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TO GENERA AND SPECIES

ERRATA

Pages 217 and 219
add Gossypium Barbosanum *Phillips & Clement* at beginning of caption

Page 239, line 13
for colorss read colors

Page 241, line 18
for legomo- read legumo-

Page 250, line 17
for Oaxal- read Oxal-

Page 258, line 3
for *ellottii* read *elliottii*

Page 259, line 13
for abundantinsect read abundant insect

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NOVELTIES IN THE ORCHID FLORA OF THE GUAYANA HIGHLANDS II*

BY

CHARLES SCHWEINFURTH

THE following paper is the last and concluding article treating the new species and other novelties which have recently appeared during my work on the Guayana Highlands. These novelties consist of seven new species (including a genus now first recorded for the New World), one new variety, two new combinations, two new names and one new form. There are included also the description and citation of two orchids which are highly variable and have not previously been reported from the area under investigation. Of both species, the accompanying detailed drawings are the first careful illustrations that have appeared.

As in the former paper (Bot. Mus. Leafl. Harvard Univ. 19, no. 9 (1961) 195–214), the order of genera follows the system proposed by Dr. Rudolph Schlechter in Notizblatt der Botanischen Gartens und Museums, Berlin-Dahlem 9, no. 88 (1926) 563–591.

Spiranthes callifera *C. Schweinfurth sp. nov.*

Herba terrestris, mediocris, circiter 38 cm. alta. Radices numerosae, fasciculatae. Folia septem ut videtur, plan-

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* All of these investigations were made possible by a grant from the National Science Foundation.

tae basi fasciculata, petiolata; lamina ovato-lanceolata, acuminata, basi late cuneata, usque ad 9.4 cm. longa et 3.5 cm. lata, margine ochroleuco-crispato; petiolus angustus, canaliculatus, basi amplectenti dilatatus, usque ad 5.4 cm. longus. Pedunculus usque ad racemum circiter 20 cm. altus, obscure pilosus, vaginis pluribus, scariosis, longe acuminatis, tubularibus maxima pro parte obtectus. Racemus laxus, quindecim-florus, rhachide pilosa. Bracteae anguste lanceolatae, longe acuminatae, infimae fere 4 cm. longae. Flores mediocres, erecto-patentes, angusti, cum ovario pedicellato circiter 3.5 cm. longi. Sepala extus glanduloso-pilosa. Sepalum dorsale oblongo-oblanceolatum, concavum, breviter acuminatum, trinervium, circiter 16 mm. longum et 5 mm. latum expansum. Sepala lateralia supra libera, inferne connata; pars libera lineari-oblanceolata, acuminata, cum marginibus valde involutis, inferne paulo obliqua et latiora, circiter 16 mm. longa et 2.5 mm. lata expansa; pars connata circiter 12.5 mm. longa, saccum anguste ellipsoideum ovario adnatum et calcar breve conicum formans. Petala ad sepalum dorsalem valde adhaerentia, obliquissime lineari-oblanceolata, acuta, marginibus anterioribus ciliatis, uninervia, 15 mm. longa, 2–2.3 mm. lata. Labellum lineari-oblanceolatum, unguiculatum, circiter 26 mm. longum expansum, apice trilobatum, laminae basi auricula conspicua, falcato-lanceolata, carnosa utrinque ornatum, basi sepalorum lateralium calcari valde adnatum; lobi laterales anguste semiobovati, apice callo conico praediti; lobus intermedius recurvus, rhombico-ovatus, acutus, cum ungue brevi lato; discus plusminusve dense hirsutus. Columna gracilis, superne sensim dilatata, dorso circiter 10.2 mm. alta, in pedem longum indistinctum ovario adnatum producta.

This species appears to be allied to *Spiranthes goninensis* (Pulle) C. Schweinf.,* especially vegetatively, but it has larger flowers with acute or acuminate (not obtuse) segments and a distinctly 3-lobed lip.

VENEZUELA: State of Bolívar, Chimantá Massif, along Río Tirica (Río Apururén), just above Techiné-meru, at 470 m. altitude, leaves membranaceous, "bronze and shining above, margins buff, below brown-lavender. Scape buff-greenish; cauline bracts stramineous with salmon above; ovary yellow-brown; spur pale greenish yellow; 2 lateral sepals projecting forward; margins involute, buff-creamy; dorsal sepal brownish yellow; lip recurved, white in lower half, yellow in other part, callosities on lip yellow; 2 lateral petals appressed to dorsal sepal, white." January 16, 1955, *Julian A. Steyermark & John J. Wurdack 96* (TYPE in N.Y. Bot. Gard.).

Spiranthes longiauriculata *C. Schweinfurth sp. nov.*

Herba tenuis, aphylla, usque ad plus quam 26 cm. alta. Radices fasciculatae, tuberosae, crassae. Caulis infra glaber, supra sparsim pilosus, vaginis pluribus tubulatis, strictis ornatus. Inflorescentia laxe triflora. Flores mediocres, erecti. Sepalum dorsale valde concavum, anguste elliptico-lanceolatum, cum parte apicali longa angusta et recurva, apice oblique truncato-lobulatum, columnae adnatum, circiter 12 mm. longum et medio 3.4 mm. latum, basi sparsim pilosum. Sepala lateralia linearia, cum marginibus superioribus involutis, supra recurva, apice subacuta et plusminusve lobulata, per dimidium basalem connata et laminam anguste oblongam formantia, circiter 15.2 mm. longa et 5 mm. lata expansa, basi obliqua columnae pedi infra adnata. Petala sepalo dorsali valde adnata, obliquissime oblanceolata, apice truncata vel oblique lobulata, basi columnae adnata, circiter 10.9 mm. longa et supra 2 mm. lata, uninervia. Labellum in circuitu obovato-oblongum, ungue lineari-lanceolato columnae pedis apici adnato; lamina circiter 17 mm. longa et 4.5 mm. lata, supra constricta et deinde in lobum apicalem rhombico-ovatum, parvum, acutum, reduplicatum dila-

