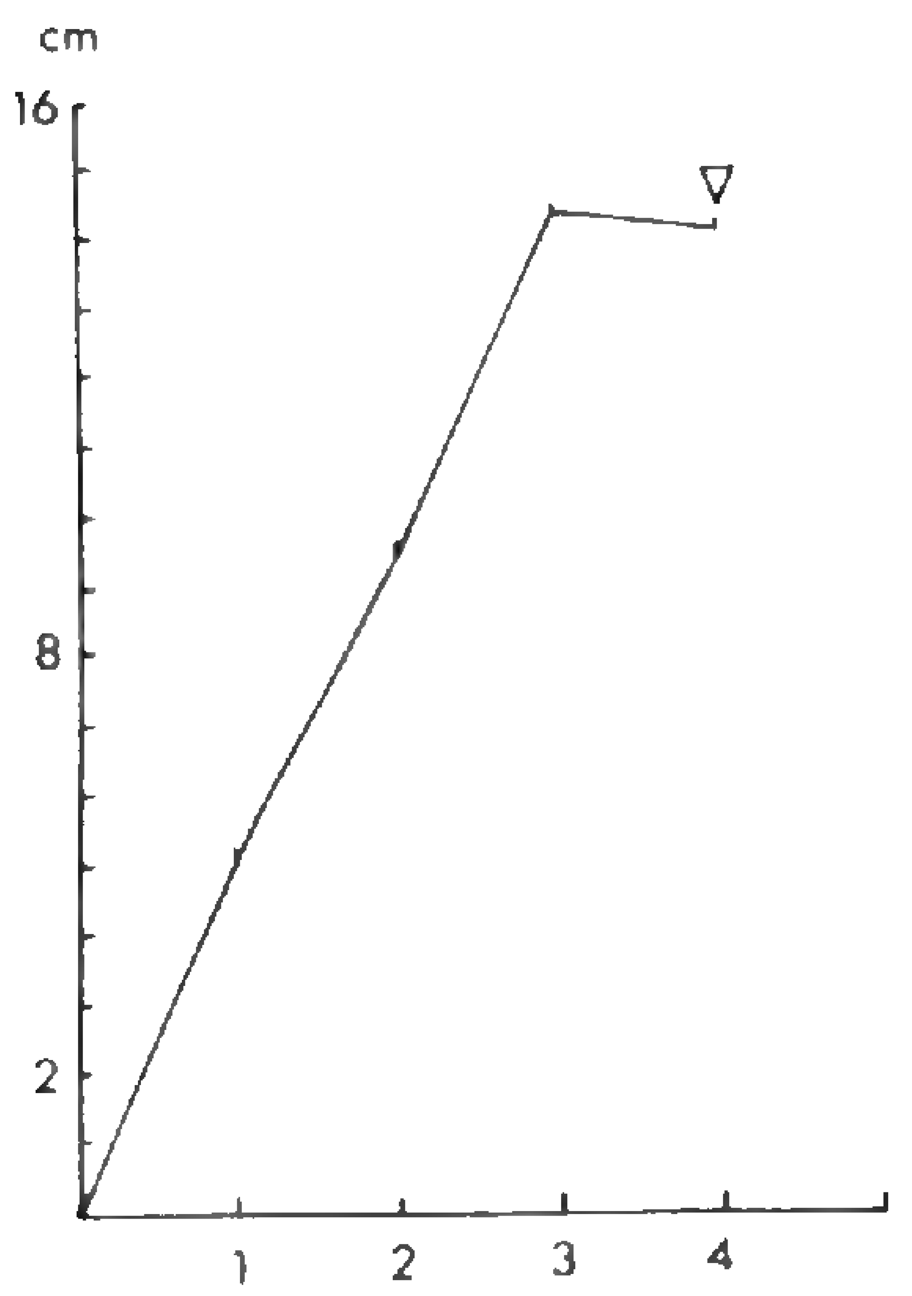

Fig. 2. Internode pattern up to the ear-bearing node of a stalk found in level 2. The pattern is almost identical with that of the Peruvian race Confite Morocho. cf. Grobman *et al.*, 1961, Fig. 51.

Ten pieces of stalk in addition to the five with attached roots were found. The diameter of these ranged from 5.6 to 12.8 mm., the average being 8.0 mm.

LEAF SHEATHS: Sixty-four specimens of leaf sheaths were identified. All of these were completely glabrous even lacking the weak pubescence usually found in modern varieties around the upper margins. In this respect the sheaths resemble those of the prehistoric corn from the caves in Tehuacán Valley. Some of the sheaths appear to have fitted rather loosely around the stalks; this is a characteristic which we have noted in some modern popcorn varieties and which have caused us to wonder whether it represents an adaptation to growth in regions of limited rainfall. We have often noticed that after a light shower in which the precipitation is not enough to wet the surface of the soil there is an area of moist soil surrounding the base of the stalks. What has happened is that rain falling on the leaves is directed toward the stalk moving from the upper leaves to the lower and finally to the soil at the base of the stalk where some of it probably reaches the roots. In plants with loose leaf sheaths, water funneled from the leaves is trapped in the spaces between the sheath and the stalk sometimes in substantial amounts so that puncturing the base of the sheaths causes a spurt of water. Can this trapped water be absorbed by the stalk? Plant physiologists to whom we have put this question have usually answered "probably" or words to that effect. However, a preliminary experiment that the senior author conducted with Galinat filling the sheath with water containing a vital dye showed no penetration of the dye into the tissues of the stalk. More refined experiments on this problem should be made. If water is not absorbed by the stalk it may be that at least it serves to reduce transpiration thus making the plant more efficient in its use of available moisture.

LEAVES: Leaves and fragments of leaves comprised fifty-one specimens. One of those from level 4 is illustrated in Plate 49. The leaf had a width of 46 mm. and a venation index of 3.9

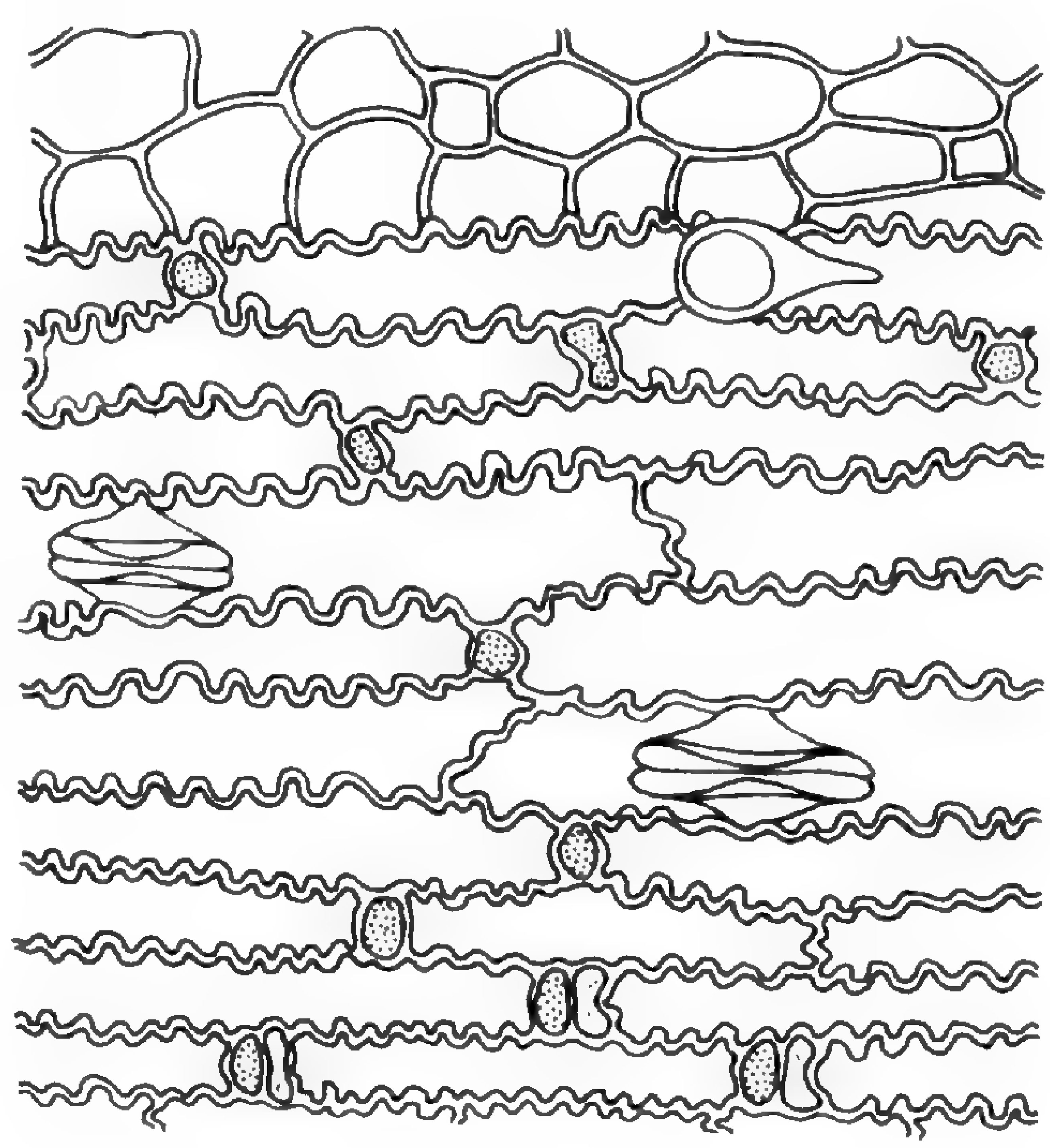

Fig. 3. Diagram showing the anatomical features of the lower epidermis of a leaf found in level 3. The leaves of prehistoric corn have all of the characteristics of those of modern corn: bulliform cells, long cells, silica cells, cork cells, and stomata.

which is almost identical with the venation index 3.8 of modern Confite Morocho.

Cámara-Hernández made a study of the lower epidermis of a leaf from level 3 and found it to have all of the characteristics described by others: bulliform cells, long cells, silica cells, cork cells, and stomata. His drawing showing these typical maize features is reproduced in Fig. 3.

HUSKS: The husks of which there were 18 specimens are similar to those of modern maize except that they are shorter on the average and have more conspicuous parallel venation. There is a tendency for prominent veins to alternate with weaker ones. This is shown especially well in the photograph reproduced in Plate 48A. The anastomosing venation between two parallel veins is not completely lacking but it is less conspicuous than that usually found in the husks of modern varieties. The husks from any one level are much longer than the longest cobs from the same level (Fig. 4) suggesting at first glance that the ears were well protected against damage from ear worms and other insects by husks extending far beyond the tip of the ear. An almost intact husk system from level 3, however, indicates that the ears may have been exposed at maturity. The shank of this particular specimen had four inter-

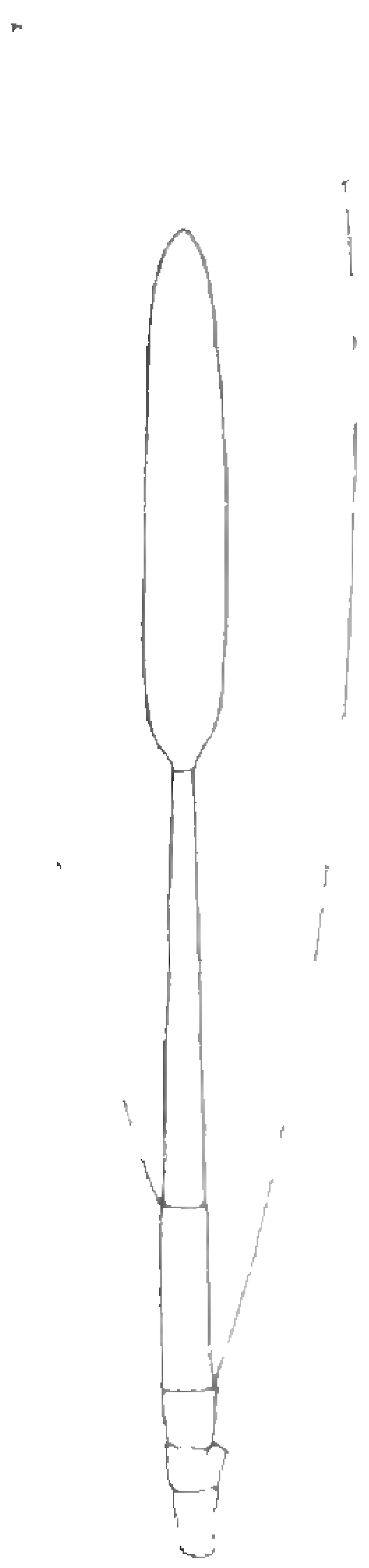

Fig. 4. Diagram of a husk system found in level 3. The uppermost internode of this specimen was missing but a shred of its rind measuring 80 mm. remained showing that the peduncle of the ear must have been at least this long. The diagram of the cob is based on the longest cob found in this same level. The long peduncle suggests that the ear borne in such a husk system might have been exposed at maturity and capable of dispersing its seeds although enclosed and protected while young. The second internode from the base shows the scar of a branch which once must have been attached at this point and which bore a second ear. The general structure of husk systems such as these and the fact that the two outer husks are somewhat differentiated from the inner, raises the question whether in primitive maize a husk system bearing two ears might have been the homolog of the staminate spikelets bearing two florets. One-half actual size.

nodes measuring from the base upward: 11.5, 7.6, 9.3, 35.7 mm. respectively. The fifth internode was missing but a shred of its rind still remained and measured 79.5 mm. showing that the ear must have been borne on a long peduncle within the husk. This husk system with its fifth internode restored and terminated by the longest cob from the same level is shown diagramatically in Fig. 4. One of its noteworthy features is the scar of a branch on the second internode. Apparently husk systems of this type enclosed not a single ear but several, in this case probably two. A similar husk system from level 1 had the shred of a peduncle measuring 48 mm. in length. The original peduncle may have been considerably longer.

There is a tendency in these prehistoric husk systems for the two outer husks to be somewhat differentiated from the remaining inner ones in the thickness of the tissues. This is also true in modern varieties but the differentiation is by no means sharp, the transition from the outermost to the innermost being a gradual one. In the prehistoric husk systems the two outer husks are definitely thicker than the remaining inner ones which are almost tissue-paper like in their texture.

The husk system showing the differences between the outer and inner husks is illustrated in Plate 48B.

TASSELS, SPIKELETS, ANTHERS, AND POLLEN: Two almost complete tassels and 12 fragments were found. A diagram of one complete tassel is shown in Fig. 5. The tassels are similar to those of the Peruvian popcorn Confite Morocho (Grobman *et al.*, 1961, Fig. 50) in the number of tassel branches and their arrangement. (Plate 50).

The staminate spikelets of the prehistoric specimens are like those of modern maize, arranged in pairs, one member of each pair sessile the other pedicellate. Their glumes which are more rounded and less strongly keeled than those of many modern varieties, are beset with short hairs as are also the stems of the tassel branches. Spikelets from three tassel fragments in Level 4 had average glume lengths of 7.8 mm., from two tassels in Level 2, average lengths of 8.8 mm., and from 9 tassels in Level 1, average lengths of 7.5 mm. Although there is no evidence of an evolutionary series in the spikelets from these three levels,

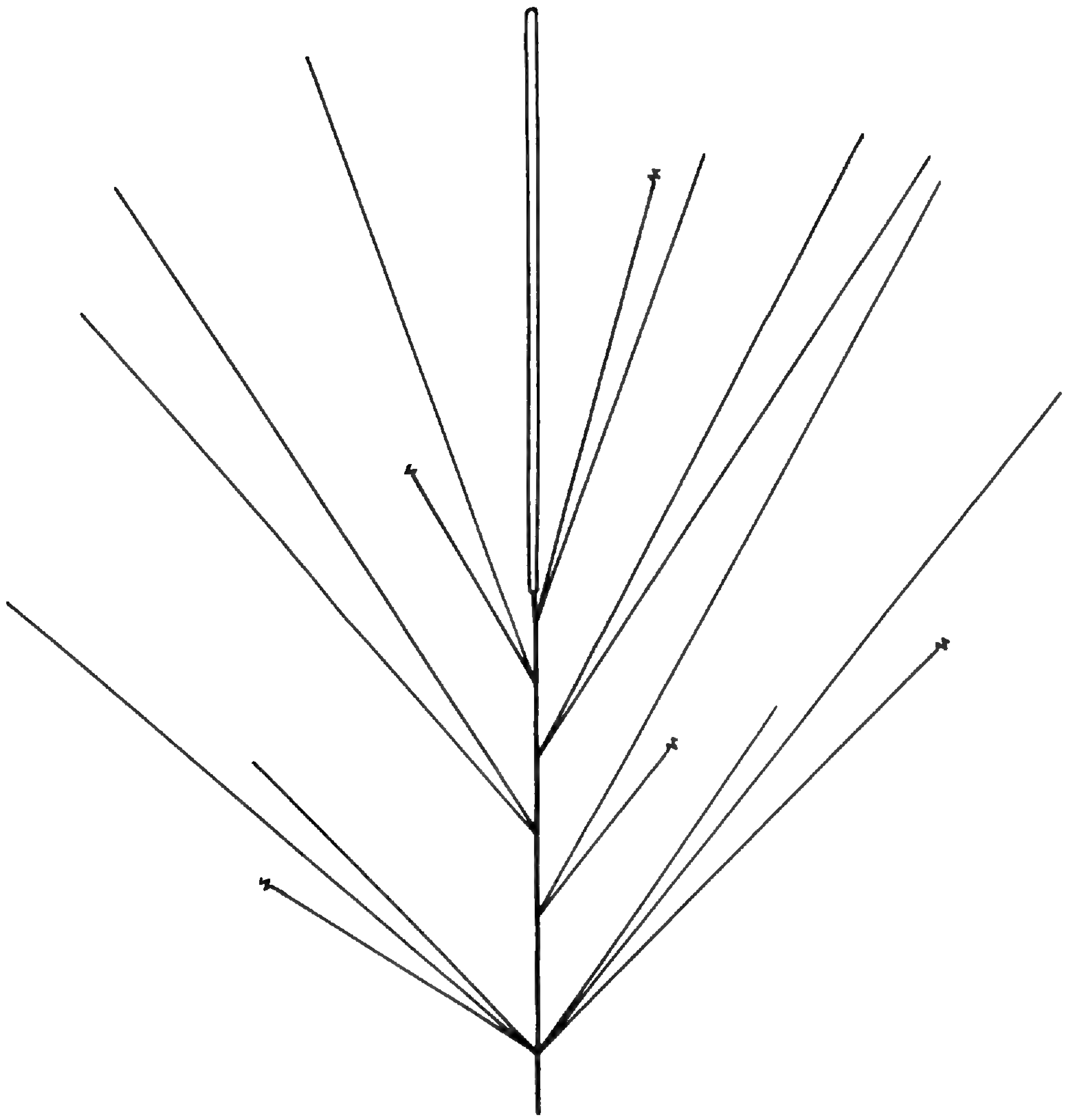

Fig. 5. Diagram of a tassel in level 2. Except for the shorter length of its central spike and branches, this tassel is almost identical with that of the Peruvian race Confite Morocho. cf. Grobman *et al.*, 1961, Fig. 50 One-fourth actual size.

all are shorter than those of most varieties of modern corn. The spikelets from the three tassels in Level 4 are almost identical in their dimensions to the earliest spikelets found in the Tehuacán site in Mexico.

Anthers containing pollen were found in three different tassels. Mounted in lactic acid the pollen grains swelled to the spherical, slightly oval shape characteristic of the pollen of modern maize. Pollen from two of the specimens included many empty grains, in one case 74 empty, 11 normal; in another 29 empty; 27 normal. The significance of these empty grains is not apparent. The normal grains from these anthers measured

80.6 and 78.1 microns in diameter. Those from a third specimen had an average diameter of 86.6 microns. These dimensions are similar to those of the pollen grains of modern races such as Nal-Tel and Palomero Toluqueño of Mexico, which have pollen diameters of 81.2 and 77.9 microns respectively (Galinat, 1961).

PROPHYLLS: Several of the husks systems, four in all, had their prophylls still attached. These are identical in their characteristics to those of modern maize in having two distinct prominent keels. These are illustrated in Plate 48B.

DISCUSSION

The specimens from the Los Gavilanes site in Huarmey, including all parts of the plant, show that the prehistoric maize from this site is virtually identical to modern maize in all its characteristics, except size. The plant-to-plant variability is less than that found in contemporary races collected at any single location. With a few exceptions the specimens can be assigned to the Peruvian popcorn race Confite Morocho, as it is found today growing in the low to middle altitudes in the Central Andes of Peru, and as it was grown in the same locations 6200 and 4700 years ago, as evidenced by MacNeish's finds in Ayacucho, Peru caves (*vide* MacNeish *et al.* 1970).

There seems to be little doubt, if any, that the Los Gavilanes maize is representative of corn grown on the Central North Coast of Peru, at a late pre-ceramic period, and that it was introduced to the Coast from the highlands of Peru at least about 5,000 years ago.

Although there is some resemblance between the early Los Gavilanes maize and early popcorn of Mexico of the Chapalote race, it is premature to speculate on the possible significance of the similarities. It may be that early maize had similar overall morphological characteristics, and this is to be expected, as the forces of mutation, selection, and hybridization would not have had the time after domestication at various sites, to effect the profound qualitative and quantitative changes in morphology that are apparent in maize today. Yet, one thing is common in the early Mexican and Peruvian corn, and that is the almost total absence of evidence of introgression with teosinte or *Tripsacum*. Tripsacoid corn is not alien to Peruvian archaeological corn, but it appears at much later periods, which would indicate either influx into the Peruvian area of corn which hybridized with *Tripsacum* in either the lowlands east of the Andes, or in the Coast of the Chocó area of Colombia, or of Central America or Mexico, or which hybridized with teosinte in Mexico or Central America. At any rate, this introduction would have occurred much later in history.

Summary

1. A collection of maize from a site named Los Gavilanes, located in the North Central Coast of Peru, in the Huarmey valley is analyzed. Judging from evidence available up to this time, the site corresponds to the Late Pre-ceramic of the cultural chronology of the Andean pre-hispanic Epoch. If it is true that certain problems concerning it still exist, there is concrete evidence that confirms the existence of this cultigen before the introduction of pottery on the Peruvian Coast.
2. The collection comprises 238 specimens including all parts of the plant, from the roots to the anthers and pollen grains.
3. The cobs reveal an evolutionary sequence from the lower to the higher levels. In their characteristics they resemble the Peruvian popcorn race Confite Morocho.
4. The stalks of the prehistoric corn are more slender than those of modern corn. The leaf sheaths are completely glabrous. The leaves have all the anatomical characteristics of those of modern corn. The husks are much longer than those of the longest cobs. This is regarded as evidence that a single husk system may have enclosed more than one ear.
5. The spikelets of the tassel are similar to those of modern corn being in pairs, one member sessile, the other pedicelled. Pollen grains are similar in size to those of modern

races of popcorn. The pattern of branching in the tassels is similar to that of the Peruvian popcorn race Confite Morocho.

6. The prehistoric maize from Huarmey is significant in differing in its characteristics from two other Peruvian coast sites, Huaca Prieta and Ica.

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PLATE 45

Plate 45. A, Upper right. Fragment of a cob from level 5. The long soft glumes indicate that this was a form of pod corn; upper center, two small cobs from level 4. Lower, typical cobs from level 4, actual size. B. enlargement x2.74, one of the small cobs from level 4 shown in A. C. Similar enlargement of the other small cob from level 4 shown in A.

PLATE 46

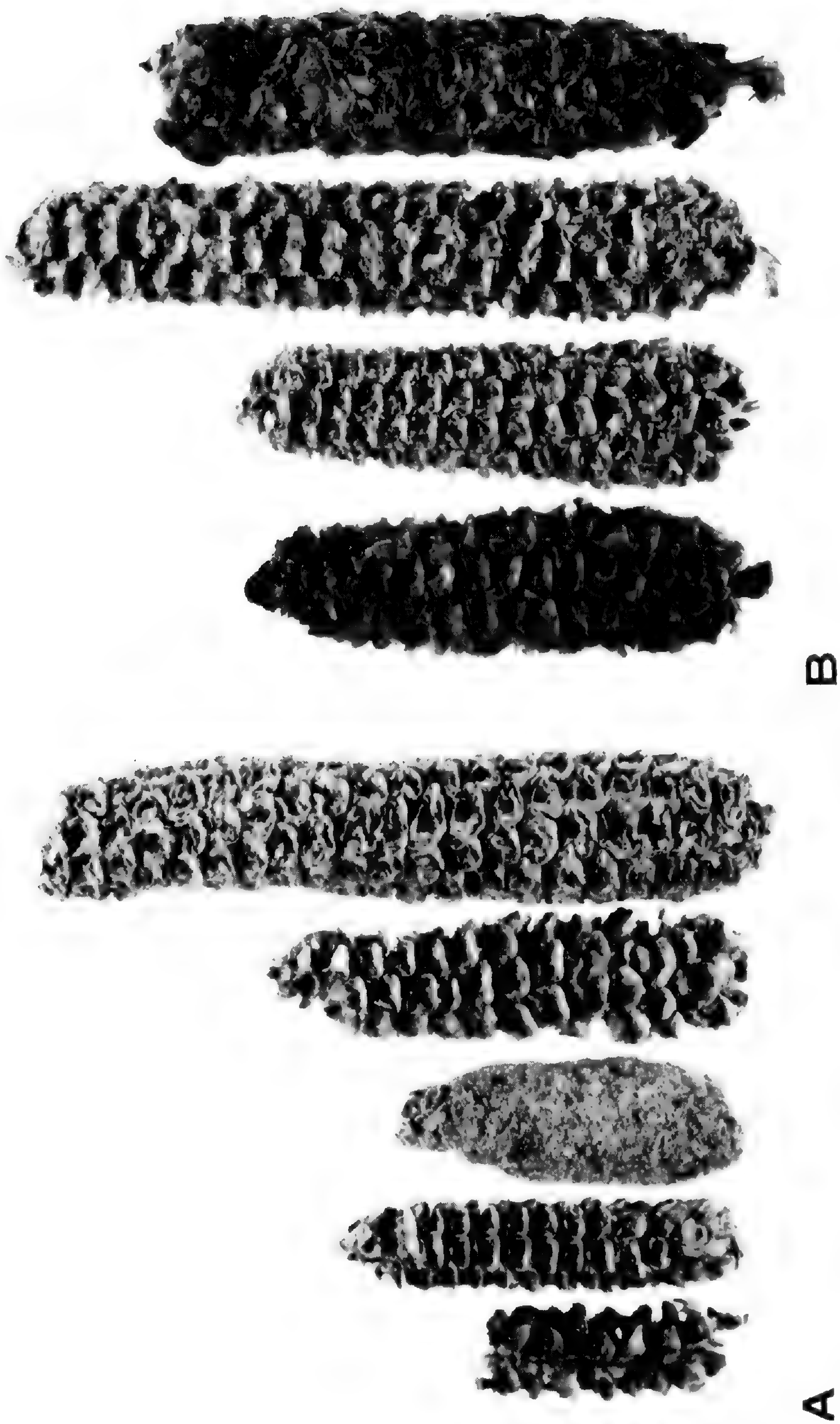

Plate 46. A. Representative cobs from level 3. The center cob is not typical of this collection but resembles some of the cobs from the Huaca Prieta site. B. Representative cobs from level 2. Actual size.

PLATE 47

B

A

Plate 47. A. Stalks and roots from level 3. B. A root system from level 2. Actual size.

PLATE 48

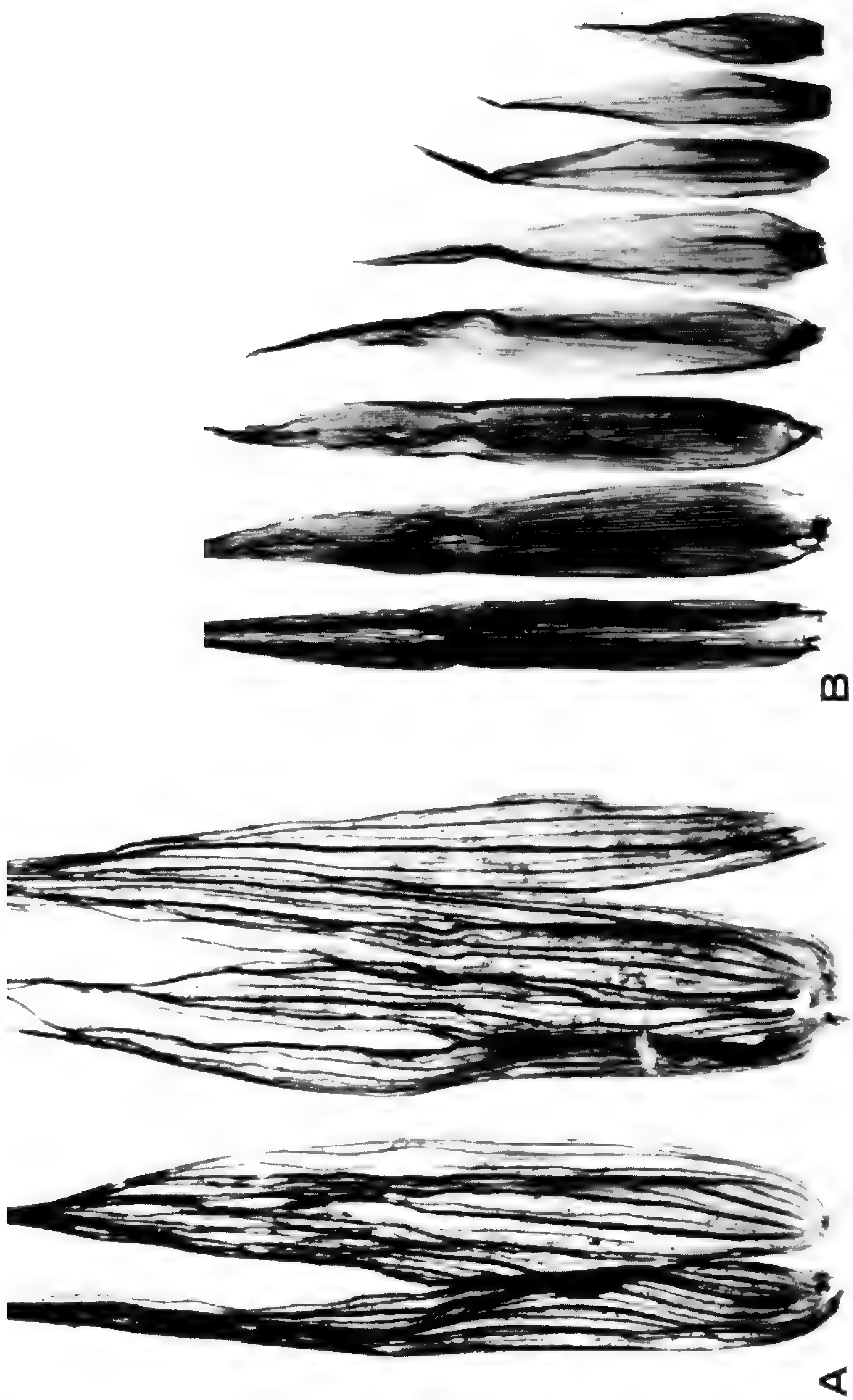

Plate 48. A. The two outer husks of a husk system from level 4 illuminated from below to show the prominent parallel venation associated with a tendency for strong veins to alternate with weaker ones. Actual size. B. A prophyll and successive husks from an undeveloped second ear on a stalk from level 2. Note the prominent keels of the prophyll and the fact that the two outer husks are thicker than the inner ones suggesting a degree of differentiation. Actual size.

PLATE 49

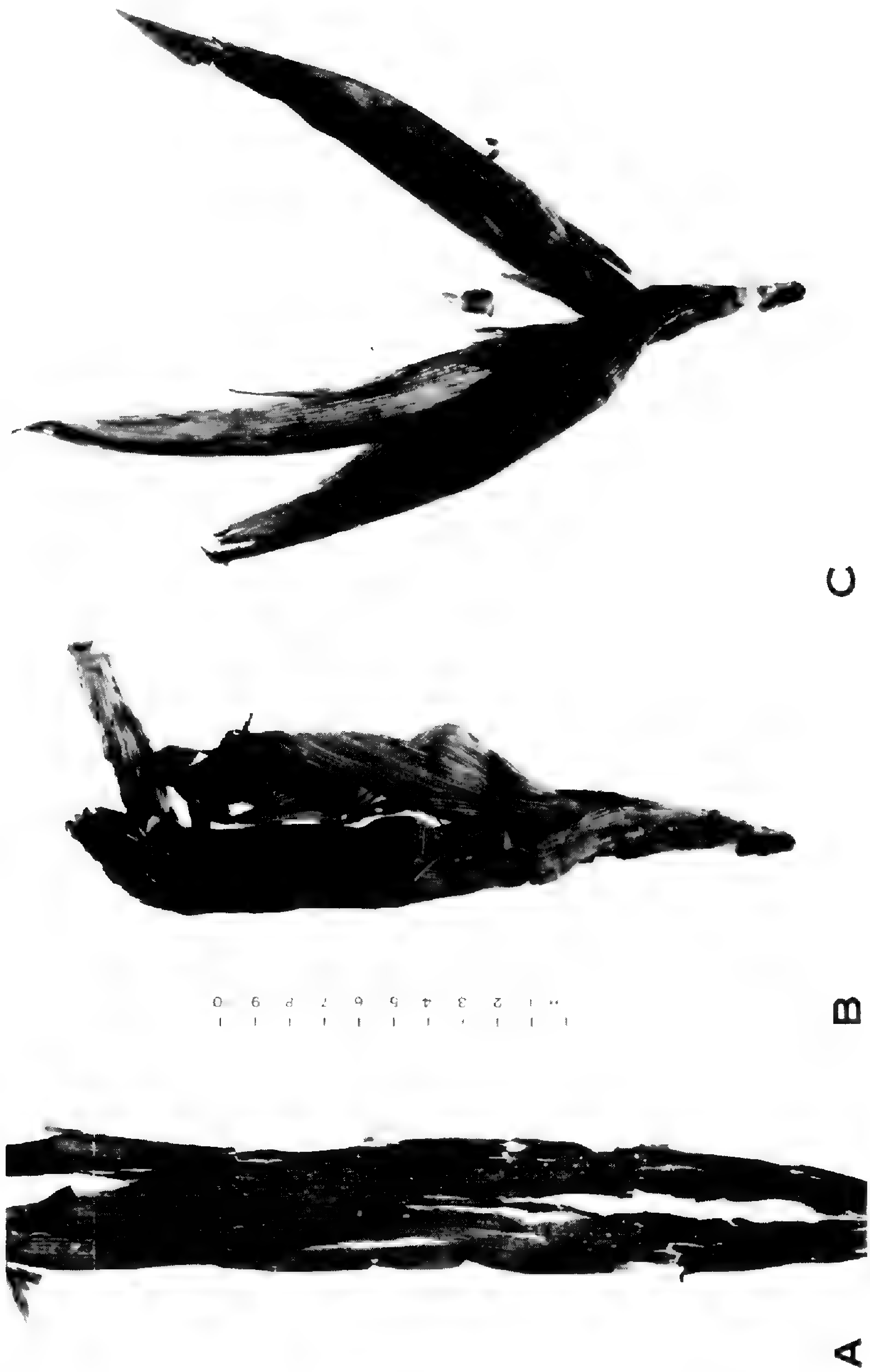

Plate 49. A. Part of a leaf blade from level 4. A drawing illustrating the anatomy of the lower epidermis is reproduced in Fig. 3 and shows that the characteristics of the epidermis of prehistoric corn are similar to those of modern corn. Actual size. B. A husk system from level 2, one-half actual size. C. A husk system from level 2 showing the shred of a broken peduncle indicating that the ear enclosed by this husk system was borne on a relatively long peduncle. One-half actual size. Another husk system of this kind is illustrated by the diagram in Fig. 4.

PLATE 50

Plate 50. A. Part of a tassel from level 4. Actual size. B. Fragment of a tassel from level 5 showing the relatively small spikelets. Actual size. C. A complete tassel from level 2. A central spike is present but is much less prominent than in the tassels of modern corn. One-half actual size.

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A NEW INFRAGENERIC CLASSIFICATION OF *HEVEA*

RICHARD EVANS SCHULTES

I. HISTORICAL CONSIDERATIONS ON INFRAGENERIC CLASSIFICATIONS

The genus *Hevea*, now the source of 98% of the world's natural rubber, was first known to botany in 1775, when Aublet accurately and thoroughly described *Hevea guianensis* from French Guiana. For half a century, this was the only species known to science.

In 1824, Willdenow recognized a rubber-yielding tree collected near the mouth of the Amazon as a distinct species and, without actually describing it, he named it *Siphonia brasiliensis*. A year later, Humboldt, Bonpland and Kunth described as *Siphonia brasiliensis* a plant from the Orinoco, where what we know as *Hevea brasiliensis* does not occur. Since Willdenow's species is what we now recognize as true *H. brasiliensis* and since, in lieu of a description, he published diagnostic drawings of the critical parts of the plant, his "description" of *H. brasiliensis* is accepted on the basis of priority.

The genus *Siphonia* was later shown to be congeneric with *Hevea*. *Siphonia brasiliensis* was transferred by Mueller Argoviensis in 1865 to *H. brasiliensis*.

In 1854, five new species were described (under *Siphonia*) by Bentham, and the following year another was proposed by Spruce — all on the basis of the extensive collections sent from Brazil by the English plant explorer, Richard Spruce.

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By this time, Bentham believed that some kind of infrageneric classification could be significant in understanding the genus. He put what he then called *Siphonia elastica*, *S. brasiliensis*, *S. discolor*, *S. Spruceana* and *S. pauciflora* into one Section, characterized by a sessile, divaricate-trilobed stigma; into another section, he placed *S. lutea* and *S. rigidifolia*, with a short, attenuate style. It is now recognized that this classification groups together species that are not closely related. Bentham pointed out, however, that, prior to Spruce's field studies, little was known about floral structure in the genus: he wrote that, although the characters "have been verified in each instance in several, and often, in many flowers . . . it remains to be seen how far they may prove constant when we have specimens from a greater variety of sources".

A second attempt to an infrageneric classification was made in 1858 by Baillon in his *Etude générale du groupe des Euphorbiacées*. Using the epithet *Siphonia*, Baillon divided the species then known into two Sections: *Hevea* and *Bisiphonia*. Pointing out that there were, among the concepts then recognized, species which were intermediate, he placed what are now called *Hevea guianensis* and its variety *lutea* in Section *Hevea*; what are now known as *H. brasiliensis*, *H. pauciflora*, *H. Spruceana*, *H. Benthamiana* and *H. rigidifolia* he included in *Bisiphonia*. The former Section had an isostemonous androecium and no disk, or, at best, an inconspicuous one; the latter, was characterized by having a diplostemonous androecium and a more or less well developed disk. Later, in 1864, Baillon merely enumerated seven species (unexplainably omitting *H. guianensis*) without making mention of an infrageneric classification.

Baillon's infrageneric classification of *Hevea* into two groups, sections or series has come down to the present time, even though in recent years its naturalness has been questioned and its acceptance has been denied by most taxonomists who have worked on the genus during the past thirty years.

In 1865, Mueller offered his classification of the Euphorbiaceae, placing the genus *Hevea* in Subtribe *Heveeae* — the only genus in this subtribe. He divided *Hevea* into two Sections: *Euhevea* (equivalent to Baillon's Section *Hevea*), made up of one species, *H. guianensis*; and Section *Bisiphonia* (the same as Baillon's Section *Bisiphonia*) comprising what are now known as *H. Benthamiana*, *H. brasiliensis*, *H. guianensis* var. *lutea*, *H. pauciflora*, *H. rigidifolia* and *H. Spruceana*. In 1866, he revised his family classification of the Euphorbiaceae but maintained his earlier infrageneric classification of *Hevea* with the same number of species. His only change in treatment consisted in a grouping together of the species of Section *Bisiphonia*, according to the shape of the staminate buds: *H. Spruceana* (with subovoid, obtuse buds with a calyx laciniate for only slightly more than half its length); *H. pauciflora* (with ovoid, obtuse buds, with a calyx divided for 2/3 and 3/4 its length); and *H. rigidifolia*, *H. Benthamiana*, *H. brasiliensis* and *H. guianensis* var. *lutea* (with oblong-conic-ovoid and acute buds, apically slightly twisted). Again, in 1874, Mueller divided the genus, as he had done previously, into *Euhevea* (*H. guianensis*) and *Bisiphonia* (all other species). At this time, he arranged the species in *Bisiphonia* into only two groups: those with staminate buds obtuse (*H. Spruceana*, *H. pauciflora*) and those with buds acuminate (*H. rigidifolia*, *H. nitida*, *H. Benthamiana*, *H. brasiliensis* and *H. guianensis* var. *lutea*).

No further attention was apparently given to infrageneric classification of *Hevea* until 1906, when Huber initiated his detailed studies of the genus. Huber, the first botanist acquainted with living trees in their native habitat to consider *Hevea* generically from a taxonomic viewpoint, followed the earlier division of *Hevea* into *Euhevea* and *Bisiphonia*. Under *Bisiphonia*, however, he made three Series, giving them technical Latin designations. Into Series *Luteae* he put what he recognized as *H. lutea*, *H. apiculata*, *H. cuneata*, *H. Benthamiana*, *H. Duckei*, *H. paludosa* and *H. rigidifolia*: with anthers in two incomplete whorls and staminate buds acuminate; these specific concepts he separated into three groups on characters in the disk of the staminate flower. Series *Intermediae* comprised his *H. minor*, *H. microphylla*, *H. Randiana* and *H. brasiliensis*: with anthers in two complete whorls and acuminate buds; these species he divided into two groups, based on characters in the style. His Series *Obtusiflorae* included what he recognized as *H. Spruceana*, *H. discolor*, *H.*

similis, *H. pauciflora*, *H. confusa*, *H. nitida*, *H. viridis*, *H. Kunthiana*; he arranged these series into two groups based on characters of the disk of the pistillate flower, with the last three (incompletely known species) in a grouping which he called *Incertae sedis*.

Huber maintained that Section *Euhevea* is "very natural and well characterized". While quite distinct from *Euhevea*, *Bisiphonia* is, he confessed, "not very homogeneous and does not have a rational subdivision" — for which reason he set up his three Series.

As late as 1913, Huber still continued to maintain these two Sections and the three Series in *Bisiphonia*, believing that, in general, this treatment represented natural trends. He did state of Series *Luteae*, nonetheless, that "species in the Linnean sense seem almost non-existent in this group. . . . With the present state of our understanding, all appear to be in movement and fluctuation, and we must be satisfied if we arrive at a rational grouping of small, provisional species."

In 1910, Pax used the division of *Hevea* into Sections *Euhevea* and *Bisiphonia*, separating the two solely on the basis of the number and placement of the anthers. Of the 17 species that he accepted, he grouped three in *Euhevea* (*H. guianensis*, *H. nigra*, *H. collina*) and 14 in *Bisiphonia* (*H. Benthamiana*, *H. Duckei*, *H. nitida*, *H. paludosa*, *H. brasiliensis*, *H. lutea*, *H. rigidifolia*, *H. spruceana*, *H. similis*, *H. discolor*, *H. minor*, *H. microphylla*, *H. pauciflora*, *H. membranacea*). He pointed out that the flowers of *Hevea* exhibit few sharp characteristics of use in separating species and that the fruits and seeds, which might provide good differentiating characters, were not known for some species. He further pointed out that the differentiating character employed for Section *Bisiphonia* were not sharp, noting that he could find intermediates in the anthers of *H. guianensis* and *H. lutea*.