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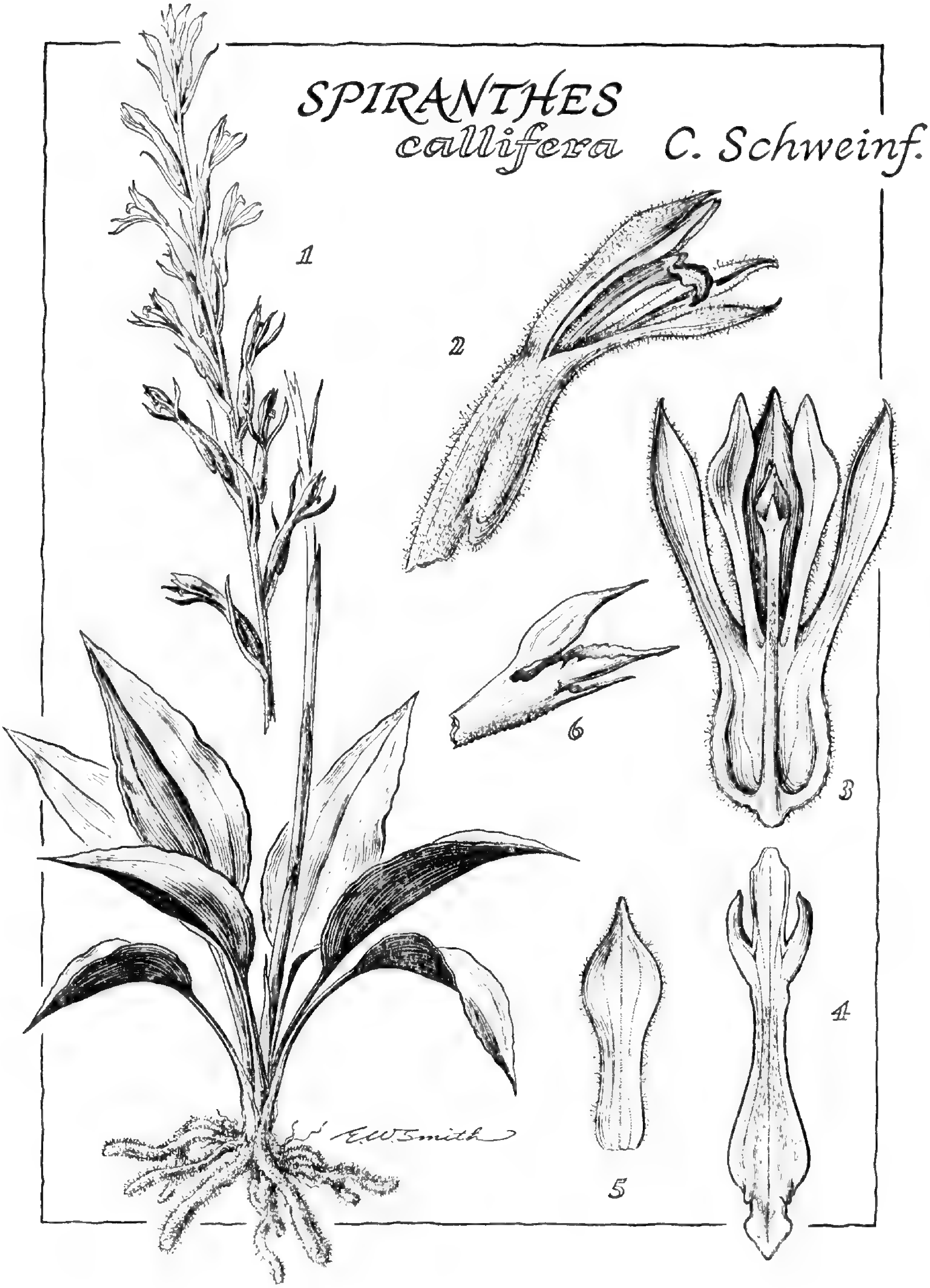
***Spiranthes goninensis** (*Pulle*) *C. Schweinf. comb. nov.*

Syn. *Stenorrhynchus goninensis* Pulle in Rec. Trav. Bot. Néerl. 6 (1909) 238.

PLATE I



SPIRANTHES CALLIFERA *C. Schweinfurth.* 1, plant (with stem broken to show the inflorescence), one half natural size. 2, flower from side, natural position, twice natural size. 3, flower from front, expanded, with lip removed and lateral sepals separated along their line of fusion, twice natural size. 4, lip, expanded, twice natural size. 5, dorsal sepal, expanded, twice natural size. 6, apical part of column from side, about five times natural size. *Drawn by* ELMER W. SMITH tata, basi auricula lanceolato-lineari carnosa incurva circiter 5 mm. longa utrinque praedita; discus supra dense pubescens. Columna parva, gracilis, circiter 5 mm. longa, in pedem elongatum ovario adnatum producta.

This species appears to be allied to *Spiranthes cordatiloba* C. Schweinf.*, but differs in having lobulate apices to the sepals and petals, connate lateral sepals and a dissimilar mid-lobe of the lip.

VENEZUELA: State of Bolívar, vicinity of Urimán, in large savanna, at 300 meters altitude, sepals and petals white with a median green stripe, lip ascending, white with linear green bands, April 30, 1953, *Julian A. Steyermark 75298* (TYPE in Herb. Ames No. 69531).

Manniella americana *C. Schweinfurth & L. A. Garay sp. nov.*

Herba parvula, gracilis, usque ad fere 22 cm. alta, terrestris ut videtur. Radices comparate crassae, fasciculatae, lanuginosae. Folia parva, usque ad quinque, plantae basi fasciculata, petiolata; lamina ovata vel suborbiculari-ovata, acuta vel breviter acuminata, usque ad 1.7 cm. longa et 1 cm. lata; petiolus angustus, canaliculatus, ad basim vaginantem sensim dilatatus, usque ad 2.8 cm. longus; folium solitarium caulinare multo minus, elliptico-lanceolatum prope basim stat. Caulis usque ad inflorescentiam gracilis, inferne glaber, superne breviter pubescens, 8.5–18.5 cm. altus. Racemus perlaxe biflorus. Flores ochroleuci, glabri, cum segmentis subparallelis. Sepala per partem basalem longe connata. Sepalum dorsale longitudinaliter concavum, oblongo-lanceolatum, superne angustatum, apice rotundatum vel leviter retusum, in positu naturali circiter 8.2 mm. longum et 2 mm. latum, uninervium. Sepala lateralia oblique oblongo-lanceolata marginibus superioribus involutis, obtusa vel

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***Spiranthes cordatiloba** *C. Schweinf. nom. nov.*
Syn. *Sarcoglottis tenuis* Schltr. in Anex. Mem. Inst. Butantan, Sec. Bot. 1, fasc. 4 (1922) 28, t. 4, fig. 1, not *Spiranthes tenuis* Lindl.