It is now clear that Pax's infrageneric classification, as well as those attempts that preceded his, were far from natural. Pax, a specialist in the Euphorbiaceae, was at a great disadvantage in not having seen *Hevea* growing in the natural state.

In 1929, Ducke wrote that "the natural system of the *Hevea* is still to be made; the species are very difficult to group because of their affinities that are too close". It was not, however, until 1923 that he considered definitely the infrageneric divisions of *Hevea*: "While still awaiting fuller material of certain species, I have already been able to affirm that the sections *Euhevea* and *Bisiphonia* . . . are not so well defined as one has thought: I have found, amongst the many specimens of *H. guianensis*, some that have the anther-whorl slightly irregular due to the insertion of one of the anthers a little too low. In this same species, in trees of one single locality, the staminate buds vary from wholly obtuse (almost globose) to rather distinctly acuminate". This point of view he reiterated in 1935. Ducke's silence on this matter in later publications may be taken as an indication of abandonment of the whole system of grouping the species into subgeneric affinities. I know this to be true, for when we discussed this point in depth, he stated that he had no further use for the proposed infrageneric classifications that had been published. And our refusal to recognize these classifications was crystallized when, in 1945, we jointly reduced *Hevea lutea* (up to that time a typical member of *Bisiphonia*) to varietal status under *H. guianensis* (the only species of *Euhevea*).

Ducke spent more than half a century studying wild *Hevea* in the Amazon, and he was, undoubtedly, the taxonomist most thoroughly acquainted with *Hevea* over most of its natural range. Ducke's taxonomic outlook in *Hevea* underwent three distinct periods. In his earlier years, still under the influence of his teacher, Huber, Ducke often described minor variants as species (*H. gracilis*, *H. Huberiana*, *H. humilior*, *H. marginata*). In what we may consider his intermediate stage, he reduced some of these "species" to varieties and forms and described a large number of additional infraspecific variants. Towards the end of his life, he recognized a limited number of species and fewer varieties and forms, reducing many of the concepts that he himself had previously described.

In his papers on *Hevea*, Baldwin failed to discuss infrageneric classification. That he did not consider the available treatments as natural, however, may be inferred from several of his statements. An example is the following opinion: ". . . . Ducke found a tree which he considered to be intermediate between *H. guianensis* and *H. lutea*, and for this and comparable reasons he and Schultes have recently made *lutea* a variety of *H. guianensis*. . . . One might with almost as much reason render the genus unispecific". In another context, he wrote that, while he preferred to recognize "nine — or fewer — species. . . .", "in nature and in various localities entities so intergrade that if one wishes . . . he could . . . reduce the genus to one species and consider it in terms of trinomials with many forms appended".

Nor did Seibert discuss in great detail Mueller's two Sections *Euhevea* and *Bisiphonia*, except to state that he had "arrived at the conclusion that exact number of anthers is of little taxonomic significance within the limits of certain tendencies", pointing out that the number of anthers "may vary within the species and between flowers on the same tree."

Ever since 1945, when, jointly with Ducke, I reduced *Hevea lutea* to varietal rank under *H. guianensis*, I have considered the classical infragenetic grouping of species to be both unworkable and unnatural.

II. HISTORICAL NOTES ON *HEVEA MICROPHYLLA*

A natural classification of species into infrageneric groupings should rest, whenever possible, preferably on several different characters — for example: both floral and fruit characters — in which little or no integradation is discernable. Extensive field work on wild *Hevea* in the Amazon and examination of thousands of specimens in the major herbaria have convinced me that such differences exist and that they may be used as the basis of an infrageneric classification which, in my opinion, is natural, showing two rather widely divergent trends in evolutionary development of the genus.

In 1905, Ule, who had spent a long period studying *Hevea* in numerous areas of the Amazon, described a most interesting species: *Hevea microphylla*, which he had collected in fruit in 1902 on the Ilha Xibarú, slightly downstream from the mouth of the Rio Branco on the Rio Negro in Brazil. Later exploration has shown that this species is endemic to the Rio Negro, from the middle to the upper course of the river.

In 1910, Pax treated the species as comprising two varieties: var. *typica* and var. *major*, on the basis of differences in size of the leaflets.

Unfortunately, *Hevea microphylla*, which only with the greatest difficulty and misunderstanding could be confounded with any other species, was, until recently, confused with Hemsley's *H. minor*, now considered to be a synonym of *H. pauciflora* var. *coriacea*. In 1906, Huber suggested that *Hevea microphylla* might be synonymous with *H. minor*, pointing out several characters in which the two concepts, as described, seemed to agree. He admitted, nonetheless, that there appeared to be differences in other characters, so he chose "to consider *H. microphylla* a distinct species for the present". Identifying erroneously a flowering collection of *H. microphylla* made by Ducke (*Ducke 7027*) in the lower-middle Rio Negro as *H. minor*, Huber published an extended description of *H. minor*. In describing the flowers of the Ducke specimens, Huber indicated still that the two species appeared to be close allies, although he believed that flowers were still unknown for *H. microphylla*. In 1913, he yet maintained *H. minor* and *H. microphylla* as distinct, including both in his Series *Intermediae* — as he had done previously — but intimating that further studies might make it necessary to remove *H. microphylla* and *H. minor* from Series *Intermedia* and, together with *H. rigidifolia*, to form a new Series for them.

Ducke apparently accepted Huber's identification of his flowering collection (*Ducke 7027*) as *Hevea minor*. He had collected topotypical material of *H. microphylla* (*Ducke HJBR23750*) which agreed in all characters with his earlier collection (*Ducke 7027*). Consequently, he reduced *H. microphylla* to synonymy under *H. minor* in 1935, maintaining this position in 1946.

In 1947, Baldwin indicated apparent acceptance of Ducke's treatment of *Hevea microphylla*.

In the same year, I studied the type material of *Hevea minor* collected on the upper Rio Negro near the confluence with the Casiquiare and herbarium specimens of the Ule and the Ducke collections of *H. microphylla*. It became apparent immediately that the two concepts were completely distinct and not in any way closely allied. I published the results of my studies, indicating that *H. microphylla* is, indeed, the most unique species in the genus and that, in addition to morphological characters easily to separate it from all other species, there are, likewise, strong ecological differences setting *H. microphylla* apart from *H. minor*: periodically and deeply flooded forested river banks in the former; scrub-forest in sandy, almost permanently flooded caatingas in the latter. Seibert accepted my treatment of *H. microphylla* as distinct; and, in 1949, Ducke (in litt.) likewise followed my interpretation, although, in publishing his acceptance of it in 1950, he stated that it was "lamentable, because it would have been better, for true scientific purpose, if that change could have been avoided."

For several years following my article in 1947, I was able to carry out intensive plant exploration in the Rio Negro basin of Brazil, Colombia and Venezuela, studying abundant stands of *Hevea microphylla*. These studies substantiated the uniqueness of this species and led, in 1952, to a paper on its range and variability and an extended description of the concept. At that time, I wrote: There are so many differentiating characters of the first magnitude to be found exclusively in *H. microphylla* that we are forced to regard the concept as standing entirely alone with no close allies in the genus". In 1967, whilst on the Alpha-Helix Amazon Expedition, I was fortunate again to meet with extensive stands of *H. microphylla*, not too distant from the type locality. These studies intensified my belief that we were concerned here with a species that had gone off on an evolutionary tangent of its own and that it, therefore, merited some special recognition in any treatment of infrageneric classifications of the genus.

III. THE UNIQUENESS OF *HEVEA MICROPHYLLA*

Hevea microphylla stands quite alone in the genus. It is unique in several basic characters — characters in both the flower and fruit and which are so distinct that there appear to be no intermediates.

The pistillate flowers of *Hevea microphylla* differ markedly from those of all other species in having a greatly swollen torus which is conspicuous not in the flowers but also at the base of the fruit. A torus is present, of course, in the pistillate flowers of all species but, except for *Hevea pauciflora*, it is so inconspicuous as to be for all practical purposes of taxonomic use essentially non-existent. In *H. pauciflora*, it is sufficiently pronounced as to be easily visible, but it in no way approaches the size and conspicuousness of that of *H. microphylla*, nor is it obvious at the base of the ripened fruit.

The fruit is unique in being pyramidal, triangular in cross section, conspicuously keeled and with a long-acute apex. The carpel walls are thin and leathery, made up of a thick-papery pericarp and an excessively thin, coriaceous endocarp. In all other species, the capsule is subglobose, ovoid or ellipsoid, trigastic or round in cross section, and emarginate, with a rounded or slightly mucronate tip. The carpel walls are thick and ligneous, made up of a more or less fleshy pericarp and a heavy, thick, woody endocarp.

This unique structure of the capsule of *Hevea microphylla* is strongly reflected in the method of seed dissemination. In *H. microphylla*, the capsule dehisces slowly, not explosively, and the valves open gradually, twisting as they dry out, and adhere to the receptacle long after dehiscence. The seeds gently drop directly from the capsule and are not propelled violently a great distance fron the tree. In all other species, the capsule opens explosively, usually sending the seeds in several directions far beyond the area beneath the crown of the tree. The heavy, ligneous valves contort only slightly, if at all, and fall to the ground at the moment the capsule bursts open and frees the seeds. Only in *Hevea Spruceana* are the heavily ligneous valves persistent and, although the capsule does open explosively, the seeds are not propelled so far as in other species, primarily because of their greater size and weight.

IV. INFRAGENERIC CLASSIFICATION

Hevea Aublet, Hist. Pl. Guian. Franç. 2 (1775) 871.

Subgenus **Hevea**

Typus: *Hevea guianensis* Aublet

Flos pistillatus toro valde inconspicuo, capsula matura haud manifesto. Capsula subglobosa, ovoidea vel ellipsoidea (nunquam pyramidalis), transversaliter trigastra vel circularis, ecarinata, apice rotundata vel parum mucronata, eruptione dehiscens, semina ab arbore distante propullulans. Valvae crassae, pericarpio plus minusve carnoso atque epicarpio grosso, denso, lignoso, siccitate non convolutae, usualiter non perdurantes.

The following species and varieties, as the genus is now understood, belong to this subgenus.

Hevea Benthaminana Mueller Argoviensis in Linnaea 34 (1865) 204.

Hevea brasiliensis (Willd. ex A. Juss.) Mueller Argoviensis loc. cit. 204.

Hevea camporum Ducke in Arch. Jard. Bot. Rio Jan. 4 (1925) 111.

Hevea guianensis Aublet loc. cit. 871.

Hevea guianensis Aublet *var.* **lutea** (Spr. ex Benth.) Ducke et R.E.Schultes in Caldasia 3 (1945) 249.

Hevea guianensis Aublet *var.* **marginata** (Ducke) Ducke loc. cit. 6 (1933) 51.

Hevea nitida Martius ex Mueller Argoviensis in Martius Fl. Bras. 11, pt. 2 (1874) 301.

Hevea nitida Martius ex Mueller Argoviensis *var.* **toxicodendroides** R.E Schultes et Vinton) R.E. Schultes in Bot. Mus. Leafl., Harvard Univ. 13 (1947) 11.

Hevea pauciflora (Spr. ex Benth.) Mueller Argoviensis in Linnaea 34 (1865) 203.

Hevea pauciflora (Spr. ex Benth.) Mueller Argoviensis *var.* **coriacea** (Ducke) Ducke in Arch. Inst. Biol. Veg. Rio Jan. 2 (1935) 239.

Hevea rigidifolia (Spr. ex Benth.) Mueller Argoviensis loc. cit. 203.

Hevea Spruceana (Benth.) Mueller Argoviensis loc. cit. 204.

Subgenus **Microphyllae** *R. E. Schultes subgen. nov.*

Typus: *Hevea microphylla* Ule

Flos pistillatus toro manifeste incrassato capsulae maturae ad basim persistente, conspicuoque. Capsula pyramidalis, transversaliter triangularis, conspicue carinata, apice longe acuta, lente paulatimque (non eruptione) dehiscens, semina directe sub arbore cadens. Valvae tenues, coriaceae, pericarpio crassipapyraceo atque endocarpio tenuissimo chartaceoque, siccitate valde convolutae, perdurantes.

The only species in this subgenus is

Hevea microphylla Ule in Engler Bot. Jahrb. 35 (1905) 669.

Explanation of Plate 51

1 and 2, habit. 3, leaf showing departure from normal shape. 4, valves of capsule showing mode of dehiscence. 5, seed. 6, pistillate bud, showing terminal spiralling. 7, staminate bud. 8, staminate flower with calyx removed. 9, pistillate flower with calyx removed, showing large torus.

Drawn by Elmer W. Smith

PLATE 51

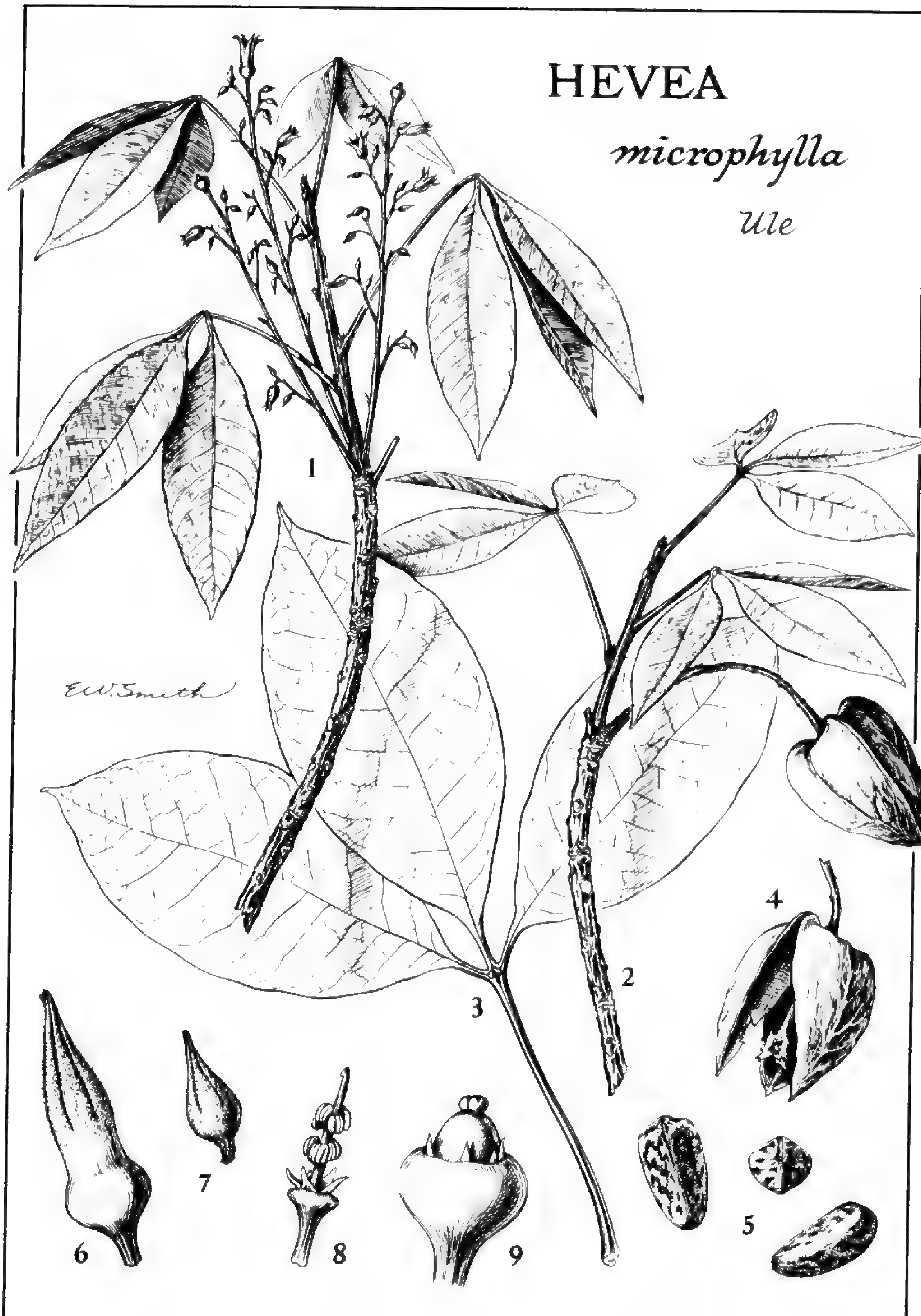


PLATE 52

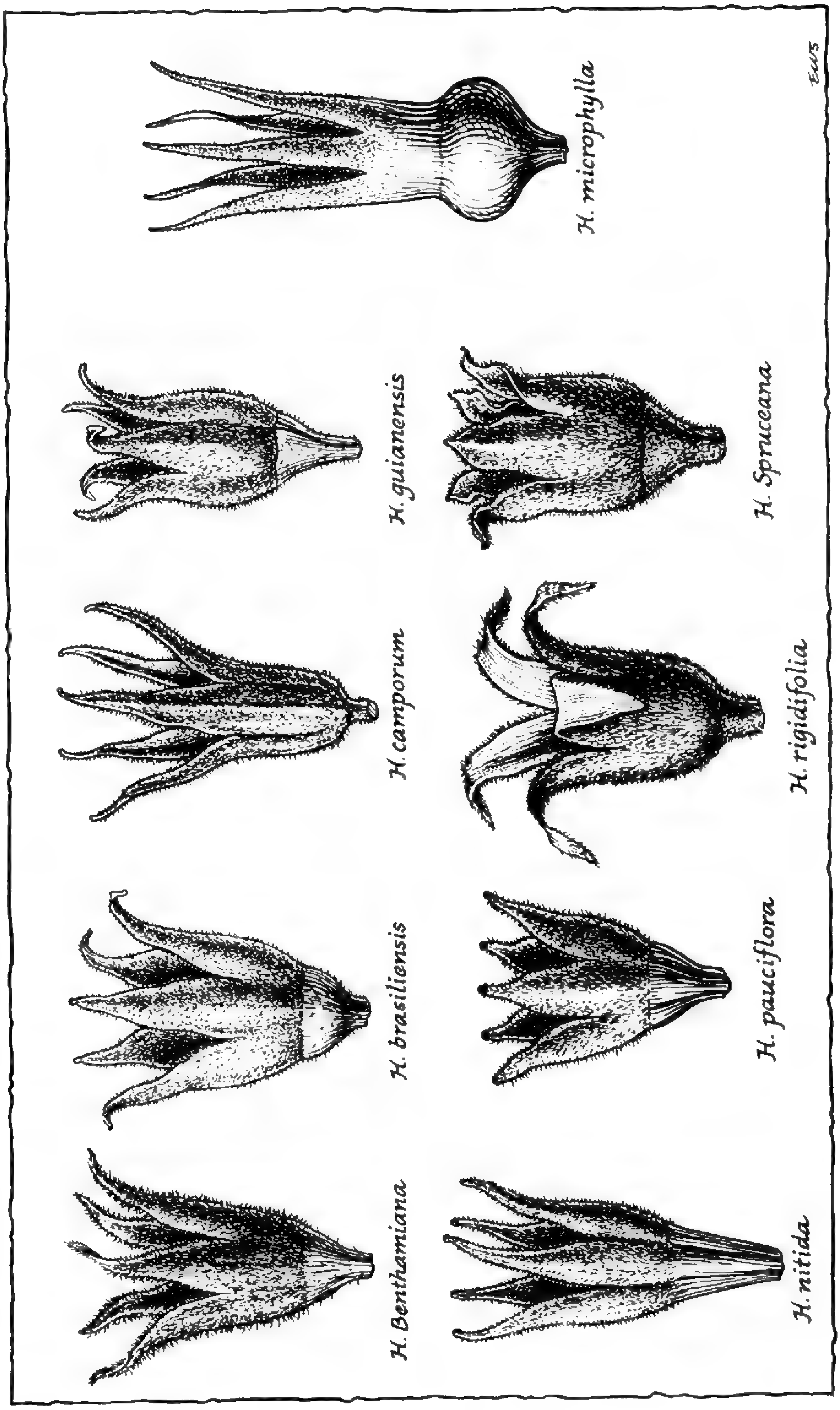


Plate 52. Comparison of the pistillate flowers of the nine known species of Hevea. Drawn by E. W. Smith.

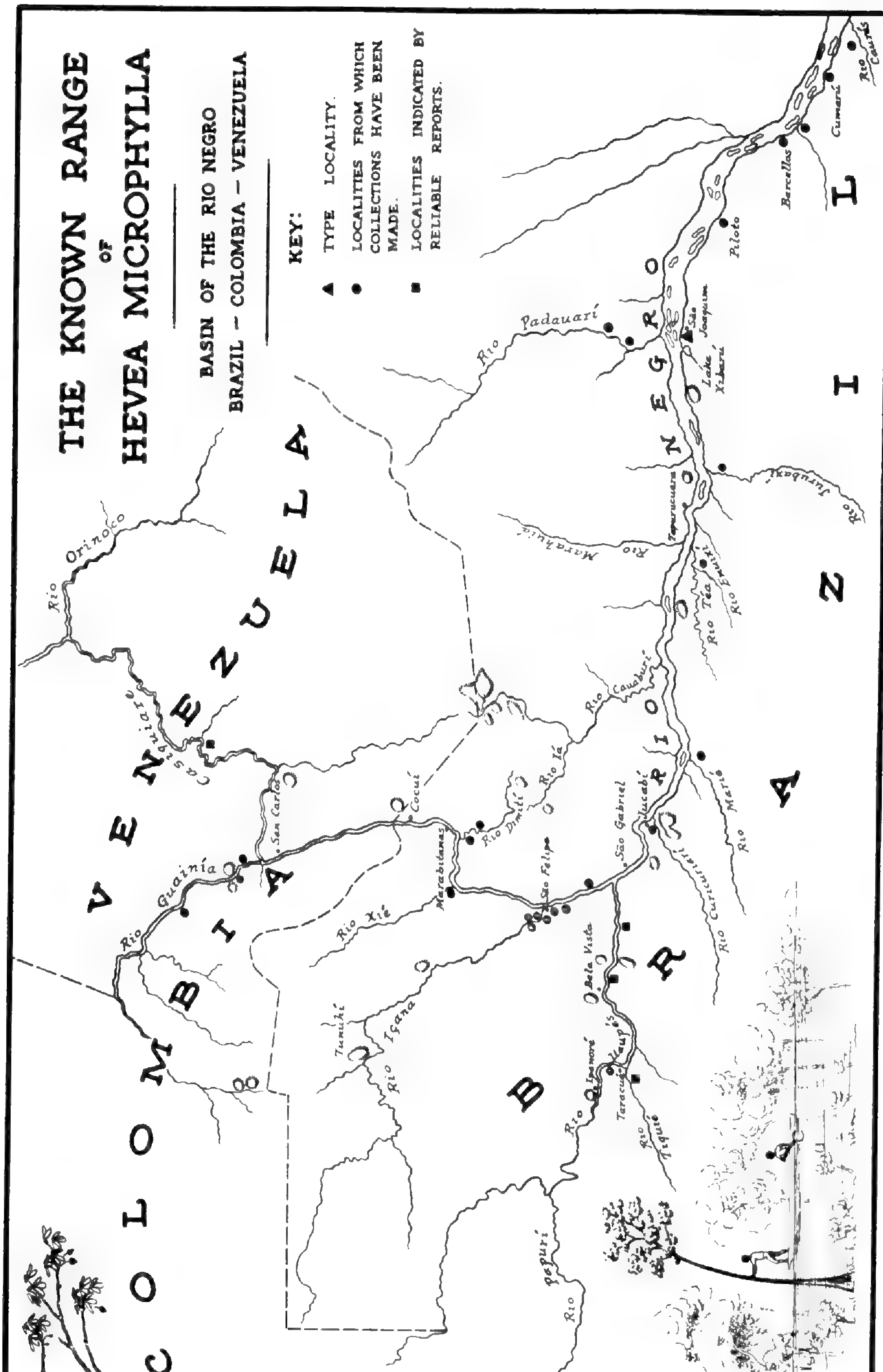
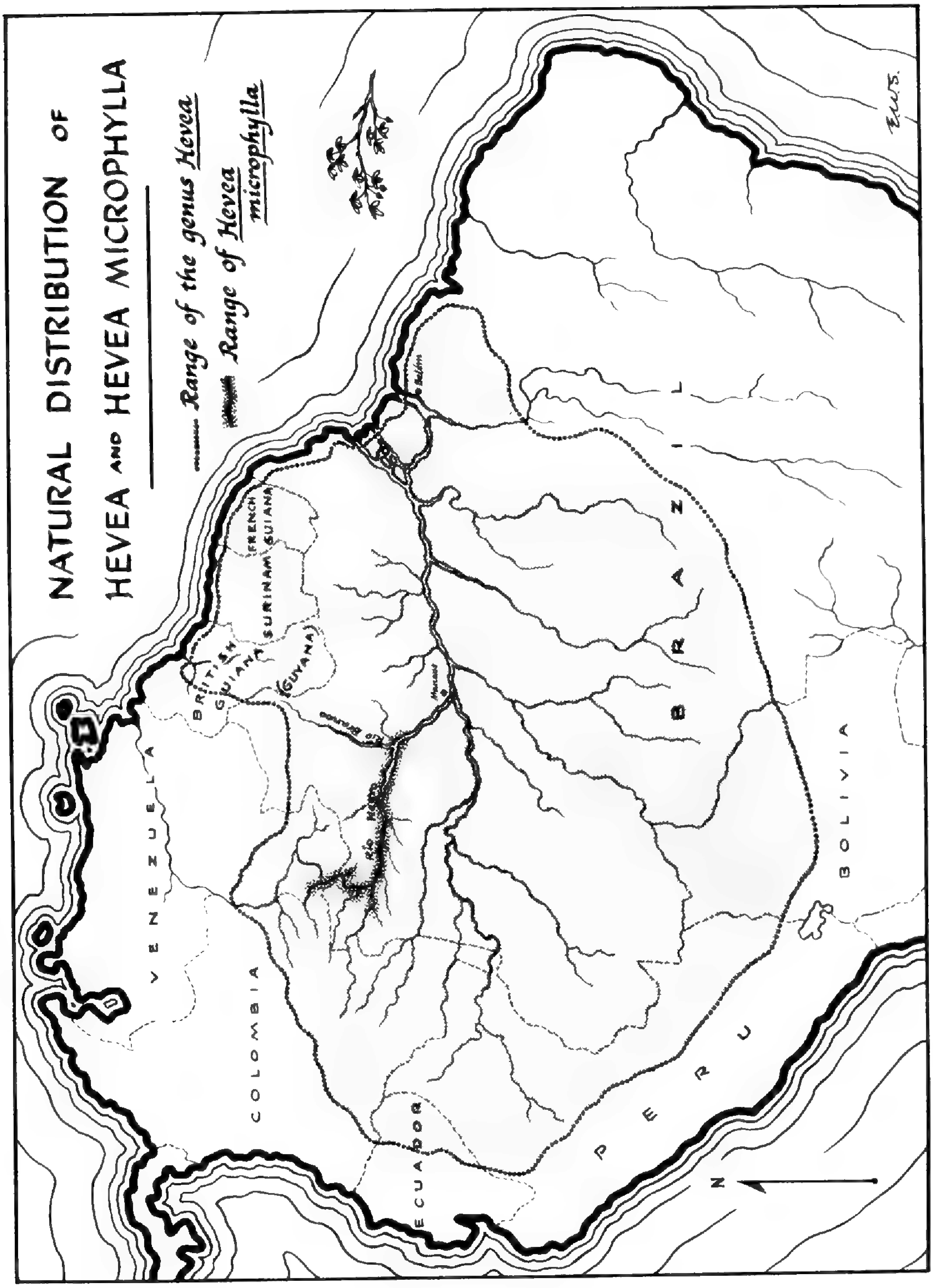

THE KNOWN RANGE OF HEVEA MICROPHYLLA
BASIN OF THE RIO NEGRO
BRAZIL — COLOMBIA — VENEZUELA
KEY:
TYPE LOCALITY.
LOCALITIES FROM WHICH COLLECTIONS HAVE BEEN MADE.
LOCALITIES INDICATED BY RELIABLE REPORTS.
VENEZUELA
COLOMBIA
BRAZIL
RIO NEGRO
Rio Orinoco
Casiquiare
Rio Guainía
San Carlos
Cocuí
Rio Xié
Marabitanas
Rio Içana
São Felipe
São Gabriel
Rio Uaupés
Bela Vista
Ipanoré
Taracuá
Rio Tiquié
Rio Papuri
Rio Curicuriarí
Rio Marié
Rio Cauaburí
Rio Téa
Rio Maraüiá
Tapurucuara
Rio Padauarí
São Joaquim
Lake Xibaru
Piloto
Barcellos
Cumarú
Rio Caurés

PLATE 54



NATURAL DISTRIBUTION OF
HEVEA AND HEVEA MICROPHYLLA
Range of the genus Hevea
Range of Hevea microphylla
VENEZUELA
COLOMBIA
ECUADOR
PERU
BOLIVIA
BRAZIL
BRITISH GUIANA
(GUYANA)
SURINAM
FRENCH GUIANA
RIO NEGRO
N

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DE PLANTIS TOXICARIIS E MUNDO NOVO TROPICALE COMMENTATIONES XVII

Virola as an oral hallucinogen among the Boras of Peru*

Richard Evans Schultes
Tony Swain and
Timothy C. Plowman

The hallucinogenic use of *Virola* bark was first reported from Amazonian Colombia in 1954 (Schultes, 1954), and preparation of a psychoactive snuff from a red, resin-like substance in the bark was described. Later investigations in Colombia and Brazil extended our knowledge of the use and methods of preparing this snuff in a variety of tribes (Biocca, 1966; Schultes & Holmstedt, 1968; Prance, 1970, 1972).

In 1969, the custom of orally ingesting a paste made from the bark of *Virola* was first reported from information received from a Witoto Indian resident in the Leticia region of Colombia (Schultes, 1969). These natives no longer use the drug, but they remember its preparation by the older generations.

Later, in April 1970, more intensive field studies in the Río Karaparaná area of Amazonian Colombia, where Witoto medicine men still employ *Virola* in witchcraft and medicine, clarified several points of uncertainty concerning the preparation and use of the orally administered resin. The method followed by these Karaparaná Witotos in making the thick paste from which small balls or pellets are shaped was fully described in 1976 (Schultes & Swain, 1976). It was pointed out that even in the "one limited area of the Witoto country along the Karaparaná, the preparation of orally administered *Virola* resin varies appreciably from one Indian village to another and

*The field work represented in this contribution was carried out as part of Phase VII of the Alpha Helix Amazon Expedition 1976-1977 and was funded by the National Science Foundation, Grant No. OCE 76-80874.

likewise in accord with the way in which the drug is to be utilized."

In April-May 1977, while on Phase VII of the Alpha-Helix Amazon Expedition, 1976-1977, we had an opportunity to carry out ethnotoxicological investigations in the region of Pebas in Amazonian Peru, where the numerically most important Indians belong to the Witoto and Bora tribes. Many of these Indians, originally from the Colombian region of the Ríos Karaparaná and Igaraparaná, were transplanted to the Pebas region in the 1930's. Substantial populations still live in the Karaparaná-Igaraparaná region under Colombian jurisdiction, and there is still some contact between the several groups.

Many of the Witotos in the Pebas area are now so acculturated that even the older men — although some know the kinds of *Virola* once employed for the drug — no longer are familiar with the relatively simple methods of elaborating the pellets for hallucinogenic use. The Boras, on the other hand, are somewhat less acculturated and conserve many of their older tribal customs, notwithstanding the inroads of Western religious and civil influences.

We were able to witness on several occasions the preparation of the *Virola* paste amongst a group of Boras living in Brillo Nuevo on the Río Yaguasyacu, an affluent of the Río Ampiyacu which, in turn, empties into the Amazonas at the town of Pebas. These Boras no longer take *Virola*, or *cumala*, as it is commonly known in Peru, for hallucinogenic purposes of witchcraft, but older members of the group still remember how their elders prepared and used the drug. Knowledge of the methods of preparation of the product has been handed down even to the younger generation.

What has apparently often been forgotten, we found, is which of the sundry species of *Virola* in the forests of the region were chosen for their psychoactivity and which were eschewed. Consequently, we had the Indians prepare paste from all of the species available and later sorted them out chemically in the laboratory: some containing the active tryptamines, others lacking these indolic compounds. A phytochemical summary of these analyses will be the subject of a later paper. We are here interested primarily in outlining the methods employed in the elaboration of the paste and a comparison of these methods with those followed by the Witoto Indians of the same original geographic area.

The Karaparaná Witotos select their trees by slashing a small strip of bark and tasting, sniffing and feeling the cambial layer, discarding trees which did not meet the right criteria: an ample cambial layer, bitter to taste and with a musty odour. That this custom is part of an old tradition was confirmed by an elderly Bora from the village of Tierra Firme on the Río Ampiyacu who selected several Virolas and classified them according to their potency (which later chemical analysis proved to be correct): he had, in effect, chosen the species with the highest concentration of tryptamines as ascertained by his tasting and smelling the cut bark.

It is obvious from our field observations in 1970 (Schultes & Swain, 1976) and 1977 that it is not the trees producing the most red resin that give the best preparation for inebriating effects or even contain the highest amount of tryptamines. Indeed, the *Virola* tree which produced the most copious amount of resin proved to contain no tryptamines either in the phloem or in the resin itself, although small amounts were found in the bark.

Among the Boras, the first step consists in stripping bark from the trunk of the tree and carrying it back to the house for immediate processing. If the tree is standing in water (during the season of high water), the bark is stripped directly from the standing tree from a dugout canoe; if the tree grows on high land, the tree is usually felled for stripping. Strips of bark approximately two and a half feet long are cut from the tree with a machete, usually — and undoubtedly only for convenience — from the lower four to eight feet of the trunk. If an unusually large amount of paste is to be prepared, bark is taken from other parts of the main trunk.

This primary operation stands in sharp contrast to the Witoto method employed on the Karaparaná where, in the forest, the shiny cambial layer left of the inner surface of the strips of bark and that are still adhering to the decorticated trunk is rasped off with the back of a machete, and the raspings are gathered carefully in a gourd for processing in the house (Schultes & Swain, 1976).

Upon returning, the Boras chip the hard, brittle outermost layer of bark from each strip, leaving only the thick, softer layer of the inner bark and phloem, called *tem'-bee-ho-o* in Bora. This cortical layer, now turned reddish brown with a congealed, oxidized "resin", is pounded on a log with a wooden mallet, until it is quite shredded. Cut into short pieces of convenient length, these shredded sections of bark are placed in a pot of a two-foot diameter with three or four inches of water at air temperature. They are allowed to soak for one half to three quarters of an hour with occasional kneading. The water soon becomes a chocolate brown colour.

When the colour of the water is sufficiently deep, the pot is slowly brought to a boil and, with the pieces of bark still in the liquid, it is boiled vigourously for about an hour, when the shredded bark is taken out, and, after the liquid is squeezed out back into the pot, it is discarded. The liquid is then boiled with almost constant stirring for another forty-five minutes to an hour, until a richly chocolate-coloured syrup remains. Stirring must be constant and careful towards the very end of the evaporation, so that a thick, sticky but homogeneous paste is left. The Boras call this paste *ko'do*.

We would venture to assume that the Witoto technique is more efficient than that followed by the Boras. The nearly colourless liquid which rapidly turns reddish or brownish and which, for lack of a better term, we have called "resin", is present only in or near the cambial layer, not in the outer layers of bast or phloem. It is clear that the active principles themselves — the tryptamines — occur mainly in the cambial sap and that boiling of the cambial tissue coagulates proteins and perhaps polysaccharides. When only this delicate cambial tissue is present, as in the Witoto method, it is obvious that such coagulation must proceed more efficiently than when, as in the Bora method, most of the material — consisting of shredded outer phloem — is relatively inert.

The paste may be ingested directly without any further elaboration. If the drug is to be kept for later use, however, the paste is made into small balls or pellets and rolled in a white or greyish powder referred to as "salt" or, in Bora, *ü'-meh* or *oo'me*. This "salt" is the residue from the filtrate of ashes of one of two plants: one, known as *pee-ye-ee-pa-a* in Bora, an epiphytic species of the cyclanthaceous genus *Carludovica*, the leaves and stump of which are burned; the other a large palm, *Scheelea* sp., the leaves of which are reduced to ashes. The ashes of these plants are placed in a funnel made of a pliable piece of bark. Hot water is slowly poured into the funnel, passing through the ashes and dripping out into a receptacle placed under the funnel. The filtrate is then evaporated by heating, leaving the solid powder or "salt".

Another contrast with the Karaparaná Witoto preparation of *Virola* pellets lies in the much larger number of plants employed by the Witotos as sources of the "salt" for coating the paste.

It is of interest to note in passing that a "salt" from ashes of the leaves and stems of a low palm of the genus *Chelyocarpus* is similarly prepared by the Boras on this region for mixing with the thick syrup of tobacco, known in Bora as *am-pi'-ree*, applied to the tongue frequently during the use of the powdered coca, a narcotic characteristic of the region. The same tobacco preparation — with "salts" prepared from other plants — is made by the Witotos of the Ríos Karaparaná and Igaraparaná (Schultes, 1945).

The Bora group at Brillo Nuevo recognized several species of *Virola* but pointed out as the "best" tree a species that occurs abundantly along the banks of the Río Yaguasyacu. This "best" tree has been identified as *Virola elongata* (Benth.) Warburg (*Plowman, Schultes et Tovar 7263*). It is a stout, columnar tree up to 75 or 80 feet tall, with a diameter of two to two and a half feet, standing in deep water during most of the rainy season. The crown is not extensive for a tree of such height. The leaves are narrowly lanceolate-elliptic, greyish brown on the nether surface, bright green above; their consistency is firmly chartaceous. The bark is hard, externally greyish black, light reddish brown within, about one quarter of an inch thick; when stripped from the trunk for use, an almost colourless resin-like liquid accumulates on the innermost surface and rapidly — within four or five minutes, some times even sooner — becomes a rich brownish red. The local name of this tree in Spanish is *cumala blanca*; the Boras call it *ko-de-ko*, apparently a generic term for *Virola*.

Several other species of *Virola* were indicated by these Boras, and paste was prepared from them. It was obvious that there was some confusion as a result of discontinuation of the native use of *Virola* in witchcraft. The species indicated were *Virola surinamensis* (Rol.) Warburg (*cumala colorada*) (*Plowman, Schultes et Tovar 7260*) and *V. loretensis* A. C. Smith (*Plowman, Schultes et Tovar 7259*).

At the Bora town of Tierra Firme on the Río Ampiyacu, the species indicated as the basis for the inebriating preparation were: *Virola Pavonis* (DC.) A.C. Smith (*Plowman, Schultes et Tovar 7091*) and *V. elongata* (*Plowman, Schultes et Tovar 7092*). The very "strongest", these natives indicated, is represented by *Plowman, Schultes et Tovar 7094*, a sterile collection which we cannot identify and which may be an undescribed species of *Virola*. At Tierra Firme, *Virola calophylloidea* Markgraf (*Plowman, Schultes et Tovar 7093*) and *Osteophloeum platyspermum* (DC.) Warburg (*Plowman, Schultes et Tovar 7095*) were definitely indicated as "cumalas" which are *not* employed in the elaboration of the narcotic paste.

Amongst the Witotos, who live in the relatively new settlement of Puca Urquillo, near the mouth of the Río Ampiyacu, on the other hand, a medicine man pointed out two species of *Virola* as possible sources of the hallucinogenic drug, even though he no longer knew the method of preparing the paste. These two species are: *Virola elongata*, of the forest well above flood level (*Plowman, Tovar et Schultes 6920, 6595*), and *V. surinamensis*, common along the deeply flooded banks of rivers and creeks as well as on higher level, known as *cumala* (*Plowman, Tovar et Schultes 6688, 6920*); the Witoto name for both kinds is *oo-koo'-na*. We believe that our informant was confused, and, that actually, the Witotos formerly used only *Virola elongata*.

Very significantly, these Witotos pointed out *Iryanthera macrophylla* (Benth.) Warburg (*Plowman, Schultes et Tovar 6919*) as also a source of the narcotic paste. This report represents the first involving the related genus *Iryanthera* as an hallucinogenic group of plants.

Voucher specimens of the Virolas cited above have been added to the Economic Herbarium of Oakes Ames in the Botanical Museum of Harvard University, the herbarium in the Museo de Historica Natural "Javier Prado" in Lima, Peru, and the herbarium of the Instituto Nacional de Pesquizas da Amazônia in Manáos, Brazil. The material was determined by Prof. Richard Evans Schultes, Dr. Timothy C. Plowman and Dr. William Rodrigues.

Species indicated in the foregoing discussion:

Iryanthera macrophylla (Benth.) Warburg in Nov. Act. Nat. Cur. 68 (1897) 155.
Osteophloem platyspermum (DC.) Warburg loc. cit. 162.
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PLATE 55

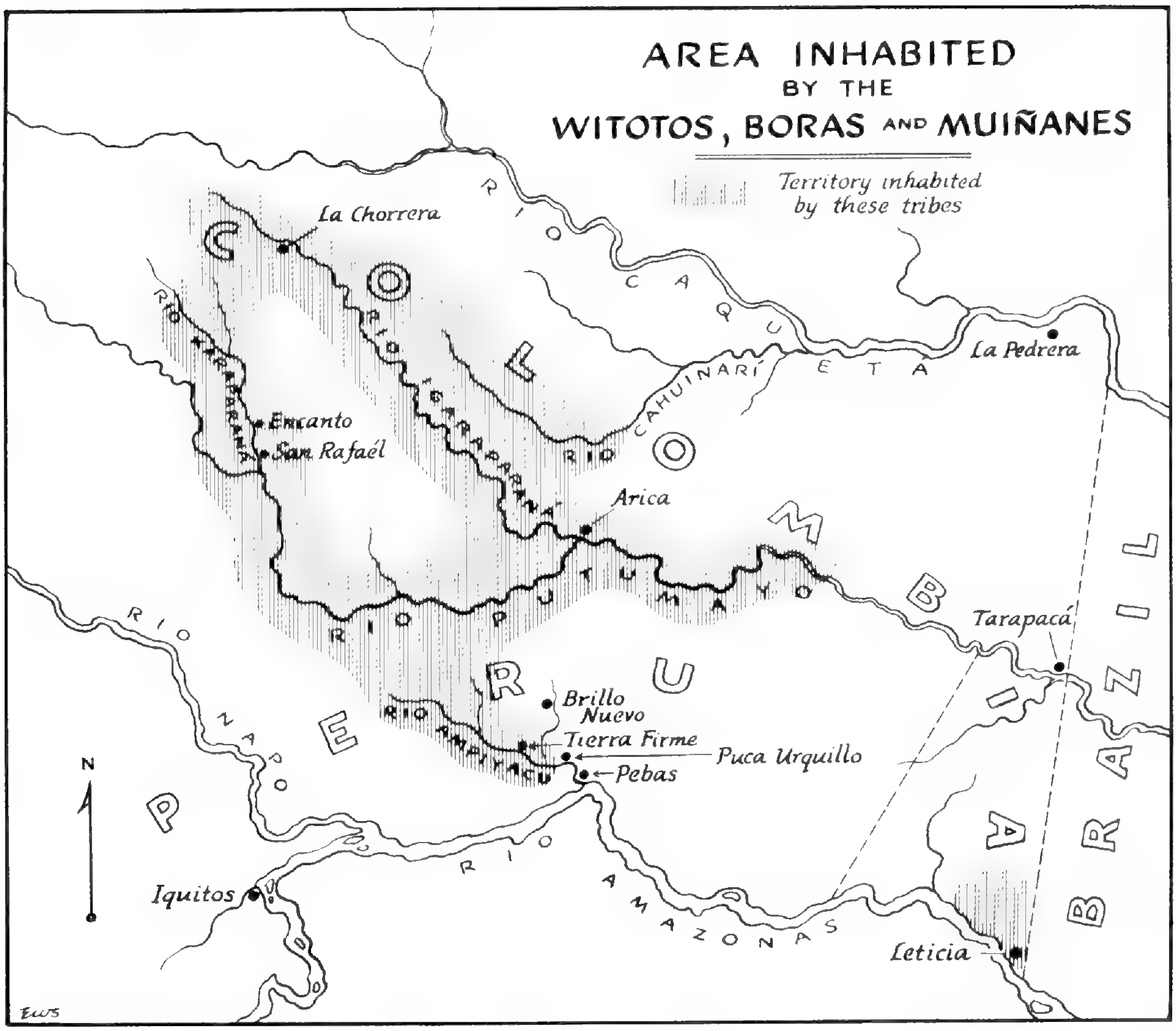
AREA INHABITED
BY THE
WITOTOS, BORAS AND MUIÑANES
Territory inhabited
by these tribes
La Chorrera
RIO CAQUETA
La Pedrera
RIO KARAPARANA
Encanto
San Rafaél
RIO IGARAPARANA
RIO CAHUINARI
Arica
RIO PUTUMAYO
COLOMBIA
Tarapacá
BRAZIL
RIO NAPO
PERU
Brillo
Nuevo
RIO AMPIYACU
Tierra Firme
Puca Urquillo
Pebas
N
Iquitos
RIO AMAZONAS
Leticia
EWS

PLATE 56

Plate 56. Bora Indian stripping bark from trunk of *Virola elongata* for preparation of hallucinogenic paste. Brillo Nuevo, Rio Yaguasyacu, Loreto, Peru. Photograph: R. E. Schultes.