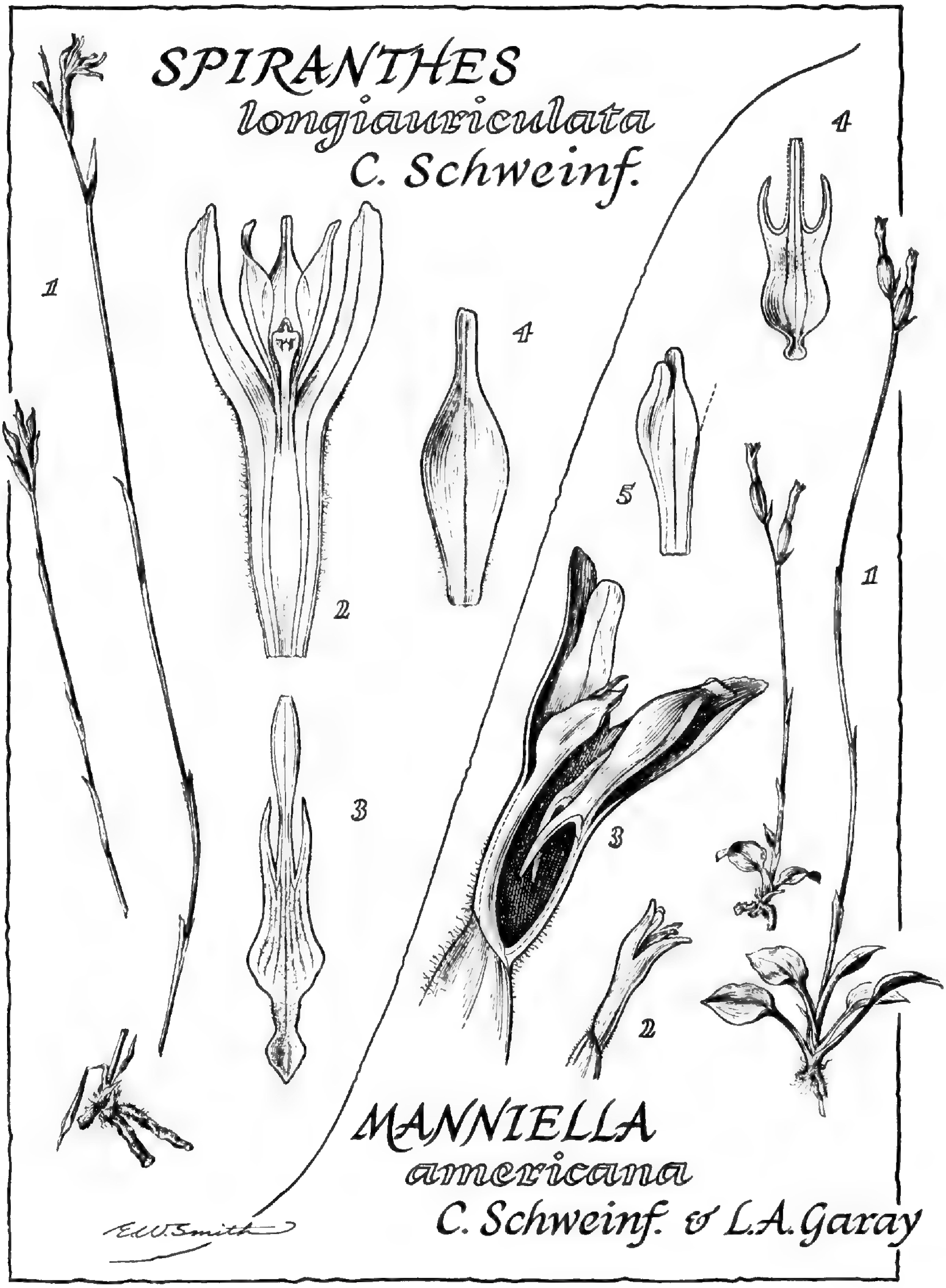
EXPLANATION OF THE ILLUSTRATION

PLATE II. SPIRANTHES LONGIAURICULATA *C. Schweinfurth.* 1, plant, one half natural size. 2, flower from front, expanded, with lip removed, twice natural size. 3, lip, expanded, twice natural size. 4, dorsal sepal, expanded, three times natural size.

MANNIELLA AMERICANA *C. Schweinfurth & L. A. Garay.* 1, plants, one half natural size. 2, flower from side, natural position, about twice natural size. 3, sagittal (lateral) section of flower (with lip and column intact), about five times natural size. 4, lip, expanded, three times natural size. 5, dorsal sepal with one partly adherent petal, three times natural size.

Drawn by ELMER W. SMITH

PLATE II


SPIRANTHES
longiauriculata
C. Schweinf.
1
2
3
4
MANNIELLA
americana
C. Schweinf. & L.A. Garay
1
2
3
4
5
E.W. Smith

subacuta, usque ad 9 mm. longa, circiter 2 mm. lata. Petala sepalo dorsali apice excepto valde adnata, oblanceolato-linearia, apice rotundata, basi columnae adhaerentia, circiter 6.2 mm. longa et 1 mm. lata, uninervia. Labellum oblongum vel obovato-oblongum, prope medium panduratum, basi cuneata sepalis lateralibus adnatum, supra concavum, prope apicem utrinque leviter constrictum et lobulum suborbicularem formans, basi utrinque auricula lineari prominenti ornatum, usque ad 6.3 mm. longum et superne 3.6 mm. latum. Columna circiter 5.5 mm. alta, sepalo dorsali adnata, in pedem brevem obliquum producta.

This little orchid is the first American representative of the heretofore monotypic genus *Manniella* from Africa.

VENEZUELA: State of Bolívar, Cerro Guaiquinima, Río Parágua, "North Valley," at 1600–1700 m. altitude, occasional in bogs, January 4, 1952, *B. Maguire 32978* (TYPE in N.Y. Bot. Gard.)—Between El Dorado and Santa Elena, *J. A. Steyermark & S. Nilsson 278.*

Erythrodes robusta *C. Schweinfurth sp. nov.*

Herba terrestris, valde robusta, circiter 9 dm. longitudine (segmentis in typo fractis). Caulis crassus, inferne decumbens cum radicibus perlongis gracilibus simplicibus, circiter 1.3 cm. in diametro, multiarticulatus, foliis quinque vel sex supra medium praeditus. Folia longe petiolata; lamina ovato-elliptica vel elliptico-lanceolata, longe acuminata, usque ad 19–20 cm. longa et 7 cm. lata; petiolus canaliculatus, supra in folii basim cuneatam sensim dilatatus et infra in basim laxe vaginantem sensim dilatatus, usque ad circiter 8.5 cm. longus. Racemus densissime multiflorus, circiter 17 cm. longus, cum pedunculo brevi glabro. Bracteae oblongo-ovatae, acutae vel subacuminatae, concavae, usque ad circiter 3.5 cm. longae, extus et in margine sparsim glanduloso-pubescentes. Sepala densius glanduloso-pubescentia. Sepalum dorsale valde cucullatum et cum petalis galeam formans, lanceolato-ellipticum, obtusum, circiter 1.57 cm. longum et 5 mm. latum expansum, trinervium. Sepala lateralia oblique oblongo-lanceolata, subacuta, circiter 1.52 cm. longa et 5 mm. lata. Petala sepalo dorsali agglutinata, oblique spathulato-oblanceolata, subobtusa, circiter 1.5 cm. longa et supra 4 mm. lata. Labellum albidum, carnosum, columnae inferne adnatum, portio libera in partes duas divisa; pars posterior tubulari-involuta, comparate magna, utrinque late rotundata cum apice subacuta, circiter 9 mm. longa; pars anterior parva, abrupte reflexa, ex ungue brevissimo in laminam transverse oblongo-ellipticam, triangulari-acutam dilatata, circiter 3.2 mm. longa et 6 mm. lata; calcar ovarium pedicellatum paulo excedens, anguste cylindraceum, circiter 2.6 cm. longum, in portionem superiorem semi-ellipsoideam abrupte dilatatum. Columna brevis, supra sensim dilatata, circiter 12.7 mm. alta, cum anthera elongata circiter 8 mm. longa.

This species has two rather near allies. It differs from *Erythrodes clavigera* (Reichb. f.) Ames in having much larger flowers, dissimilar lip and nearly twice longer spur. It is separable from *E. cylindrostachys* Garay in having much longer and more slender roots, much broader leaves, larger flowers and a different lip.

VENEZUELA: State of Bolívar, Tirepón-tepuí, at 1100–1200 meters altitude, terrestrial in slope rain forest between Base Camp and Camp 2, January 3, 1953, *John J. Wurdack 34024* (TYPE in Herb. Ames No. 69537).

Pleurothallis coffeicola *Schltr.* in Fedde Repert. 27: 50. 1929; Pabst in Orquidea 22: 4, t., 1960.

A detailed description of this species, of which the Venezuelan examples show considerable variation from the type, is here appended, together with a carefully prepared illustration.

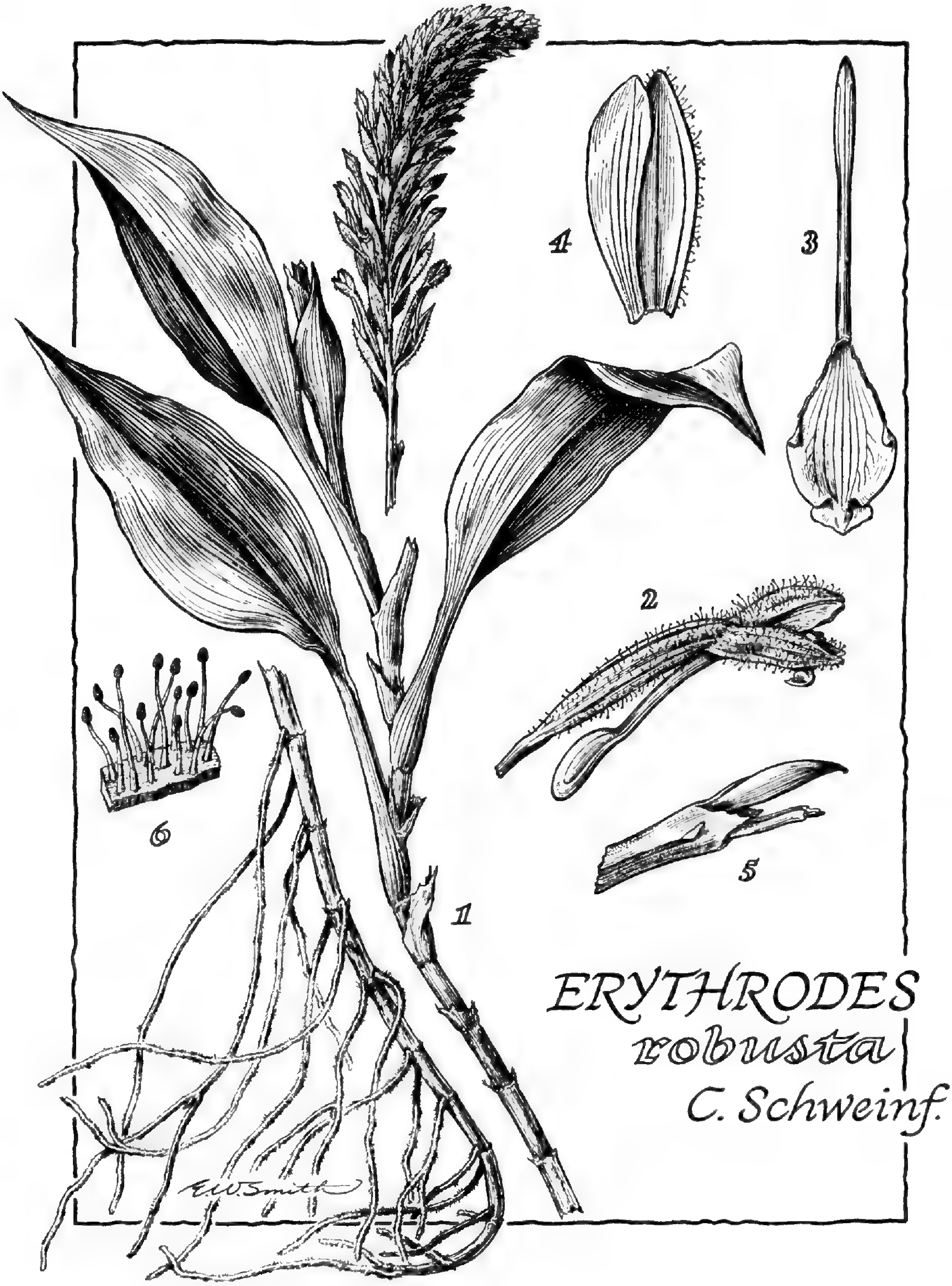
Plant medium-sized, epiphytic, rhizomatose. Rhizome

EXPLANATION OF THE ILLUSTRATION

PLATE III. ERYTHRODES ROBUSTA *C. Schweinfurth.* 1, plant, severed to show lower rooting, median leafy and apical flowering portions, one third natural size. 2, flower from side, natural position, about natural size. 3, spur and lip, expanded, one and one half times natural size. 4, dorsal sepal with partially adherent petal, twice natural size. 5, column from side, two and one half times natural size. 6, glandular hairs on outer surface of sepals, about eight times natural size.