PLATE 57

Plate 57. Bora Indians pounding strips of Virola bark to separate the inner portion for boiling. Brillo Nuevo, Rio Yaguasyacu, Loreto, Peru. Photograph: R. E. Schultes.

PLATE 58

Plate 58. Inner part of Virola bark stripped from whole bark and macerated, ready for boiling. Brillo Nuevo, Rio Yaguasyacu, Loreto, Peru. Photograph: R. E. Schultes.

PLATE 59

Plate 59. Appearance of Virola bark after one hour of boiling and stirring in Bora method of preparation of hallucinogenic paste. Brillo Nuevo, Rio Yaguasyacu, Loreto, Peru. Photograph: R. E. Schultes.

PLATE 60

Plate 60. Apparatus used by Bora Indians in preparing the "salt" or filtrate of ashes for coating pills of Virola paste. Brillo, Nuevo, Rio Yaguasyacu, Loreto, Peru. Photograph: R. E. Schultes.

BOTANICAL MUSEUM LEAFLETS
HARVARD UNIVERSITY

CAMBRIDGE, MASSACHUSETTS, DECEMBER 30, 1977 VOL. 25, NO. 10

DE PLANTIS TOXICARIIS E MUNDO NOVO TROPICALE COMMENTATIONES XVIII

Phytochemical examination of Spruce's ethnobotanical collection of *Anadenanthera peregrina*.

Richard Evans Schultes[1] Jan-Erik Lindgren[2] and
Bo Holmstedt[2] Laurent Rivier[2 3]

One of the classical hallucinogens of the Americas is the snuff prepared from beans of the leguminous tree *Anadenanthera peregrina* (L.)Speg., better known in the literature by its former name *Piptadenia peregrina* (L.)Benth. (1).

Long known from the Orinoco River basin of Colombia and Venezuela, this psychoactive drug has been mentioned by virtually all of the early scientific explorers of the area. In 1916, it was identified by Safford as the source of the enigmatic *cohoba*, the narcotic snuff of the West Indies, the use and effects of which were seen among the Taino Indians of Hispaniola by early Spanish explorers in 1496 (2).

While the drug is no longer employed anywhere in the Caribbean islands, the extent of the use of *Anadenanthera peregrina* has still not been clearly defined. It may be that, in isolated localities in the southern part of the Amazon Valley, the tree was until recently the source of a snuff. There is circumstantial evidence, too, that the very closely allied *Anadenanthera co-*

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lubrina was employed in preparing an intoxicating snuff known as *cébil* or *huilca,* used in former times in parts of northern Argentina, Paraguay and possibly in Bolivia and Peru (3).

Our earliest botanical knowledge of *niopo* or *yopo* — as the snuff is called in the Orinoco — goes back to 1801, when von Humboldt and Bonpland encountered its use in Colombia and Venezuela (4). Kunth reported briefly on their observations: "Ex seminibus tritis calci vivae admixtis fit tabacum nobile quo Indi Otomacos et Guajibos utuuntur." Humboldt identified the source as *Piptadenia Niopo,* which he believed represented the same species as Willdenow's *Inga Niopo.* Humboldt, like the earlier explorer of the Orinoco, Padre Gumilla, erroneously believed that the intoxicating effects of the snuff could be attributed to the alkaline admixture and not to the seeds employed in elaborating the powder.

The next major botanical encounter with the drug was that of Richard Spruce, who met with its use in June, 1854 amongst the Guahibos of the upper Orinoco (5). Spruce wrote that his "specimens of the leaves, flowers and fruit agree so well with Kunth's description of *Acacia Niopo* that I cannot doubt their being the same species; especially as I have traced the tree all the way from the Amazon to the Orinoco, and found it everywhere identical." An important point in Spruce's meticulous observation of the preparation of the snuff, however, is his statement that "there is no admixture of quicklime."

Spruce found ". . .a wandering horde of Guahibo Indians . . . encamped on the svannas of Maypures [on the Orinoco] and . . . an old man grinding Niopo seeds . . . . The seeds, being first roasted, are powdered on a wooden platter, nearly the shape of a watch-glass, but rather longer than broad (9¼ inches by 8 inches). It is held on the knee by a broad, thin handle, which is grasped in the left hand, while the fingers of the right hold a small spatula or pestle of the hard wood of the Palo de arco (*Tecoma* sp.) with which the seeds are crushed . . . . For taking the snuff, they use an apparatus made of the leg-bones of herons . . . in the shape of the letter Y, or something like a tuning-fork, and the two upper tubes are tipped with small black perforated knobs (the endocarps of a palm). The lower tube being inserted in the snuff-box and the knobs in the nostrils, the snuff is forcibly inhaled, with the effect of thoroughly narcotising a novice or indeed a practiced hand, if taken in sufficient quantity . . . ." The apparatus which Spruce described and which he purchased at Maypures on the Orinoco may still be seen at the Royal Botanic Gardens at Kew. An illustration of this parephernalia is herewith published.

There are also at Kew — in the Economic Botany Museum — specimens of the pods of *Anadenanthera peregrina* which Spruce collected in 1854 on the Colombo-Venezuelan border at the Savannahs of Maypures. These pods were purchased from an old Guahibo Indian who was grinding the seeds for preparation of the snuff.

In our desire to analyze as many specimens of seeds of this species from as many localities as possible, we expressed to the authorities at Kew our interest in submitting some of Spruce's 120-year old material to modern chemical examination. We owe a debt of gratitude to the former director, Dr. John Heslop-Harrison, the former Keeper, Dr. J. P. M. Brenan, Dr. Tony Swain, formerly director of the Biochemical Laboratory and Miss Rosemary Angel of the Economic Botany Museum for finding and making available to us the necessary pods and seeds. The analytic study is detailed below.

We were encouraged to examine this important material collected by Spruce for several reasons (6,7).

First: we wanted to compare its analysis with that of very recently collected material.

Second: Spruce was far ahead of the customs of botanical explorers of his time in being willing to collect material of medicinal and narcotic plants for chemical analysis.

Third: we had been successful in analyzing material of the hallucinogen *Banisteriopsis Caapi* of the Malpighiaceae, collected by Spruce on the Rio Uaupés of Brazil in 1852 (8). This material was examined in April 1968 in the Karolinska Institutet in Stockholm, 114 years after its collection. The yield of alkaloids was 0.4% as against 0.5% for a recently collected specimen of the same species. The alkaloid content of Spruce's material consisted exclusively of harmine, as contrasted with harmine, harmaline and tetrahydroharmine, as well as two minor constituents in the modern material.

As we did with the Spruce material of *Banisteriopsis*, the examination of the seeds of the collection *Spruce 119* of *Anadenanthera peregrina* was compared with the analysis of similar freshly collected material. For several years, we have been studying a colony of beautiful trees of this species — obviously planted, perhaps some 40 years ago — in Barrio St. Just of Carolina, near San Juan, Puerto Rico. This colony grows on a hill immediately behind the El Comandante horse-racing track. Our most recent botanical studies on the colony were made in the month of December 1974, when the pods are still immature. Mature pods for the present analyses were also collected from the same colony of trees by Dr. Thomas Schubert and Mr. José Zambrana of the United States Department of Agriculture Forest Service, Institute of Tropical Forestry, Río Piedras, Puerto Rico on March 13, 1975, when the pods had fully ripened.

All of our collections from the Puerto Rican site are deposited in the Economic Herbarium of Oakes Ames in the Harvard Botanical Museum.

PUERTO RICO: La Carolina, Barrio St. Just, adjacent to Hipódromo. "Tree 60 feet tall. Pods brownish. *Cojoba*." December 8, 1970. *R. E. Schultes 26091*. — Same locality and date. "Seedlings under tree of collection *26091*." *R. E. Schultes 26091 A*. — Same locality. "Tree in grove on hillside. Height 70 feet. Pods green-brown, ripening black. Bark with large conical spines." December 13, 1972. *R. E. Schultes 26363*. — Same locality and date. *R. E. Schultes 26364*. — Same locality. "Tree 45 feet tall. Secondary forest. Cork black." December 12, 1974. *R. E. Schultes, S. von R. Altschul et B. Holmstedt s.n.*

CHEMICAL ANALYSIS

MATERIAL AND METHODS: The following botanical materials will be referred to as below:

seeds "December 1972"— for immature seeds collected in Puerto Rico. Voucher specimen: *R. E. Schultes 26363*, December 13, 1972; and

seeds "March 1975"— for mature seeds collected from the same colony of trees in Puerto Rico. Voucher specimen: *R. E. Schultes, S. von R. Altschul et B. Holmstedt s.n.*, December 12, 1974.

REFERENCE SUBSTANCES: All reference substances have been previously described (9).

ABBREVIATIONS:

DMT	N,N-dimethyltryptamine
5-MeO-DMT	5-methoxy-N,N-dimethyltryptamine
5-MeO-MMT	5-methoxy-N,N-monomethyltriptamine
5-OH-DMT	5-hydroxy-N,N-dimethyltryptamine or bufotenine
MTHC	2-methyl-1,2,3,4-tetrahydro-β-carboline
6-MeO-THC	2-methyl-6-methoxy-1,2,3,4-tetrahydro-β-carboline
6-MeO-DMTHC	1,2-dimethyl-6-methoxy-1,2,3,4-tetrahydro-β--carboline

ISOLATION OF THE ALKALOIDS: The vegetal material was ground and extracted according to a procedure first used by Fish *et al.* (10).

GAS CHROMATOGRAPHY (GC): The gas chromatographic analyses were performed with a Varian Model 2100 GC equipped with a flame ionization detector system. A 180 x 0.2 cm (i.d.) glass column was silanized and packed with 3% OV-17 coated on Gas Chrom Q, 100-120 mesh (Applied Science Laboratories, State Coll., Pa.). The separations were obtained at a column temperature of 190°C with a nitrogen carrier gas flow rate of 30 ml per min. The vaporizer and the detector temperatures were 250°C and 300°C, respectively. The amounts of alkaloids were determined by peak heights using 5-hydroxy-N, N-dimethyltryptamine as a standard.

GAS CHROMATOGRAPHY - MASS SPECTROMETRY (GC-MS): An LKB Model 9000 GC-MS (LKB-Produkter AB, Bromma, Sweden) was used to confirm the structure of the alkaloids. Separation was obtained on a 160 x 0.2 cm (i.d.) silanized glass column, packed with the same packing material as for the GC analyses but maintained at 170°C. The flow rate of the helium carrier gas was 40 ml per min. The ionizing potential and the trap current were 70 eV and 60 μA, respectively. The ion source was kept at 250°C.

Table 1. Gas chromatographic and mass spectrometric data for reference compounds.

Compound[a]	R_t[b]	Mass spectrum[c]
DMT	2.5	58 (base peak), 103, 105, 130, 143, 188 (M^+)
MTHC	4.3	78, 102, 115, 143 (base peak), 186 (M^+)
5-MeO-DMT	5.8	58 (base peak), 103, 117. 160, 173, 218 (M^+)
5-OH-DMT	8.4	58 (base peak), 103, 117, 146, 159, 204 (M^+)

[a]For abbreviations, see material and methods.

[b]LKB 9000 GC-MS with helium as carrier gas on 3% OV-17 on Gas Chrom Q at 170°C. R_t= retention time in minutes.

[c]Ionizing potential was 70 eV. m/e values of the major peaks are given.

MASS FRAGMENTOGRAPHY (MF): In order to confirm the presence or absence of minor alkaloids in the plant materials, the specific and sensitive method of mass fragmentography was used (11). The principles of the technique have already been described (12). The mass spectrometer was controlled by a PDP-12 computer system. The channels used were focussed carefully on the molecular ion of each compound of interest: m/e = 204 for 5-OH-DMT; m/e = 186 for MTHC; m/e = 188 for DMT; and m/e = 218 for 5-MeO-DMT. During another experiment m/e = 58 was chosen with two different sensitivities on two channels.

RESULTS

The gas chromatographic trace of the chloroform-soluble bases from the seeds collected in 1854 by Spruce gave a single peak. Its mass spectrum was identical to that of 5-OH-DMT. The mass fragmentogram of the same extract is in agreement with that result (Fig. 1). The extract of mature seeds freshly collected in Puerto Rico, seeds "March 1975", showed several GC peaks. Beside 5-OH-DMT they have been identified by GC-MS and are DMT, MTHC and 5-MeO-DMT (Table 1). The mass fragmentographic recording confirms in a single run the presence of the four alkaloids (Fig. 2). The relative amount of the compounds in the plant material is given in Table 2. In the same table are listed the results of similar analyses of various plant parts of *Anadenanthera peregrina*, originating from the same colony of trees in Puerto Rico. Included in the table are also specimens of more or less well defined botanical or ethnological origin.

DISCUSSION

The finding of 5-OH-DMT as the only alkaloid in the Spruce material is significant for several reasons. First: it indicates that, with modern analytical tools, it is possible to detect and identify alkaloids in plant materials more than 100 years old. Second: identification of the botanical specimen is strengthened by the results of the chemical analyses, because the same compound has been found in both old and the freshly collected seeds. One previous analysis of seeds of *Anadenanthera peregrina* originating from Puerto Rico has shown the presence of 5-OH-DMT as the principal alkaloid (13). A sample of *A. peregrina* seeds collected in southern Venezuela contained 7.5% of 5-OH-DMT (14, 15). Holmstedt and Lindgren (16) have reviewed the alkaloid composition of many specimens.

DMT alone or together with 5-MeO-DMT has been isolated from *Anadenanthera peregrina* originating from Brazil (10). A similar composition was found in related species (9, 16).

Table 2 illustrates the differences in alkaloid contents in various parts of *Anadenanthera peregrina*. The root contained the highest amount of alkaloids. In this collection, 5-MeO-DMT was the predominant alkaloid in all plant parts, except the seeds, where DMT was found in the highest amount. However, it should be mentioned here that the seeds were not fully ripe at the time of collection (seeds "December 1972").

SAMPLE NO. : 3
WAITING PERIOD 1 SAMPLE PERIOD 15
ANADENANTHERA PEREGRINA PUERTO RICO

CHANNEL	MASS	HEIGHT	RET. TIME	RATIO
1	204	869	8.40999	1
2	186	140	4.32999	.161104
3	188	711	2.53000	.818181
4	218	180	5.77000	.207134

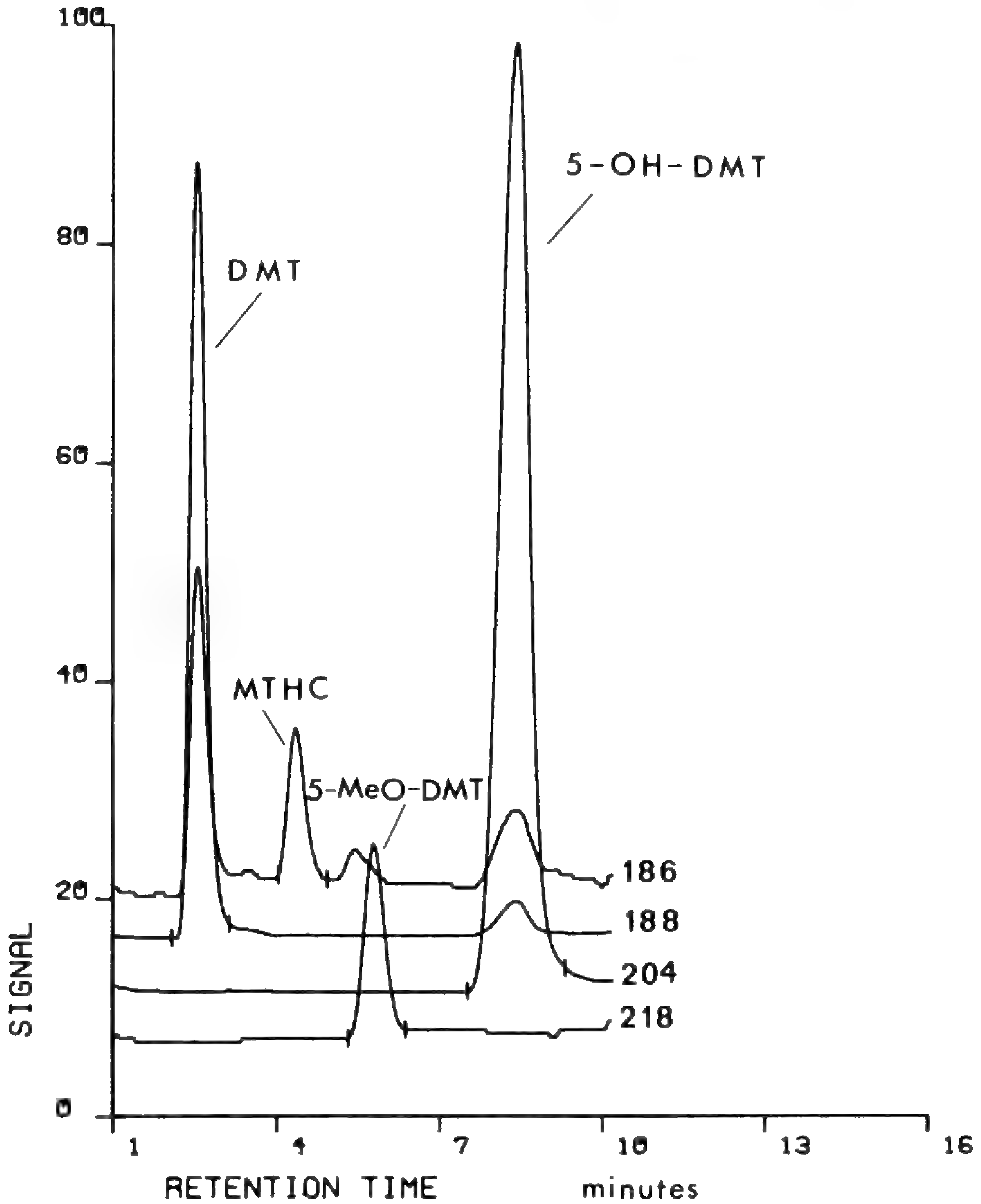

Fig. 1. Mass fragmentogram (OV-17) of the alkaloidal fraction from the *Anadenanthera peregrina* seeds collected by Richard Spruce in 1854.