Drawn by ELMER W. SMITH

PLATE III

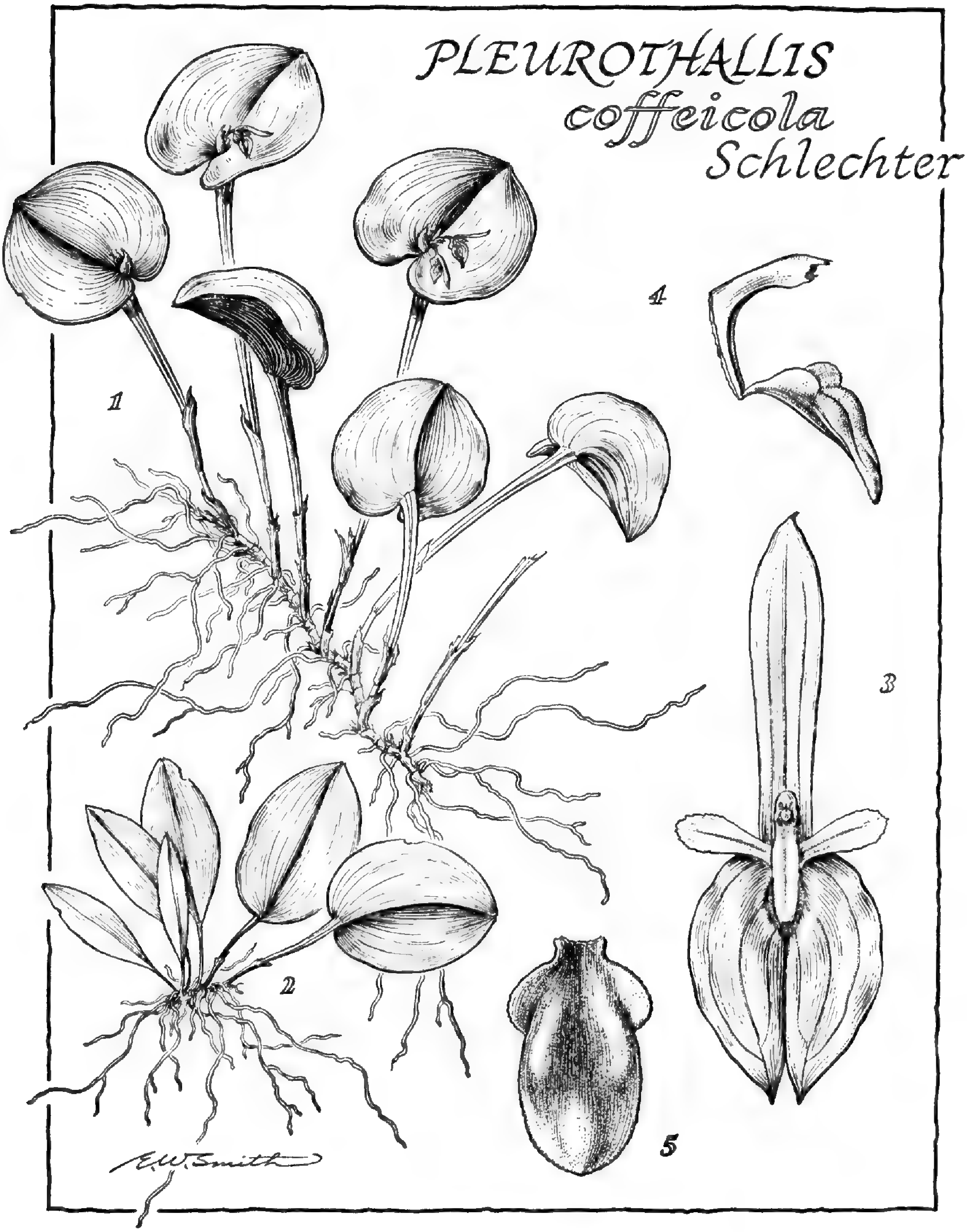


ERYTHRODES
robusta
C. Schweinf.

serpentine, many-jointed with the internodes concealed by evanescent scarious sheaths, and producing numerous slender, fibrous roots. Secondary stems subapproximate to 1.5 cm. apart, gradually dilated and bialate upward, unifoliate at the apex, up to 9.3 cm. high, 1-jointed near the base, the node provided with a loose, tubular, evanescent sheath. Leaf when mature suborbicular (the young blades ranging from elliptic to broadly ovate), subacute to obtuse, or rounded with a minutely tridenticulate apex, more or less cordate at the base, horizontally spreading, up to 4.4 cm. in greatest length and 4.2 cm. wide. Inflorescences several, fasciculate, 1-flowered (2- to 4-flowered in the type), the abbreviated peduncles embraced by a rather prominent, conduplicate, scarious sheath. Flower rather small, bilabiate. Dorsal sepal narrowly oblanceolate-oblong, acute and dorsally mucronate at the apex, about 9.2–10.3 mm. long and 2 mm. wide above, concave at the base, fleshy-thickened near the apex, 3-nerved. Lateral sepals connate into a suborbicular-ovate lamina which is bidentate and forming a pair of sharp points at the apex, 6-nerved, about 7 mm. in greatest length and 6 mm. wide when expanded, concave at the base. Petals dwarf, spatulate-cuneate, rounded with a minutely irregular margin at the apex, 1-nerved, about 3 mm. long and 1 mm. wide above. Lip arcuate-recurved and about 4.3 mm. long in natural position, and 1.6 mm. wide, ovate-oblong in outline, rounded in front, biauriculate below the cuneate base which is tubular-involute; disc 3-nerved, with a pair of fleshy, indistinct callose keels near the middle, the apical margin being minutely erose. Column slightly shorter than the petals, lightly arcuate, about 2.8 mm. high at the back, terminating in a trilobulate apex of which the narrow middle tooth is retuse, produced into a conspicuous, subequally long foot.

This species appears to be most closely allied to *Pleuro-*

PLATE IV

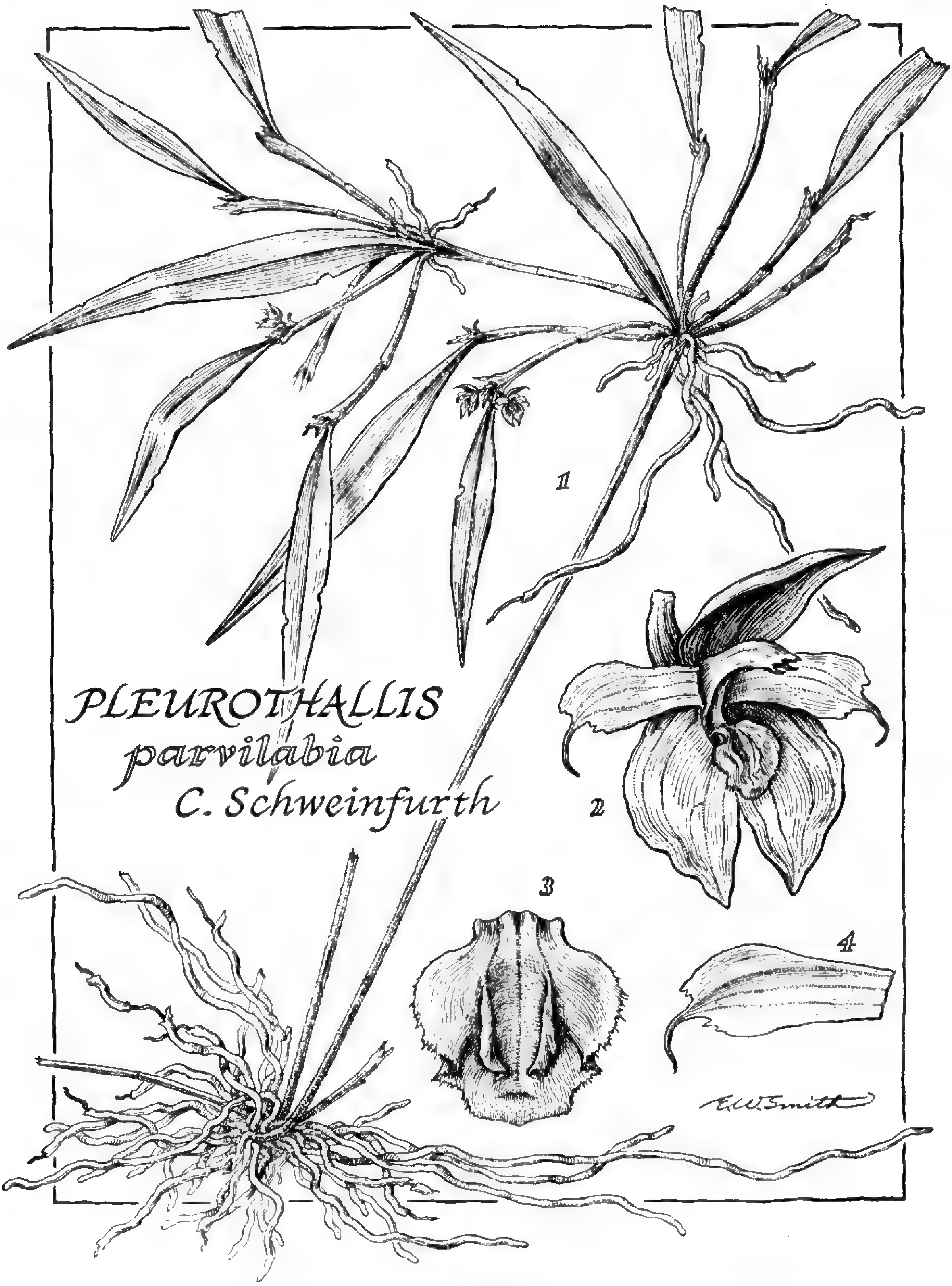


PLEUROTHALLIS COFFEICOLA *Schlechter*. 1, plant, one half natural size. 2, immature plant showing various shapes of young leaves, one half natural size. 3, flower from front, expanded, with lip removed, four and one half times natural size. 4, column and lip from side, natural position, about five and one half times natural size. 5, lip, expanded, about seven times natural size. *Drawn by* ELMER W. SMITH *thallis harpophylla* Reichb.f., which differs in having a much smaller "oblong-lanceolate" leaf and dissimilar petals. The specific name is in allusion to the habitat.

VENEZUELA: Territory of Amazonas, Casiquiare, Río Yatua, rare epiphyte in flooded forest along the uppermost part of river, at 100–140 meters altitude, "corolla purple with yellowish spur," December 7–8, 1953, *Bassett Maguire, John J. Wurdack and George S. Bunting 36730* (immature leaves elliptic).—Same date and flower-color, December 12, 1953, *Maguire, Wurdack & Bunting 36763.*—Along uppermost Río Yatua above the mouth of Río Yacibo, at 100–140 meters altitude, "perianth maroon, the long narrow member cream," January 30–31, 1954, *Maguire, Wurdack & Bunting 37430.*—Also Bolivia (type) and Brazil.

Pleurothallis parvilabia *C. Schweinfurth sp. nov.* Herba magna, epiphytica, vagans. Caules superpositi, graciles, usque ad 24 cm. longi, unifoliati, vaginis atropubescentibus arcte velati. Folia anguste lanceolata vel elliptico-oblonga, ad apicem minute tridenticulatum sensim angustata, basi cuneata sessilia, circiter 8–12.7 cm. longa, usque ad 1.5 cm. lata, subcoriacea. Flores plures, axillares, parvi, membranacei, bilabiati, virides et purpurei. Sepalum dorsale valde cucullatum, expansum elliptico-lanceolatum, acuminatum, quinquenervium, positu naturali circiter 7 mm. longum, expansum 3.2 mm. latum. Sepala lateralia in laminam late elliptico-ovatam prope medium bidentatam connata; sepalum utrumque obliquissime ovatum, acutum vel acuminatum, quadrinervium, circiter 6 mm. longum et 2.9 mm. latum. Petala inferne usque supra medium obovato-ligulata, apice utrinque paucidentata, deinde e basi triangulari in apicem carnosum longe aristata, trinervia, circiter 5.6 mm. longa et prope medium 2 mm. lata. Labellum segmentis ceteris multo minus, in positu naturali suborbiculare, recurvum et 1.9 mm. longum, expansum circiter 2 mm. latum, late obtusum, dorso per medium carina carnosa ornatum, marginibus basi apiceque exceptis multo

PLATE V



PLEUROTHALLIS PARVILABIA *C. Schweinfurth.* 1, plant, one half natural size. 2, flower, three-quarters view, about four and one half times natural size. 3, lip, expanded, about fifteen times natural size. 4, petal, six times natural size. *Drawn by* ELMER W. SMITH serrulatis; discus trinervius, conspicue bilamellatus. Columna brevis, arcuata, antice valde concava, circiter 3 mm. alta, in pedem prope 2 mm. longum producta.

This plant has two allied species which are especially similar in vegetative characters. It differs from *Pleurothallis frutex* Schltr. in all of the floral segments and from *P. hystrix* Reichb. f. in the shape of the petals and lip.

British Guiana: Serra Acarai, on rocky hill top, 7 miles east of Onoro, epiphytic on low tree, about 4 feet from the ground, October 2, 1952, Forestry Department, Field No. G 340, Record No. 7316 (Type in N.Y. Botanical Garden).

Pleurothallis scandens *Ames* var. **simplicicaulis** *C. Schweinfurth var. nov.*

Herba epiphytica, caulibus simplicibus et floris colore diversa a specie differt.

Plant epiphytic, caespitose. Stems numerous, simple, apically unifoliate, up to 25 cm. high, entirely concealed by close, tubular, dark-pubescent sheaths. Leaf linear-lanceolate to oblong-linear, up to 10.7 cm. long and 8 mm. wide, generally somewhat broader than that of the type. Flowers very similar to those of the type, but of a different color, and with a somewhat more prominently ciliolate lip. The altitude of these collections is distinctly higher than the average habitat of the typical form.

Venezuela: State of Bolívar, Sororopán-tepuí, 1500–1700 m. alt., frequent epiphyte on middle slopes, flowers bronze-yellow, December 16, 1952, *Bassett Maguire & John J. Wurdack 33836.*—Chimantá Massif, Torono-tepuí, in *Clusia* forest on slopes of Middle Falls of Río Tirica, below Summit Camp, at 1760–1880 meters altitude, on tree branch, leaves coriaceous, deep green above and paler beneath, sepals and petals tawny yellow, the dorsal one with a central pale lavender stripe, lip dark maroon, column dull lavender at the base, cream-white at the apex, March 1, 1955, *Julian A. Steyermark & John J. Wurdack 1210.*—Same locality, on densely forested slopes between the upper reaches of Río Tirica (left-hand fork) and Riscobel Ledema Camp, southeast portion of Apácara-tepuí, at 1700–1850 meters altitude, leaves coriaceous, deep green above and paler beneath, flowers yellow and madder purple, June 23, 1953, *Steyermark 75957* (Type in Herb. Ames No. 69533).

Epidendrum Lechleri *Reichb.f.* in Linnaea 41 (1876) 38.

Epidendrum Evelynae Reichb. f. in Xenia 3 (1878) 23.

Epidendrum nephroglossum Schltr. in Fedde Repert. Beih. 9 (1921) 89; Mansf. in Fedde Repert. Beih. 57 (1929) t. 119, nr. 469; C. Schweinf. in Bot. Mus. Leafl. Harvard Univ. 11 (1944) 238; Schweinf. in Fieldiana Bot. 30 (Orch. of Peru), No. 2 (1959) 481.