Since it may be assumed (in fact, examination of the seeds established) that the seeds collected by Spruce had matured, it was necessary for comparison to analyze similar material. Investigation of mature seeds ("March 1975") from the Puerto Rican locality, where immature seeds had been collected pre-

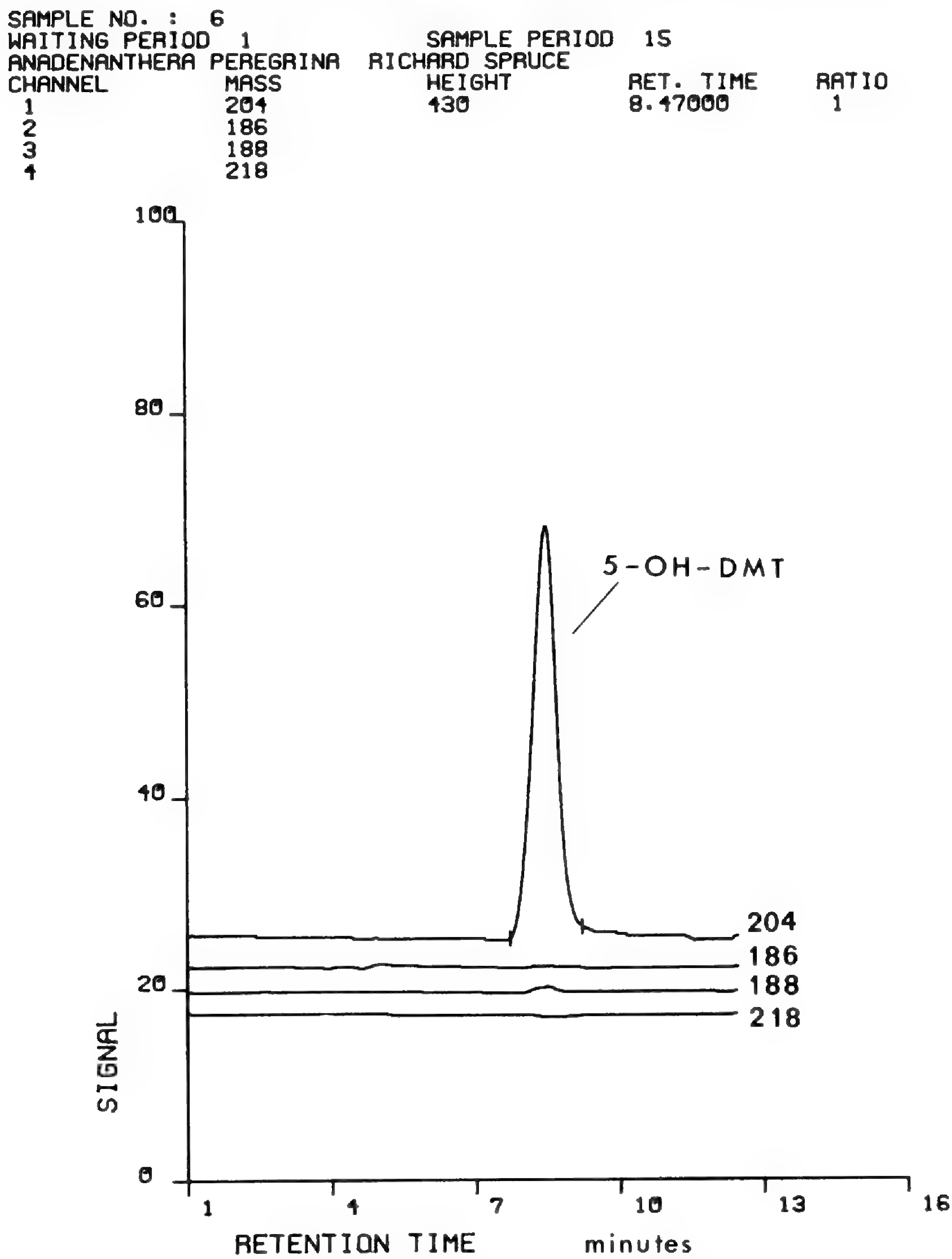

Fig. 2. Mass fragmentogram (OV-17) of the alkaloidal fraction from the *Anadenanthera peregrina* seeds of Puerto Rico (seeds "March 1975") analysed in 1975).

Table 2. Distribution of the indole alkaloids.

Voucher No.	Species	Part of the plant	Alkaloids mg/100 g dry plant	Alkaloids	%
R. Spruce 119	A. peregrina o: Rio Negro, Brazil, 1854	Seeds	614	5-OH-DMT	100
R.F. Schultes, S. von R. Altschul and B. Holmstedt, sin. num	A. peregrina o: San Juan, Puerto Rico, 1975, "March 1975"	Seeds	a) not determined (analysed 1975)	5-OH-DMT DMT 5-MeO-DMT MTHC	80 19 1 traces
			b) 3523 (analysed 1977)	5-OH-DMT	100
R.E. Schultes 26363	A. peregrina o: San Juan, Puerto Rico, 1972, "March 1972"	Seeds	209	DMT 5-MeO-DMT 5-OH-DMT	75 19 6
		Seedlings	25	DMT 5-MeO-DMT 5-OH-DMT	4 95 1
		Pods without seeds	13	DMT 5-MeO-DMT 5-OH-DMT	8 91 1
		Leaves	107	DMT 5-MeO-DMT	12 88
		Twigs	38	DMT 5-MeO DMT 5-OH-DMT	5 94 1
		Bark	410	DMT 5-MeO-DMT	5 95
		Roots	699	DMT 5-MeO-DMT 5-OH-DMT	2 97 1
	Anadenanthera presumably c: Biocca Cocco, 1963 o: Upper Orinoco El Platanal Machekototeri	Seeds	1	DMT	100
	Anadenanthera c: Biocca Cocco, 1965 o: Upper Orinoco Rio Ocamo	Seeds	6	DMT	100
	Anadenanthera c: G. Seitz, 1965	Seeds	38	DMT	100
	Anadenanthera c: G. Seitz, 1965	Seedlings	29	DMT 5-MeO-DMT	96 4
R.E. Schultes 24625	A. peregrina o: Boa Vista, Brazil (9)	Leaves	13	DMT 5-MeO-DMT	49 48
		Bark	42	DMT 5-MeO-DMT 6-MeO-DMTHC 5-MeO-MMT 6-MeO-THC	1 59 2 36 2
Abbott Lab., 1948 N2003C	Piptadenia peregrina o: San Juan Puerto Rico, (16)	Seeds	9	DMT	100
	Piptadenia peregrina c: J. Yde, 1964, H4685	Seedlings	1	DMT	100
	Piptadenia, Tupari c: Caspar, 1964 o: Guaporé, Brazil	Seeds	13	DMT 5-MeO-DMT	15 85
	Schupfsnuff, Tupari c. G. Baer, 1964 o. Brazil	Snuff	16	DMT	100
	Yopo c: L. Persson, 1966 o: R. Miriti-Parana Caqueta, Columbia	Snuff	16	DMT	100

c: = collector
o: = origin

viously, shows a different picture [mostly 5-OH-DMT and DMT, with less MTHC and 5-MeO-DMT (Fig. 2)]. Analysis of these seeds was done in August 1975, five months after collection. No quantitation of alkaloid contents was performed at that time.

We repeated the analysis of the same material two years later. At this time, the Puerto Rican seeds were no longer able to germinate. In the analysis of this material, the seeds ("March 1975") contained only 5-OH-DMT, with no trace of any of the other alkaloids found earlier. This fact might imply that the relative content of the various alkaloids upon storage follows with time a certain pattern.

The seeds of the Puerto Rican material kept for two years and the 123 year old Spruce material thus contain the same alkaloid: 5-OH-DMT. Transformation of alkaloids during storage of botanical material is known to occur (17).

CONCLUSIONS

In yet another ethnobotanical collection made by Spruce more than a 100 years ago, it has been possible to identify alkaloidal material by the use of modern analytical techniques never dreamed of by this intrepid plant explorer. Of several alkaloids found in freshly collected reference material, only one remained in the Spruce collection: bufotenine (5-OH-DMT). Storage of freshly collected material for two years resulted in the disappearance of all alkaloids except 5-OH-DMT. This may raise speculation as to whether or not they were originally contained in the Spruce material. Our observation stresses the importance of storage-time in addition to knowledge of plant part, soil, season and climatic conditions, when alkaloid analysis is carried out on seeds and on the snuffs prepared from them.

ACKNOWLEDGMENTS

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PLATE 61

Plate 61. Paraphernalia for preparing and taking *yopo* snuff, collected on the Orinoco River by Richard Spruce. Photograph courtesy of the Royal Botanic Gardens, Kew.

PLATE 62

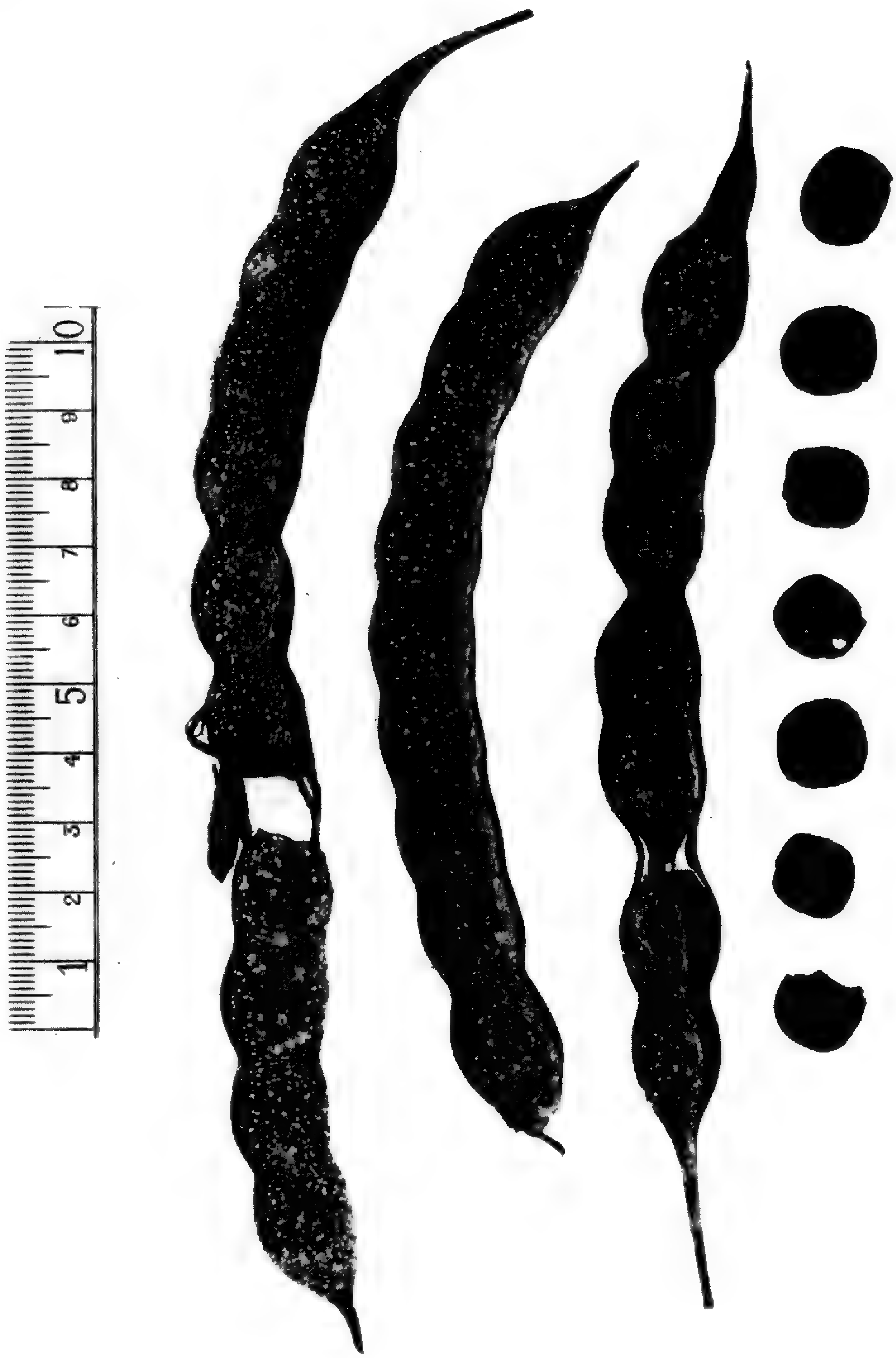

Plate 62. Pods and beans of *Anadenanthera peregrina* collected on the Orinoco River in 1854 by Richard Spruce. Photograph courtesy of the Royal Botanic Gardens, Kew.

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BRUNFELSIA IN ETHNOMEDICINE*

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The genus *Brunfelsia* belongs to the alkaloid-rich family Solanaceae and usually is placed in the relatively advanced tribe Salpiglossideae. *Brunfelsia* is a medium-sized genus of about 42 species of small trees and shrubs: 22 species are confined to the West Indies; 20 species are found in tropical South America.

Various species from South America have long been recognized by native peoples for their medicinal properties. Some of these plants are cultivated for use as household remedies with specific therapeutic effects. These effects have apparently been discovered independently by unrelated peoples in widely separated parts of the continent. Yet chemically and pharmacologically, species of *Brunfelsia* are still virtually unknown — a disturbing fact considering the many important drug plants in the Solanaceae which are commonly used in pharmacy today.

At least five species of *Brunfelsia* are known to be of some medicinal importance. Other species of the genus are suspected of having pharmacological activity or of possessing alkaloids or other active constituents. My purpose in this account is to review the literature on these plants and to present pertinent ethnobotanical data collected during my own field work and that of other workers, in order to rekindle the interest of chemists and medical researchers in this pharmacologically rich genus.

1. **Brunfelsia uniflora** (Pohl) D. Don

The most important medicinal species of *Brunfelsia* is *B. uniflora*, the well known *manacá* root of the Brazilian phar-

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macopeia. This plant is often referred to, albeit incorrectly, by a later synonym, *B. Hopeana* (Hook.) Benth., particularly in horticultural and pharmaceutical literature. It has also been confused with two closely related species: *B. australis* Benth. and *B. pilosa* Plowman (Plowman, 1974).

Brunfelsia uniflora is one of the most widely distributed species of the genus. It occurs throughout southeastern Brazil south to São Paulo, extending northward along the coast nearly to Belém do Pará. Disjunct populations are found in the eastern Andes of southern Bolivia and northwestern Argentina, and in northern Venezuela.

In its native Brazil, this plant was aboriginally known by a number of Tupí names. The most frequent is *manacá* (or its variant *manacán*), a word attributed to the most beautiful girl of the tribe and transferred to the most beautiful flower of the forest (von Marius, 1843). Throughout Brazil, the name *manacá* may be used for any species of *Brunfelsia*. However, in the pharmaceutical trade, the term "*manacá* root" always refers to *B. uniflora* and will be used in this strict sense in this paper.

Other vernacular names of *Brunfelsia uniflora* are related to its use in folk medicine. *Cangambá* and variants *camgâba, cambambá, camganiba* and *caá-gambá* mean the "tree of the gambá". *Gambá* is a species of opossum *(Didelphis cancrivora)*, known as *mucurá* in Portuguese the odor of which the roots of *B. uniflora* are said to emit (Peckolt, 1909; Tastevin, 1922). *Jeratacaca* and variant *jeratacá* loosely translate "snake bite remedy", taken from the native name of the snake *Mephitis suffocans* (Tastevin, 1922). *Umbura-puama* is another name for *manacá* which means "medicine tree" (Peckolt, 1909).

In addition to the indigenous Tupí names, *manacá* also bears several Portuguese common names: *mercurio vegetal* (vegetable mercury, referring to its antisyphilitic properties), *mercurio dos pobres* (poor man's mercury), *flor da Quaresma* (Easter flower), *flor de Natal, Santa Maria* and *boas noites* (Peckolt, 1909).

When the first Portuguese explorers arrived in Brazil, they found *Brunfelsia uniflora* in use by aboriginal Tupí *payés* or medicine men, employed both for healing and magical properties. An extract of the root was a constituent in arrow poisons (Peckolt, 1909).

The first reference to *manacá* root appeared in the literature in 1648 in *De Medicina Brasiliensi*, an early materia medica written by Willem Piso. Piso was a Dutch physician who traveled in northeastern Brazil from 1637 to 1644 with the German physician Georg Marcgraf. Piso's work provided a description of *manacá* root and its uses, as well as a line drawing, the first illustration of the genus *Brunfelsia*. He states that the scraped bark is a strong purgative, resembling scammony (*Convolvulus scammoniae* L.). Piso's remarks and illustration were repeated by Marcgraf in his *Historia Rerum Naturalium Brasiliae*, published posthumously and bound together with the work of Piso.

Manacá was first named scientifically *Franciscea uniflora* by Pohl in 1827. The correct combination *Brunfelsia uniflora* was made in 1829 by David Don, who recognized the similarity of *Franciscea* to the earlier genus *Brunfelsia*. In 1843, von Martius, an outstanding student of Brazilian medical botany, discussed at length the medicinal uses and pharmacological effects of *manacá* root. His observations were very thorough for the time and often copied by later authors. The substance of his account of *manacá* follows:

> "The whole plant, most of all the large root, stimulates the lymphatic system with great efficacy. It melts away the disease-producing parts and eliminates sweat and urine. It is very useful in syphilis and is called 'vegetable mercury' by some. The inner bark and all the herbaceous parts have a nauseating bitterness and are effective for *fauces vellicantes*. A small dose relaxes the body. A larger dose moves the bowels and the urine, produces abortion and expels the venom of snakebites. An excessive dose acts like a bitter poison . . . . Among some tribes of Indians in the Amazon region, an extract of *manacá* is used in arrow poisons."

Further observations on the effects of *manacá* root appeared in 1871 in a work on toxic plants of Brazil by J.M. Caminhoá. Quoting several obscure authors, Caminhoá reported the following effects not mentioned by von Martius: abundant salivation, vertigo, general anesthesia, partial paralysis of the face, swollen tongue and turbid vision. He also mentions the great usefulness of the drug in treating rheumatism.

Baêna, cited by Caminhoá, claimed that *manacá* was used by the Indians to produce "furious delirium and persistent insanity" as well as "confusion of ideas, inconstant delirium and tremor". This is one of the few accounts reporting the use of *manacá* for narcotic or possibly hallucinogenic effects, in this case resembling belladonna intoxication. Another such account is found in a glossary of Tupí names of plants and animals (Tastevin, 1922):

> "One kind of *manacá* has the property of causing intoxication, blindness, and the retention of urine during the day; but after having drunk the infusion of the root or bark of this tree, a man is always happy in his hunting and fishing."

Unfortunately we do not know the specific identity of this kind of *manacá*.

The roots of *manacá* used either fresh or dried and are considered to be the most effective part of the plant. All parts, however, are used medicinally in Brazil. The root is most often powdered or prepared as a fluid extract, of which a usual dose is 10 -30 minims (0.6 -1.8 cc.) three times daily. It is a powerful and energetic healing agent which has been used for many disorders. In recent times, its most general application has been against syphilis and rheumatism, and for its diuretic and diaphoretic properties. The known pharmacological effects and medicinal uses of *manacá* root are summarized as follows:

Summary of Pharmacological Effects of Manacá Root
(Brunfelsia uniflora)

1. Diuretic (von Martius, 1843; Peckolt, 1909; Wren, 1956)
2. Diaphoretic (von Martius, 1843; Brandt, 1895)
3. Purgative (Piso, 1648; von Martius, 1843; Dragendorff, 1898; de Almeida Costa, 1935)
4. Emetic (Dragendorff, 1898; Peckolt, 1909).
5. Alterative (von Martius, 1843; Peckolt, 1909; Wren, 1956)
6. Anesthetic (Caminhoá, 1871)
7. Abortifacient (von Martius, 1843; Brandl, 1895, de Almeida Costa, 1935).
8. Emmenagogue (Peckolt, 1909; Le Cointe, 1947)
9. Antirheumatic (Caminhoá, 1871; Dragendorff, 1898; Webb, 1948; Wren, 1956)
10. Antisyphilitic (von Martius, 1843; Kunkel, 1901; Peckolt, 1909; Webb, 1948)

11. Antiscrophular (Dragendorff, 1898)
12. Poisonous (von Martius, 1843; Brandl, 1895; Le Cointe, 1947; Webb, 1948)
13. Anti-inflammatory (Iyer et al., 1977)
14. Narcotic (Caminhoá, 1871)
15. Stimulates endocrine system (von Martius, 1843; Caminhoá, 1871; Brandl, 1895)
16. Stimulates lymphatic system (von Martius, 1843)
17. Lowers body temperature (Brandl, 1895)
18. Increases blood pressure and respiration (de Almeida Costa, 1935)
19. Produces parasthesia (Peckolt, 1909)
20. Produces muscular tremors and cramps (Brandl, 1895; de Almeida Costa, 1935)
21. Produces delirium, vertigo and clouded vision (Caminhoá, 1871)
22. Activates peristalsis (Brandl, 1895)

The leaves of *Brunfelsia uniflora* are also employed medicinally but only in the fresh state (Peckolt, 1909). They are considered to be less active pharmacologically than the roots. The leaves are most commonly used as an antidote for snakebite. A tincture is prepared and given in frequent doses to the victim, and a poultice of the leaves is placed directly on the wound to "draw out the poison". Poultices are also employed for skin disorders such as eczema and syphilitic ulcers. The bark and young shoots of *manacá* are considered resolvent and, in high doses, emetic (Pereira, 1929). By means of ether, a perfume is extracted from the fragrant flowers (Corrêa, 1909).

The first systematic investigations of *manacá* root began about 1880, when the drug stirred some interest among chemists and pharmacologists in Germany and in the United States. In 1880, J. L. Erwin attempted to determine the general classes of constituents in the root. He failed, however, to find any compound which could account for its potent effects. Brewer, in 1882, performed the first pharmacological studies with *manacá* by observing the effects of the fluid extract on cats and frogs and on himself. He concluded that *manacá* acts chiefly on the spinal chord by first stimulating, then abolishing the activity of the motor centers, with similar action in the respiratory center. All the glands were markedly stimulated, including salivary, gastric, intestinal, cutaneous, and the liver and kidneys. He found no effects on the brain or sense organs.

Brewer's self-experiment with *manacá* root furnishes us with a rare, firsthand account of the effects on humans. Taking the fluid extract on a full stomach, he experienced a feeling a restlessness followed by lassitude, a profuse sweating and an increase in amounts of saliva and urine.

In 1884, Lenardson, a student of Dragendorff working in Dorpat (now Tartu in Estonia), discovered an alkaloid in *manacá* root, the first to be isolated from the root. He named the compound *manacine*, which he characterized as an amorphous, hygroscopic yellow powder with the empirical forumula $C_{15}H_{23}N_4O_5$ and a melting point of 115°. Manacine was soluble in water and alcohol but insoluble in benzene, ether and chloroform. It produced non-crystalline precipitates with several alkaloid precipitation agents. In addition to manacine, Lenardson found a fluorescent substance which he thought to be gelseminic acid.