In the descriptions of both *Epidendrum Lechleri* and *E. Evelynae* the lip was noted as three-lobed, quite at variance with the strictly simple lip characteristic of *E. nephroglossum.* However, the types of all three concepts, recently made available, have a strictly simple lip (at most lightly retuse and apiculate) and show that only one species is represented by the three concepts. The Venezuelan collection cited below is the first record of the species from that country, *E. Lechleri* and *E. nephroglossum* being from Peru and *E. Evelynae* from Bolivia. The accompanying detailed drawing, made from the Venezuelan collection, is the first adequate representation of this orchid.

VENEZUELA: State of Bolívar, Chimantá Massif, above southeast-facing upper shoulder on slope leading to summit of Apácara-tepuí, at 2200–2300 meters altitude, epiphyte on *Magnolia* in upper mixed *Clusia-Magnolia* forest, stem dull purple, leaves rich green above and paler beneath, rachis pale green, pedicels lavender, sepals pale lavender edged with fulvous yellow; lip thicker, striate, pale fulvous yellow, column white, June 20, 1953, *Julian A. Steyermark 75836.*

Epidendrum leucanthum (*Schltr.*) *C. Schweinf. comb. nov.*

Encyclia leucantha Schltr., Fedde Repert. Beih. 6: (1919) 40; Mansf. in Fedde Repert. Beih. 57: (1929) t. 7, nr. 23.

A specimen recently discovered in the State of Bolívar, Venezuela, appears to be a vegetatively small form of the above species which was described from cultivated material without pseudobulb, roots or definite locality.

Plant small, about 20 cm. high. Roots fibrous, stout, whitish, glabrous. Pseudobulb oblong-pyriform, about 3 cm. high, bifoliate near the apex, concealed by several imbricating, scarious, evanescent sheaths which are progressively larger upward. Leaves linear, abruptly subacute, rigidly chartaceous, up to 15 cm. long and 9 mm. wide. Inflorescence little surpassing the leaves, very loosely 3-flowered above with a fractiflex rachis. Pedicellate ovary about 1.8 cm. long, strongly verruculose. Parts of the flower very similar to those described, except that the mid-lobe of the lip is lightly retuse.

VENEZUELA: State of Bolívar, north base of Cerro Baraguan at 100 meters altitude, epiphyte on low trees, "tepals dull yellow; lip white, becoming pale yellow, streaked with purple," occasional, January 12, 1956, *J. J. Wurdack and J. V. Monachino 41202.*

Epidendrum rectopedunculatum *C. Schweinf.* forma **denticulatum** *C. Schweinf. form. nov.*

Herba labelli lobulis valde denticulatis a specie differt.

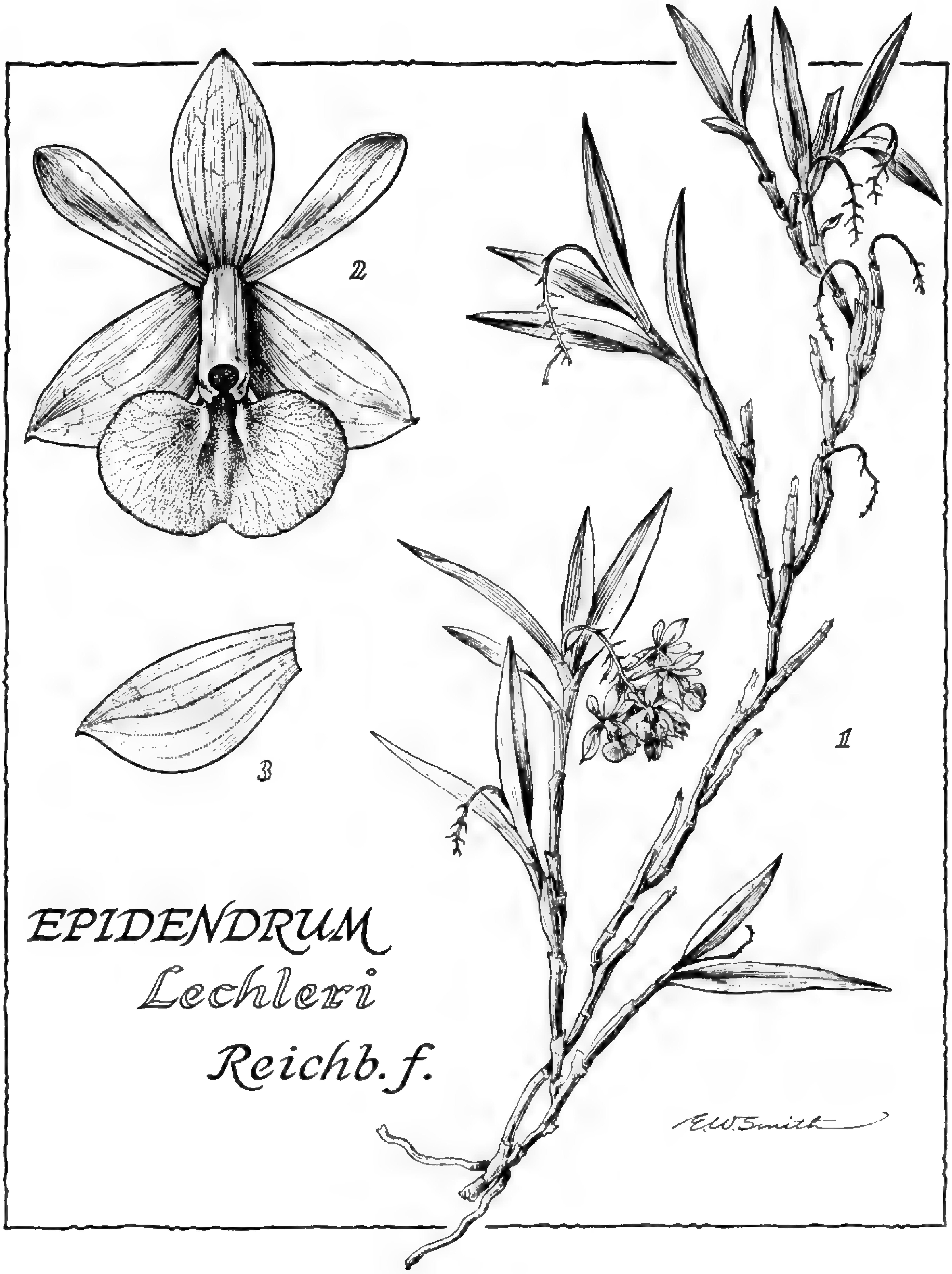
This collection of a highly variable species has conspicuously denticulate lobes of the lip. In this instance, as in some other collections, the lobes of the lip are distinctly separated by sharp sinuses.