A second alkaloid *franciscein* was reported from *manacá* root in 1887 by Lascelles-Scott, but this was never substantiated by isolation and identification of the compound.

The most complete study on *manacá* root during this period was conducted by Brandl in Germany (Brandl, 1895; Beckurts, 1895). He summarized Lenardson's dissertation and presented the results of his own detailed chemical and pharmacological investigations.

Brandl confirmed Lenardson's discovery of manacine but claimed a different empirical formula $C_{22}H_{33}N_2O_{10}$ and melting point of 125°. From the residue remaining after the alcoholic extraction of manacine, Brandl found an additional substance which he named *manaceine*. He characterized this constituent as an amorphous, white, highly refractive compound, soluble in water but insoluble in ether, chloroform and benzene. Brandl gave the empirical formula $C_{15}H_{25}N_2O_9$ for manaceine. When heated with water, manacine splits into manaceine and a resinous, fluorescent substance which he considered to be the aglycone esculetin (6, 7-dihydroxycoumarin). Although Brandl managed to isolate two alkaloids from the root, he never obtained a crystalline compound, nor was he able to characterize their structures.

Schultes (1966) suggested that manacine is an "atropine-like" alkaloid. There is in fact no basis for this statement.

Manacine actually shows the opposite effects of atropine which inhibits rather than stimulates glandular secretions. At the present, the structural identity of manacine remains unknown.

Brandl, following the work of Brewer, conducted pharmacological experiments on frogs, rabbits and guinea pigs, using the manacine and manaceine of his extractions. He found manacine to have an intense action, even in small doses. In mammals, it induced strong muscular tremors and epileptiform cramps, lowered temperature, followed by death due to respiratory paralysis. All the glands were strongly stimulated, as Brewer had observed earlier. Peristalsis was also increased. Glandular stimulation, but not peristalsis, was blocked by atropine. Frogs showed a general paralysis after an initial period of unrest, followed finally by heart arrest in diastole. With manaceine he observed a similar but less intense action.

Peckolt (1909) repeated some of Brandl's work on *manacá*. He found two products in the root, manacine and another alkaloid which he named *brunfelsine*, but he offered no further characterization of either compound. He stated that the seeds of another species, *Brunfelsia brasiliensis* (Spreng.) Smith & Downs [reported as *B. ramosissima* (Pohl) Benth.], contain 1.14% brunfelsine but no manacine. Hoppe (1958) stated that the leaves and seeds of this species contain both manacine and brunfelsine. In its native Brazil, *B. brasiliensis* is considered poisonous according to data from herbarium specimens *(V. Assis 142)*.

Pammel (1911) listed two alkaloids for *manacá* root, manacine and mandragorine. "Mandragorine" is a name given to an alkaloid isolated in 1889 from *Mandragora officinarum* L. This was later shown to be a mixture of l-hyoscyamine, l-hyoscine (l-scopolamine) and a new alkaloid known as mandragorine. This compound bears the empirical forumla $C_{15}H_{19}O_2N$ and forms a crystalline aurichloride with a melting point of 124-126°. On hydrolysis, it yields tropic acid and a base resembling tropine (Henry, 1949; Manske & Holmes, 1950). There have, however, been no subsequent reports of tropane alkaloids in *Brunfelsia* species.

More recently, the identity of the crystalline, blue-fluorescent substance in *manacá* root has been identified (Mors & Ribeiro 1957). It had earlier been determined as gelseminic acid by Lenardson (1884) and as esculetin by Brandl (1895). This constituent is now known to be the aglycone scopoletin (6-methoxy-7-hydroxycoumarin) of the lactone glycoside scopolin. It is found in all parts of the plant and in several other species as well: *Brunfelsia pauciflora* (C. & S.) Benth. (reported as *B. calycina* var. *macrantha* (Lem.) Bailey & Raffill), *B. brasiliensis* (reported as *B. ramosissima*) and *B. grandiflora* D. Don. Machado de Campos (1964) found much smaller amounts of scopoletin in the seeds of *B. uniflora* and *B. grandiflora*. This compound occurs in several other genera of Solanaceae including *Atropa*, *Solanum* and *Lycopersicon*. It may function as a regulator of growth processes in plants but is not known to be pharmacologically active in humans.

With the exception of anatomical and pharmacognostic studies on *manacá* root (Hahmann, 1920; de Almeida Costa, 1935), only one recent paper has appeared on the nature and action of the drug. Iyer *et al.* (1977) conducted hippocratic screening in rats of whole root and extracts of *Brunfelsia uniflora* (reported as *B. Hopeana*). Administered intraperitonially, the whole root showed the following dose-related symptoms: decrease in spontaneous motor activitiy, irregular respiration, paralysis of hind and forelegs, analgesia, mixed convulsions, hypersensitivity to sound, increase in pupil size and slight diuresis. These symptoms, indicating CNS depressant activity, were concentrated in a chloroform extract ("F"), the lethal dose of which was about half that of the whole root. The authors also showed that this fraction has marked anti-inflammatory activity when compared with phenylbutazone in reducing carrageenin-induced pedal edema in rats. These workers are currently undertaking a detailed investigation of the components of the chloroform extract.

Currently, *manacá* root is fully recognized in the Brazilian pharmacopeia and is considered a valuable remedy in that country where folk medicine is still very important in rural areas. Like many poorly known drugs of plant origin, *manacá* has been generally discredited in the United States for "lack of convincing evidence of its usefulness" (Osol and Farrar, 1955).

This constitutes an unjust appraisal of a potent drug with a possible future in treating rheumatism and arthritis.

2. **Brunfelsia Mire** Monachino

In 1921, H.H. Rusby of Columbia University took part in the Mulford Biological Expedition to the Amazon. During this trip he collected a plant called *miré* in the Yungas region of Bolivia. The plant was sterile at the time of collection but Rusby noted its resemblance to *manacá (Brunfelsia uniflora).* He reported that the Indians of the region employed *miré* to expel cutaneous parasites and to "paralyze the voluntary muscles as in an alcoholic intoxication". They boiled the plant to extract the drug, a process which apparently does not injure the active constituents. *Miré* produced a profuse sweating capable of destroying all cutaneous parasites but with no disturbance of the senses or intellect (Rusby, 1924).

Concurrently with Rusby's initial report, T. S. Githens published his pharmacological studies on the effects of *miré*. He confirmed the drug's paralyzing effect on the voluntary muscles through an action on the spinal chord. He also observed stimulation of the peripheral motor-apparatus indicated by muscular twitching. Both the sweat and salivary glands were stimulated in rabbits and frogs (Githens, 1924).

Two years later, Githens (1926) published an article on the chemistry of *miré*. In analyzing extracts of the root and stem, he isolated three principles:

1. A strongly fluorescent body soluble in alcohol, ether and chloroform but insoluble in water. In mice, this portion caused paralysis, but without twitching of the muscles.
2. An alkaloid soluble in alcohol but precipitated from alcoholic solution by ether. He found 0.3% crude alkaloid which was pale yellow in freshly prepared solutions but soon became a reddish wine color on standing. This fraction was very active physiologically.
3. A second alkaloid was present which was soluble in alcohol but not precipitated by the addition of ether. This body corresponded to 0.5% of the root and gave a permanently pale

yellow solution. Its action resembled that of the first alkaloidal portion.

Miré was identified in 1925 as *Brunfelsia hydrangeiformis* (Pohl) Benth. by Youngken, who carried out a detailed pharmacognostic study of *miré*. *Miré* is now known to constitute a distinct species, *B. Mire*, described by Monachino in 1957. The plant is found in parts of Amazonian Peru and Brazil and is a close relative of *B. hydrangeiformis* which is restricted to southeastern Brazil.

The findings of Rusby and Githens on *miré* recall the earlier studies on *manacá* root, especially the occurrence of two similar alkaloidal fractions and a strongly fluorescent substance. In addition, the stimulation of the sweat and salivary glands are likewise known in *manacá*, suggesting that similar types of compounds may occur in unrelated species of the genus.

One herbarium collection of *miré (Cárdenas 2813)* bears the interesting comment that cattle die when they eat the leaves, a further indication of its toxic activity. Two other species, *B. brasiliensis* and *B. grandiflora*, are also reported to be poisonous to cattle. *B. Mire* remains relatively unknown from chemical and pharmacological standpoints and clearly merits additional phytochemical work.

3. **Brunfelsia grandiflora** D. Don

Brunfelsia grandiflora is widely recognized in the upper Amazon for its potent drug effects. Yet its identity and uses have long been obscured in the literature by misidentifications and confused ethnobotanical reports. Specimens of *B. grandiflora* in herbaria are consistently and erroneously determined as *B. latifolia* (Pohl) Benth., *B. maritima* Benth. or *B. bonodora* (Vell.) Macbr. There have been numerous notes on herbarium labels that this species is medicinal, narcotic and/or poisonous, but reports in the literature are sparse and misleading.

Beginning in 1967 and in later publications, Schultes brought to the fore the question of the possible use of *Brunfelsia* as a hallucinogen, referring specifically to its widespread cultivation in the Colombian Putumayo (Schultes 1967, 1969, 1970a, 1970b, 1970c; Schultes & Hofmann, 1973). He suggested that this species (reported originally as *B. maritima*) may have been employed more extensively in the past and that, as native peoples have become acculturated, its use has died out.

Brunfelsia grandiflora is distributed throughout western South America from Venezuela south to Bolivia and east to the Brazilian Amazon. It is also extensively cultivated in the American tropics as an ornamental. However, only in western South America are its curious medicinal properties recognized by native healers. *B. grandiflora* has one subspecies — subsp. *Schultesii* Plowman — recognized chiefly by its much smaller flowers and fruits. Both forms, however, seem to be used interchangeably in folk medicine. Subsp. *Schultesii* is more widespread in the lowlands and the form more likely to be employed.

Many different Indian tribes in the Amazon region are acquainted with this species, and it is known by many vernacular names. The most widely used names are *chiricaspi* and *chiric sanango,* both Quechua words, found in southern Colombia and Amazonian Peru respectively. *Chiricaspi* means "cold tree"; *chiric sanango* signifies "cold medicine". Both names incorporate the Quechua word *chiric* which means "cold", in reference to the sensation of chills reputedly produced upon ingestion of the roots or bark. *Chiric guayusa* is another variant found in lowland Ecuador (Pinkley, 1969).

Brunfelsia grandiflora, like other plants which yield potent drugs, has multiple uses: as a medicine, as a narcotic and, in higher doses, as a poison. By no means exclusive of each other, these classes of usage frequently intergrade in everyday reality.

Brunfelsia grandiflora as a Poison

Schultes (1967) mentions that this plant is considered poisonous to cattle near Leticia in the Colombian Amazon. Data from herbarium specimens collected in Bolivia (*Steinbach 1805, 5487*) also indicate that the plant is very poisonous, especially to cattle which occasionally eat the foliage. Another collector (*Heinrichs 4961*) states that the roots are employed in Ecuador as a fish poison.

Brunfelsia grandiflora as a Medicine

Collectors of the species frequently mention the effect of cold or chills produced when the ground bark or root is taken (*Cuatrecasas 11275, Mexia 6444, Pinkley 43, 202, 444, 450, 457, Plowman 2019*). Other reports indicate that the roots are employed against rheumatism (*Mexia 6444, Plowman 2494, Woytkowski 6170*). Still other workers have stated that the plant is used against fevers (*Juajibioy 277; Pérez Arbeláez 688; Plowman 2040*), against snakebite (*Scolnik 1495*) or simply that it is medicinal (*Woytkowski 5525*).

My field work and that of others in the Amazon basin have served to substantiate these often vague claims of physiological activity. In the region around Iquitos, Peru, and probably throughout most of the Peruvian Amazon, *Brunfelsia grandiflora* is one of the most important medicines against rheumatism and arthritis. One informant, a Kokama Indian from the Río Ucayali, provided the following recipe for preparing the drug (Tina, 1969):

> "The root is scraped and placed in cold water or *chicha de maíz*. This is then taken in wineglassful doses. To increase the dose, the bark of other trees may be added, including *remocaspi* (*Pithecellobium laetum* Benth.), *chuchuhuasi* (*Heisteria pallida* Engl.) and *huacapurana* (*Campsiandra laurifolia* Benth.). The root of *chiric sanango* may also be prepared with *aguardiente* (cane alcohol). About 50 grams of scraped root and bark are added to one liter of alcohol. A small glass is then drunk before meals until four liters have been consumed."

Pinkley, who worked extensively on the ethnobotany of the Kofán tribe of Ecuador and Colombia, found that the lowland Quechuas on the Río Napo in Ecuador also utilize *Brunfelsia grandiflora* as a remedy for rheumatism:

> "They take it if they have a burning in the lower part of their back. They place their hands in the area of the kidneys. Upon

> making a drink from the leaves in hot water, they become extremely chilled after drinking." (Quoted in Schultes, 1966).

Pinkley (1969) later added that the Kofáns of the Putumayo also use the plant for high fevers and severe back pains.

The leaves of this plant are also employed in the Iquitos region as a cure for bronchitis (Tina, 1969):

> "Twelve fresh leaves of *chiric sanango* are crushed up, then squeezed and the juice mixed with a little water. A spoonful is drunk twice a day, in the morning and at evening during three days."

In contrast to the root and bark, the leaves reputedly do not cause nausea.

The Siona Indians of the Colombian Putumayo similarly employ *Brunfelsia grandiflora* as an analgesic to alleviate pain. They say that it has a strong numbing effect, permitting one to walk long distances, even if the feet ache (Langdon, 1972). In an isolated report, Steward and Métraux (1948) state that the Chama Indians of Peru take the roots of *Brunfelsia grandiflora* as an aphrodisiac. The method of use is not given.

Brunfelsia Grandiflora as a Hallucinogen

This species has long been suspected of possessing narcotic or hallucinogenic properties (Schultes, 1966, 1967; Schultes & Hofmann, 1973). Herbarium labels from Peru (*Tessmann 3243*) and southern Colombia (*Bristol 1364*, *Pinkley 420*) indicate that the plant is a *borrachera*, a term which translates "intoxicant" and which is applied to the narcotic tree Daturas and other plants. Friedberg (1965) and Pinkley (1969) first disclosed that *Brunfelsia* species serve as admixtures to the hallucinogenic drink *ayahuasca* or *yagé* prepared from *Banisteriopsis Caapi*.

In 1928, the French botanist Benoist published a new species, *Brunfelsia Tastevinii*, which he claimed was used as a hallucinogen in the Brazilian Amazon. Benoist named the plant for its discoverer P. Tastevin, a missionary and anthropologist who reported its use among the Kachinaua tribe of the Rio

Jordão, a tributary of the Rio Tarauacá. I have examined the type specimen of *B. Tastevinii* which is preserved at the Museum of Natural History in Paris. This plant is clearly *B. grandiflora* and Benoist's *B. Tastevinii* must therefore be placed in synonymy with this species.

The Kachinaua were said to cultivate the plant, which they called *keya-honi*, and to prepare a beverage from it. The effects of *keya-honi* were described by Tastevin as follows:

> "The juice of this plant plunges them [the Indians] into a kind of intoxication or stupefaction which lasts a little more than a quarter of an hour and from which they acquire magical powers, enabling them to heal all sorts of diseases through incantations. While the effects of the drink act on their brains, they are unable to fall asleep. They believe they see all kinds of fantastic animals: dragons, tigers, wild boars, which attack them and tear them to bits, etc. This action of *honi* lasts four or five hours depending on the quantity ingested."

This account raises some points of skepticism. The description of the effects of *keya-honi* is strikingly similar to that often given for *Banisteriopsis* intoxications (Rivier & Lindgren, 1972; Naranjo, 1973) and unlike any other reports of *Brunfelsia* intoxication. It is my contention that Tastevin confused these two plants. He himself stated earlier (Tastevin 1926) that the Kachinauas of the Upper Tarauacá knew and esteemed *caapi* (*Banisteriopsis*) for "learning the future, conversing with spirits, or dispelling bad luck". He further stated that the Panoan name for *caapi* is *keya-honi* or simply *honi*, "the liana". It seems possible that he was shown a plant of *Brunfelsia* used as an admixture to *caapi* and took it to be the main ingredient of the hallucinogenic mixture. Studies of hallucinogen use among the Kachinaua in neighboring Peru (Der Marderosian et al. 1970; Kensinger, 1973) demonstrated the use of *Banisteriopsis* and *Psychotria* species to prepare the hallucinogenic drink called *nixi pai*. No mention is made of *Brunfelsia* admixtures, and it is possible that knowledge of the use of this drug is dying out, at least among certain segments of the tribe.

Other reports of the use of *Brunfelsia* as an admixture to *Banisteriopsis* preparations are more substantial. In Iquitos, Peru, *B. grandiflora* is added to *ayahuasca* "to give more strength." It reputedly makes a sound "like rain in the ears" (Tina, 1969). A Witoto Indian living at Puca Urquillo on the Río Ampiyaco (Peru) informed me that *chiric sanango* is taken to gain strength at the new moon. The bark is scraped and mixed with cold water to prepare the beverage.

The Jívaro of Amazonian Ecuador and Peru are famous for their ritual use of *Banisteriopsis Caapi,* which they call *natemä,* to achieve trance-like states (Harner, 1968). A Canadian businessman, D. C. Webster, reported in a letter to R. E. Schultes the use of three plants in the preparation of the *natemä* drink among the Jívaro, along with photographs of the plants. Besides *natemä* (*Banisteriopsis*), they included chiricaspi (*Brunfelsia grandiflora*) and an unidentified liana called *hiaji.* To prepare the drink, the *natemä* is cut up into small pieces and boiled for at least 14 hours. Then the second two ingredients, also cut up, are added and the mixture boiled down to form a thick, muddy liquid (Webster, 1970).

The supposed effects of this *natemä* mixture, in addition to strong visual hallucinations, include the "melting away of disease" with beneficial effects against arthritis, intestinal parasites, tuberculosis, and poor vision. This is a good example of shamanistic healing methods, in which a strong hallucinogen provides the necessary spiritual contact with the forces of illness, while other potent herbal admixtures give specific therapeutic effects. In this preparation of *natemä,* the antiarthritic effects may be attributable to the addition of *Brunfelsia*.

Brunfelsia is known to play a part in shamanistic practices in still other tribes. Shamans often invoke the aid of a particular spirit helper in their healing ceremonies, which may take the form of a bird, snake, insect or plant. Shamans of the Lama tribe, who inhabit the region just west of Tarapoto in northern Peru, consider *B. grandiflora* a spiritual guide (Steward, 1948). Steward writes in the Handbook of South American Indians:

> "The neophyte sorcerer dieted and took tobacco juice, cigars, *ayahuasca,* and uniquely, *Brunfelsia grandiflora* and another liana. He acquired a general power from these plants but no internal "thorns". To cause illness, he impregnated a splinter with his power and cast it at his victim. To cure it, a shaman sucked out the splinter." (Steward & Mètraux, 1948).

In southern Colombia, particularly the Putumayo region, *Brunfelsia* is also added to *Banisteriopsis* preparations among several tribes, including the Siona, Kofán and Inga. Among the Inga, several classes of *chiricaspi* are recognized. All of these are considered febrifuges and the term seems to be generic for plant medicines exhibiting this effect. Three kinds of *chiricaspi* are referable to *B. grandiflora: picudo* "beaked" *chiricaspi*, *salvaje* "wild" *chiricaspi*, and *chacruco* "of cultivated ground" *chiricaspi*. Of these, *picudo chiricaspi* is considered to be the strongest variety. To counteract fevers, a small stem 30 cm. long is used. The bark is scraped in cold water, let stand for two hours, then drunk. An Ingano *curaca* or healer at Mocoa told me that if three stems are used, one becomes intoxicated as with *yagé* and that it makes the whole body cold. *Chacruco* and *salvaje chiricaspi* do not differ morphologically from *picudo chiricaspi* but may represent chemical races of the plant. A fourth class of *chiricaspi* — *calentura* "fever" *chiricaspi* — is also known to the Inga. This shrub which grows in primary forest has been identified as *Stephanopodium peruvianum* P. & E. (Dichapetalaceae). The leaves are taken in cold water against fevers, as the vernacular names suggests. To date, no alkaloids have been encountered in this family (Raffauf, 1970).

Another tribe of the Putumayo, the Siona, also employs *Brunfelsia grandiflora* which they designate generically as *huha hai*. Two classes of *huha hai* are recognized. *Yai huha hai* is not cultivated but collected wild in the forest. Jean Langdon, an anthropologist working with the Siona, supplied the following account of *yai huha hai* along with voucher specimens collected by an informant:

> "The plant is used as a drink to give visions as well as to alleviate pain. To drink it, they grate the stem and drink the juice that comes out. The leaves can also be used if they are mashed up. Nothing else is added to the preparation, but it is often taken in conjunction with *yagé* or *yoko (Paullinia Yoco)*. If taken with *yagé*, it is drunk before drinking *yagé*."

The Siona describe the effect of *yai huha hai* as one of extreme coldness. It supposedly dulls all pains. The second class of *huha hai* is cultivated and known as *bi'a huha hai*. It is cooked with *yagé*. Another Siona informant volunteered the following: "It makes you shiver when you drink *yagé*. It also makes your legs heavy and you feel like spines are sticking you. It is *fresco*, so it is good for curing sickness, as well as drinking with *yagé*." (Langdon, 1970).

The Kofán Indians of the Putumayo area are likewise familiar with the medicinal and intoxicating properties of *Brunfelsia*. Pinkley (1969, 1973) has stated that *Brunfelsia*, while not a common admixture to *Banisteriopsis*, among certain groups plays a role similar to that of *Brugmansia* in the magico-religious ceremonies of the shaman. *Brunfelsia grandiflora* is sometimes taken by the Kofán shaman in order to diagnose disease (Pinkley, 1973).

The Kofán, like other groups in the Putumayo, recognize three classes of *Brunfelsia* which are generically known as *tsontinba''k'o* in the Kofán language. Two of these are referable to *Brunfelsia grandiflora* and are distinguished primarily by where they grow. *Soci* (toucan) *tsontinba''k'o* is cultivated in houseyards around their settlements. *Chipiri* "small" *tsontinba''k'o* grows wild in the surrounding secondary forest.

4. **Brunfelsia chiricaspi** Plowman

The third kind of *Brunfelsia* known to the Kofán is called *covi* "tapir" *tsontinba''k'o*. This plant is considered to be the strongest of the *tsontinba''k'o* class and preferred for its potent drug effects. It belongs to a recently described species *Brunfelsia chiricaspi* Plowman, known only from the Colombian Putumayo and south to the Río Coca in Ecuador. This species occurs only in primary forests and is not cultivated.

While conducting ethnobotanical field work and general collecting in 1968, I visited the Kofán village of Santa Rosa on the Río Guamués, in order to study firsthand the use of *Brunfelsia* and other medicinal plants. The Kofán settlements in the Colombian Putumayo are being subjected to rapid changes as a result of large scale oil drilling operations in their territory. This made the Indians especially suspicious of strangers and highly protective of their medicinal plant lore.

I made contact with an old man in the village, who was considered knowledgeable about plants and medicines. After some time, I asked him about the use of *tsontinba''k'o* and *yagé*. He informed me that hardly anyone uses this medicine anymore because it is considered very dangerous. He disavowed any knowledge of *yagé* or of taking *tsontinba''k'o* for visions. Since it seemed no more information would be forthcoming, I asked the old Kofán to demonstrate the preparation of *covi tsontinba''k'o* for me and my companion, a Kamsá Indian from the Sibundoy Valley. He reluctantly agreed to do it and we decided to drink the drug at his small hut. In view of the complete lack of firsthand experiments with this *Brunfelsia*, I include the following account of the effects of *B. chiricaspi:*

> December 3, 1968: Village of Santa Rosa, Río Guamués, Comisaría del Putumayo, Colombia.
>
> "My companion, Pedro, and I arrived at Santa Rosa from San Antonio well before sunset on the night our Kofán *curaca* had chosen to prepare *covi tsontinba''k'o*. The *curaca* did not return to the village until nearly dark, carrying with him a handful of scraped bark which he had collected in the nearby forest. He said the plant is not common and he had had difficulty finding it. He extracted the juice of the greenish brown bark in a cup of cold water by wetting the bark and squeezing it repeatedly until the liquid became a murky light brown color. He then handed each of us half a cupful. The drink had a very bitter taste and pungent odor. We drank it quickly and sat down on the front porch of the *curaca*'s hut.
>
> "The effects of the drug appeared within about ten minutes. I first felt a tingling sensation in my lips, followed soon by the same sensation in my fingertips. This felt exactly like the feeling experienced when your leg "falls asleep", when the blood rushes back. Along with the tingling, I felt a pronounced vibrating in the affected parts.
>
> "The tingling soon spread into my mouth and upwards into my face; later into my hands and feet, tongue, elbows, and shoulders. After about an hour, the sensations were felt generally throughout my body, especially in my back, legs, face, lips and hands. There was a definite progression of the tingling from the base of my spine upwards towards the back of the neck, with ever-increasing intensity which centered at the base of my skull.
>
> "From the beginning I felt a strong urge to expectorate periodically and later realized that I was actually frothing at the mouth. In spite of the extraordinary sensations running through my body, I remained mentally lucid. I felt quite agitated from the

strong tremors produced by the drug. I was also seized by periodic waves of cold, as frequently reported by the natives.

"I next felt the tingling sensations and vibrations enter my head and scalp. Moving my head or hands increased the intensity of the sensations. The vibrations felt electric, penetrating my chest and back. Even then my thinking remained undisturbed though somewhat detached.

"After another hour, I began feeling sharp stomach cramps and occasional spasms of nausea. I wanted to vomit but could not. We had fasted since the previous day according to the *curaca*'s instructions. The tingling remained very intense in my hands and feet and my head began to ache. A bitter taste developed in my mouth and I felt vaguely cold.

"Sometime later — I was incapable of telling time at this point — I began to get used to the tingling sensations, which I found disquiting at first. I could not tell if I was becoming stronger or weaker. I became very dizzy with vertigo, which intensified precipitously. Everything started spinning to the right yet never seemed to move. My mind kept adjusting to the spin to set me right agin. There was a complete loss of muscular coordination at this point, and I could no longer walk or even stand up. I lay either prone or sat on the floor with my back against the wall for the rest of the night. The pains in my stomach became more acute. I continued to be nauseous and vertiginous and felt extremely uncomfortable.

"During the course of the evening, the *curaca* went to bed. We did not see him for the rest of the night except for a brief appearance upon our departure. Since we were feeling increasingly out of sorts in this strange place, we decided to return to the nearby village of San Antonio where we were staying in an abandoned jail cell. It was very difficult to move or stand up, but eventually we mustered enough strength to start for home. This took at least an hour with Pedro and I supporting each other, frequently stumbling and crawling along the dark trail through the forest.

"When we arrived in San Antonio, we climbed into our hammocks to rest. I lay awake for a long time, still feeling the drug in my body, particularly the tingling. The stomach cramps and vertigo began to subside, and eventually I fell asleep, completely exhausted both mentally and physically. The next day, I felt extremely weak and nearly unable to move without great discomfort. I became very dizzy if I tried to stand up or walk. I could not eat anything and remained in my hammock. Only after two full days did I begin to recover and move around without becoming dizzy."

My companion later noted the following effects which he experienced with the drug: "swollen lips and heavy tongue, crazy in the head, cold sweat, stomach ache, nausea and weak vomiting, urtication, inability to walk or move, and vertigo". He also felt "the world was spinning around me like a great blue wheel. I felt that I was going to die".

The effects described above correspond in some respects to accounts in the literature of the effects of other species of *Brunfelsia*, especially *B. grandiflora*. The notable tingling sensation, or parasthesia, apparently results from a peripheral vasal constriction of the capillaries. A well known drug with this effect is nicotine, and the same reaction is frequently reported in persons who have smoked their first cigarette. The increased stimulation of the salivary and sweat glands is highly reminiscent of the effects of *manacá* root discussed earlier.

In view of the toxic effects which we experienced from *Brunfelsia chiricaspi*, it seems unlikely that anyone would knowingly ingest the plant in this dose except possibly in a desperate medical situation. More likely, smaller amounts are used which become further diluted when mixed with extracts of other plants such as *yagé*.

We may also ask the question: why is *Brunfelsia* used in preparing *yagé*? Certainly its medicinal properties are important in this respect, for the use of *yagé* is grounded in its medicinal applications. *Yagé* itself is a strong purgative and may have vermicidal and bactericidal properties as well. Both these plants would then serve as strong medicinal agents irrespective of their psychological or hallucinogenic effects. These are, however, of equal import to the shaman.

It is well established that *Banisteriopsis caapi*, besides being a purgative, is a strong visual and perhaps auditory hallucinogen. Sundry other plants may be added to preparations of *B. caapi* to vary and intensify the experience. Most notable among these are the leaves of *Banisteriopsis Rusbyana* and *Psychotria viridis* (Pinkley, 1969; Rivier & Lindgren, 1972). Both of these plants contain the potent hallucinogen N,N-dimethyltryptamine as their main active constituent, the effects of which differ somewhat from the harmine derivatives found in *B. Caapi* (Agurell *et al.*, 1968; Der Marderosian *et al.*, 1968, 1970). Since N,N-dimethyltryptamine also produces strong visual effects, we can readily see why the shaman would include these plants in his brew.

Since *Brunfelsia* species appear to produce no striking visual hallucinations, we must look further for the rationale for including these plants in *yagé* preparations. Of the diverse physical effects of *Brunfelsia*, I would single out the tingling sensations as the most pronounced and bizarre and those which might best potentiate the hallucinatory *yagé* experience. By using smaller doses than I ingested, the Indians would be able to produce striking tactile hallucinations without the toxic side effects. The combination of these drugs may produce, perhaps synergistically, unique and other-worldy experiences and sensations. Because one often feels decreased sensitivity and numbness in the body with *yagé* alone, the addition of *Brunfelsia* to the drink may also serve to create a greater physical awareness during the ceremony.

Although each of these potent psychoactive plants is employed individually for their specific effects, their use in combination was learned and perfected by native shamans through centuries of experimentation. Only these skilled practitioners fully understand the delicate questions of dosage and correct admixture to achieve specific physical and psychic effects.

5. **Miscellaneous species**

Other species of *Brunfelsia* are known to contain active constituents such as alkaloids or to be used medicinally. Some of these such as *B. brasiliensis* and *B. pauciflora* have already been mentioned. The fruits of *B. australis*, a species of Argentina and Paraguay, are added to food as a condiment by the Guaraní Indians. Known as *azucena* or *jazmín del monte*, *B. australis* is noted on herbarium labels as being medicinal or poisonous. The root is used as *B. uniflora* as a remedy for syphilis (*Woolston 571*), and the foliage is reputed to be harmful to horses (*Pederson 10210*). *B. guianensis* Benth., which grows in Amazonian Brazil as well as the Guianas, is also used like *B. uniflora* — as an antisyphilitic, antirheumatic, depurative and poison in high doses (Le Cointe, 1947).

Brunfelsia species in the Caribbean are also known to be employed medicinally, though not nearly so commonly as in South America. *Brunfelsia americana* L., the most widespread species in the Antilles, bears an astringent fruit which has been used as a tonic to cure chronic diarrhea and stomach problems (Descourtilz, 1833; Duss, 1897; Manfred, 1947). In the island of Dominica, it is called *empoisonneur* and is employed as a poison by the Island Caribs (Hodge & Taylor, 1957). Traces of cyanide have been found in the leaves and flowers as well as in the bark of the stem and root (Quisumbing, 1951). Chlorogenic acid is reported from the leaves (Politis, 1948).

Scott and colleagues (1957) tested the leaf and stem of *B. americana* for alkaloids. They found two products: one a crystalline substance which melted at 125-130°; the other consisted of long needles which melted at 218-220°. They obtained positive alkaloid tests for both products but did no further work on the plant.

Brunfelsia nitida Benth., a widely cultivated Cuban species, is used for herbal baths (Roig & Mesa, 1945). The fruits of this species were found to be strongly alkaloid-positive (Alemán Frías, 1972). Unnamed alkaloids have also been detected in the stems of *B. undulata* Sw., a Jamaican species (Willaman & Schubert, 1961); Willamam & Li, 1970), and in the leaves and fruits of *B. Shaferi* Britt. & Wils., a Cuban endemic (Alemán Frías, 1972).

In conclusion, the need for modern detailed studies on the pharmacology and chemistry of *Brunfelsia* cannot be overemphasized. I have outlined here what is known about the folk uses and pharmacology of the species known to be active. However, the entire genus merits intensive investigation to isolate and identify its alkaloidal and other constituents, which have eluded chemists for so long. The possible value of certain species in the treatment of arthritis and rheumatism is especially important and worthy of detailed study using modern methods.

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PLATE 63

Folia habet citriis haud diſſimilia, paulo tamen longiora & molliora, & qualitate refrigerandi & abſtergendi prædita.

Præter alias dotes, quibus excellunt, vulneribus atque ulceribus opitulantur, parteſque vitiatas reparant. Cujus rei Chirurgi noſtri non ignari, ea in quotidianum uſum colligunt.

Raro videas viatores iter ſuſcipere, niſi probe hoc remedio inſtructos.

Succus oleoſus denique è ſiliquis expreſſus, ad maturanda apoſtemata reſervatur, & applicatur cum proſpero ſucceſſu.

CAP. XLIII.

De Manaca frutice, ejuſque facultatibus.

Locis umbroſis, maxime circa *Aldeam Tapicirica* luxuriat Frutex arboreſcens *Manaca*, cortice gryſeo, ligno duro quidem, ſed fragili, ex albo cinenitio, foliis acuminatis.

Flores fert exiguos, quorum alter cœruleo, alter vero (quod ut rarum, ita maxime jucundum) lacteo nitore niteſcit: Menſe Januario vegetus & valde ſpecioſe floreſcens conſpicitur, atque integras ſilvas inſigni fragrantia Narciſſi æmula implet.

Flori ſuccedit fructus baccæ Juniperi ſimilis, ſed inutilis.

Radicem habet magnam, ſolidam & albicantem, cujus medulloſa ſubſtantia in pulverem redacta, magna in Medicina pollicetur & præſtat.

Incolæ pæne omnes, tam Luſitani quam Braſiliani, licet magni æſtiment, tamen ob indomitas operationes hactenus in uſum admittere vix auſi fuerunt. Quippe periculo non vacat hoc genus medicamenti, quod nimis violenter corpus ſuperne & interne moveat. Quamobrem tantum hominibus robuſtiſſimis exhiberi ſolet, idque additis correctoriis, tum & juſta obſervata doſi, quæ Scammonęi potius inferior quam ſuperior eſſe debet: ad illud enim validum medicamentum proxime accedit hæc radix; verum non ita inſipida eſt, amarore enim & acore non plane deſtituitur.

L 3 CAP.

Plate 63. First Description and Illustration of *Manacá* Root (*Brunfelsia uniflora*) in Piso's *De Medicina Brasiliensi* (1648).

PLATE 64

Plate 64. Illustration of *Brunfelsia uniflora* in von Martius' *Flora Brasiliensis*, vol. 8 (1): plate 43. 1862.

PLATE 65

Plate 65. Medicinal Parts (Roots and Stem) of *chiric sanango* (*Brunfelsia grandiflora* subsp. *Schultesii*) collected on the Amazon River near Puerto Nariño, Amazonas, Colombia (*Plowman et al.* 2407).

PLATE 66

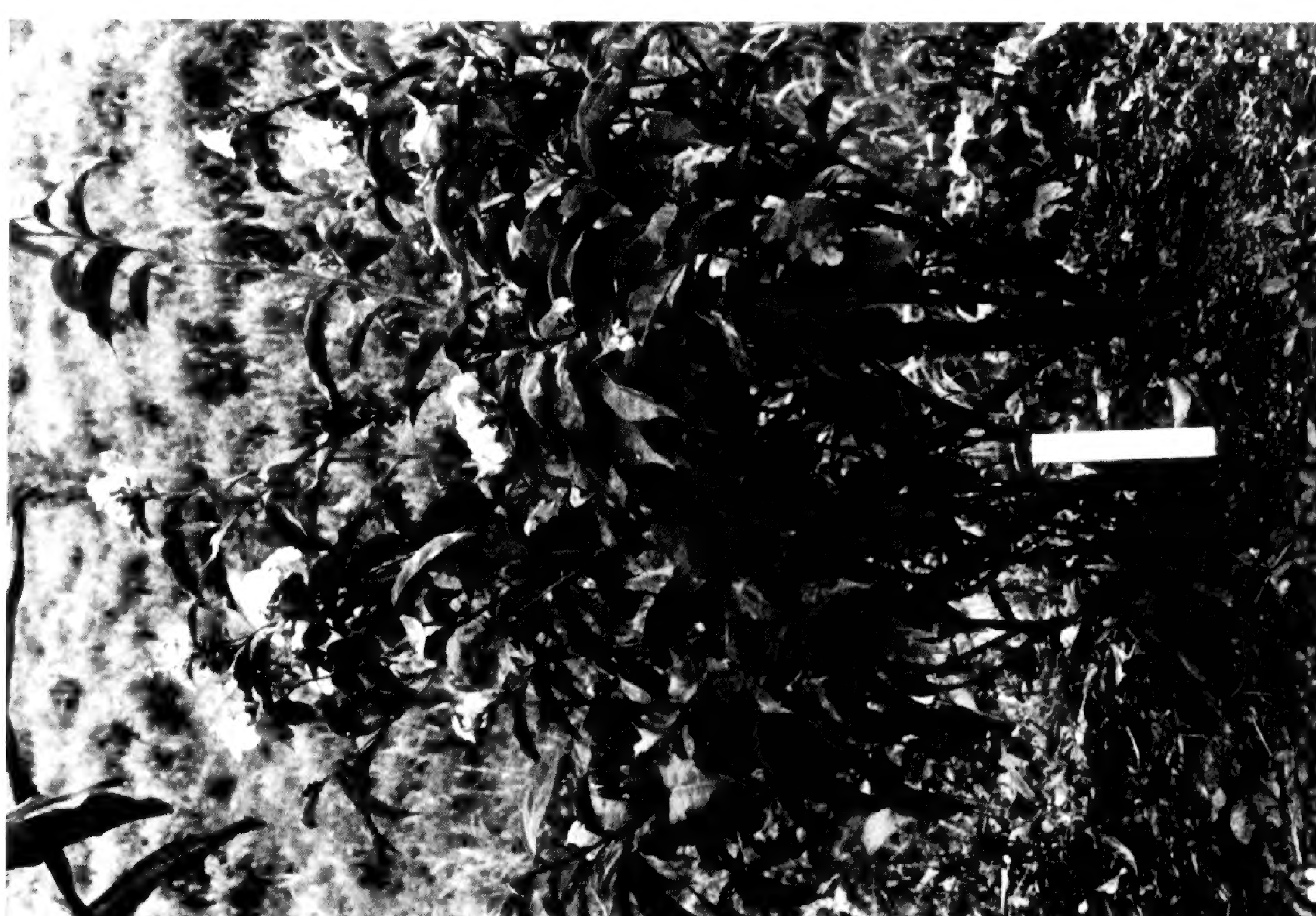

Plate 66. *Brunfelsia grandiflora* D. Don. Colombia: Comisaría del Putumayo. Left: Shrub cultivated in Indian houseyard near Mocoa. Right: Wild plant found growing in secondary forest near Puerto Limón.

PLATE 67

Plate 67. *Brunfelsia Mire* Monachino. 1. Habit. 2. Flowering Branch. 3. Fruit cluster.

PLATE 68

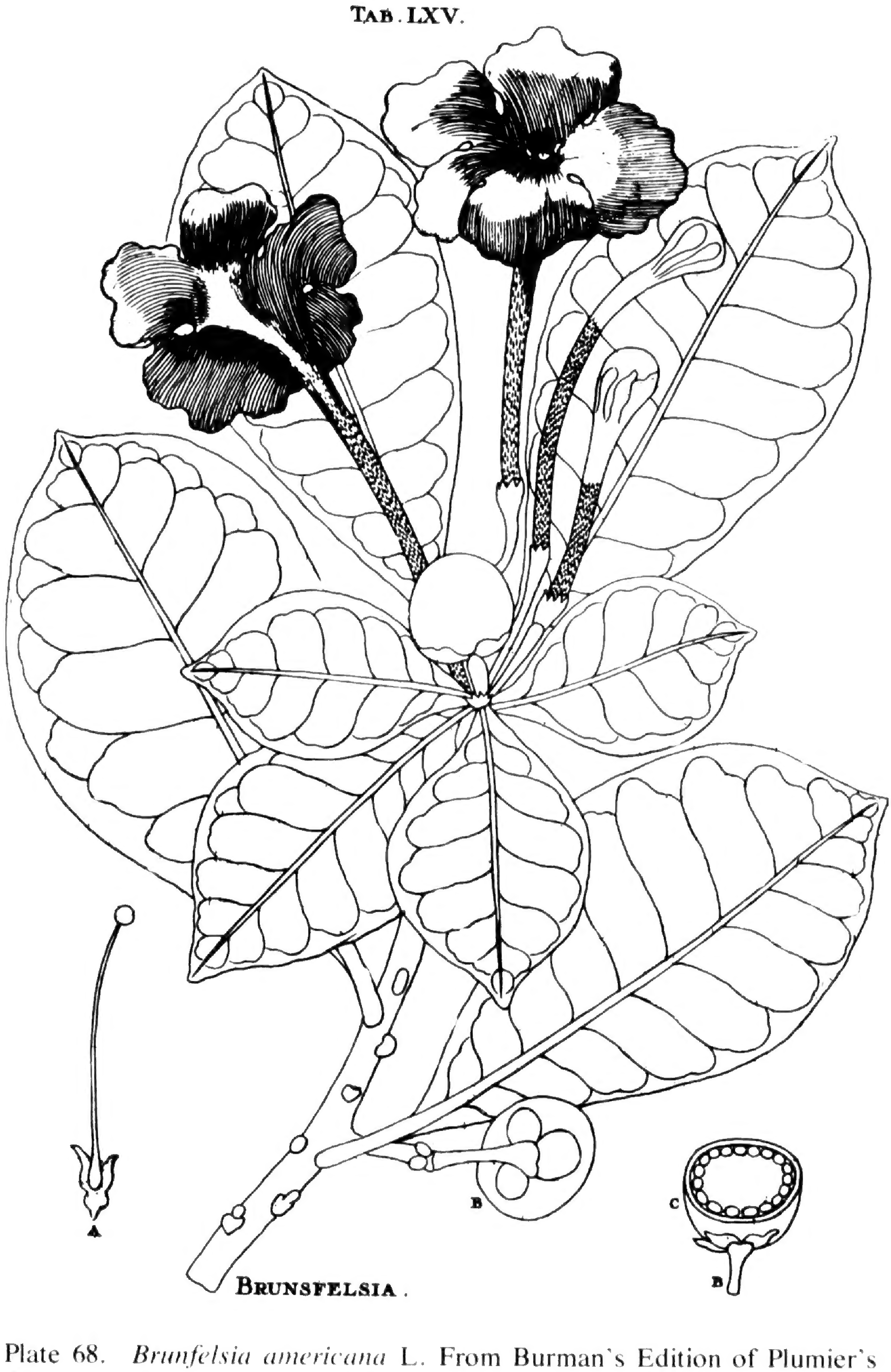

Plate 68. *Brunfelsia americana* L. From Burman's Edition of Plumier's *Plantarum Americanarum* (1756).