VENEZUELA: Territory of Amazonas, Cerro Sipapo (Paráque), between Base Camp and open scrub savanna 3 km. southwest of Base Camp, at 125–200 meters altitude, February 8, 1949, *Bassett Maguire & Louis Politi 28809* (TYPE in Herb. Ames No. 69539).

Epidendrum remotiflorum *C. Schweinfurth sp. nov.*

Herba epiphytica, mediocris, usque ad 41 cm. alta. Radices numerosae, fibrosae, glabrae. Pseudobulbi approximati, in sicco anguste pyriformes, unifoliati, circiter 2 cm. alti, vaginis marcescentibus celati. Folium lineari-oblongum, subacutum vel obtusum, ad basim sessilem

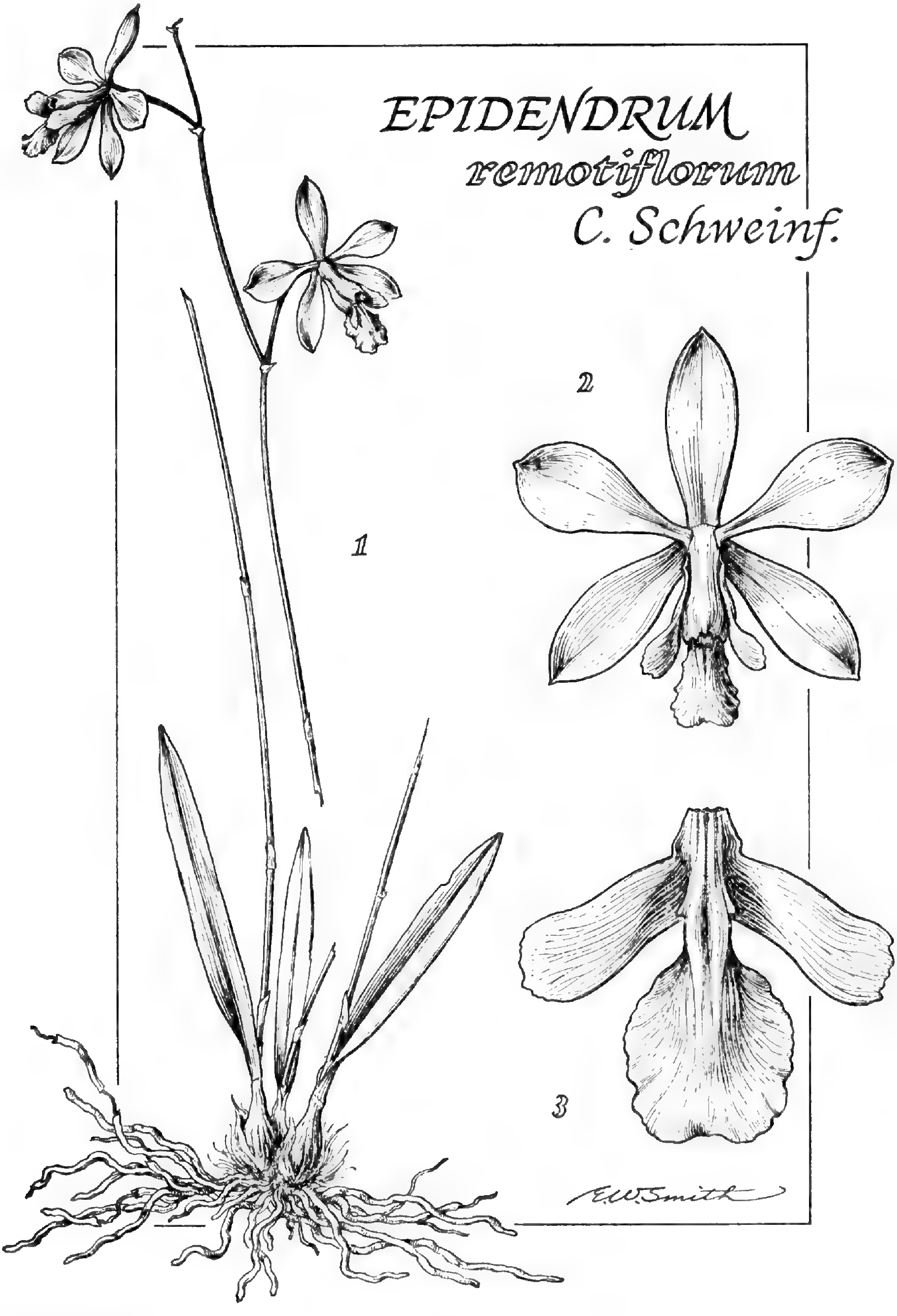
PLATE VI



EPIDENDRUM LECHLERI *Reichenbach f.* 1, plant, one half natural size. 2, flower from front, expanded, three times natural size. 3, lateral sepal, three times natural size. *Drawn by* ELMER W. SMITH vaginantem angustatum, coriaceum, rigidum, 7.4–8.8 cm. longum, usque ad 1.2 cm. latum. Inflorescentia folio multo longior, glabra; pedunculus usque ad 30.5 cm. longus, vaginis paucis, brevibus, tubulatis arcte ornatus; rhachis remote 2- vel 3-flora, usque ad 8.6 cm. alta, cum floribus inferioribus 3.8–6.3 cm. distantibus. Ovarium pedicellatum usque ad 3 cm. longum, glabrum. Flores carnosiores, usque ad 4 cm. in diametro. Sepalum dorsale oblongo-oblanceolatum, acutum, circiter 1.6–1.9 cm. longum et 6–7 mm. latum. Sepala lateralia similia, oblongo-oblanceolata vel anguste obovato-oblonga, acuta, leviter obliqua, sepalo dorsali aequilonga, 6.2–7.1 mm. lata. Petala spathulata, apice rotundato subacuta, 1.5–1.8 cm. longa, 6.8–9 mm. lata. Labellum columnae basi adnatum, profunde trilobatum, basi cuneatum; lamina circiter 1.55–1.7 cm. longa; lobi laterales erecti et columnam amplectentes, oblongi cum apice obliquo, irregulariter denticulato vel lobulato, circiter 1–1.2 cm. longi, 4–4.8 mm. prope apicem lati; lobus intermedius multo majus, in positu naturali convexo-reduplicatus, expansus suborbiculari-obovatus, inferne cuneatus cum ungue brevi, apice leviter retusus, marginibus irregulariter undulatis vel lobulatis, circiter 10.4–11.5 mm. longus, 7.8–8.9 mm. latus; discus in medio cum crassitudinibus binis approximatis et saepe cum dente utrinque, venis numerosis incrassatis superne ornatus. Columna breviora, robusta, medio leviter reflexa (quasi in *Epidendrum oncidioides* Lindl. var. *ramonense* (Reichb.f.) A., H. & S.), circiter 1–1.9 cm. alta, apice cum auriculis rotundatis prominentibus.

This species appears to be very similar to *Epidendrum ionosmum* Lindl., but differs from that taxon in having much smaller unifoliate pseudobulbs, small leaf, longer pedicellate ovary, scarcely clawed sepals and rounded auricles on the column.

PLATE VII



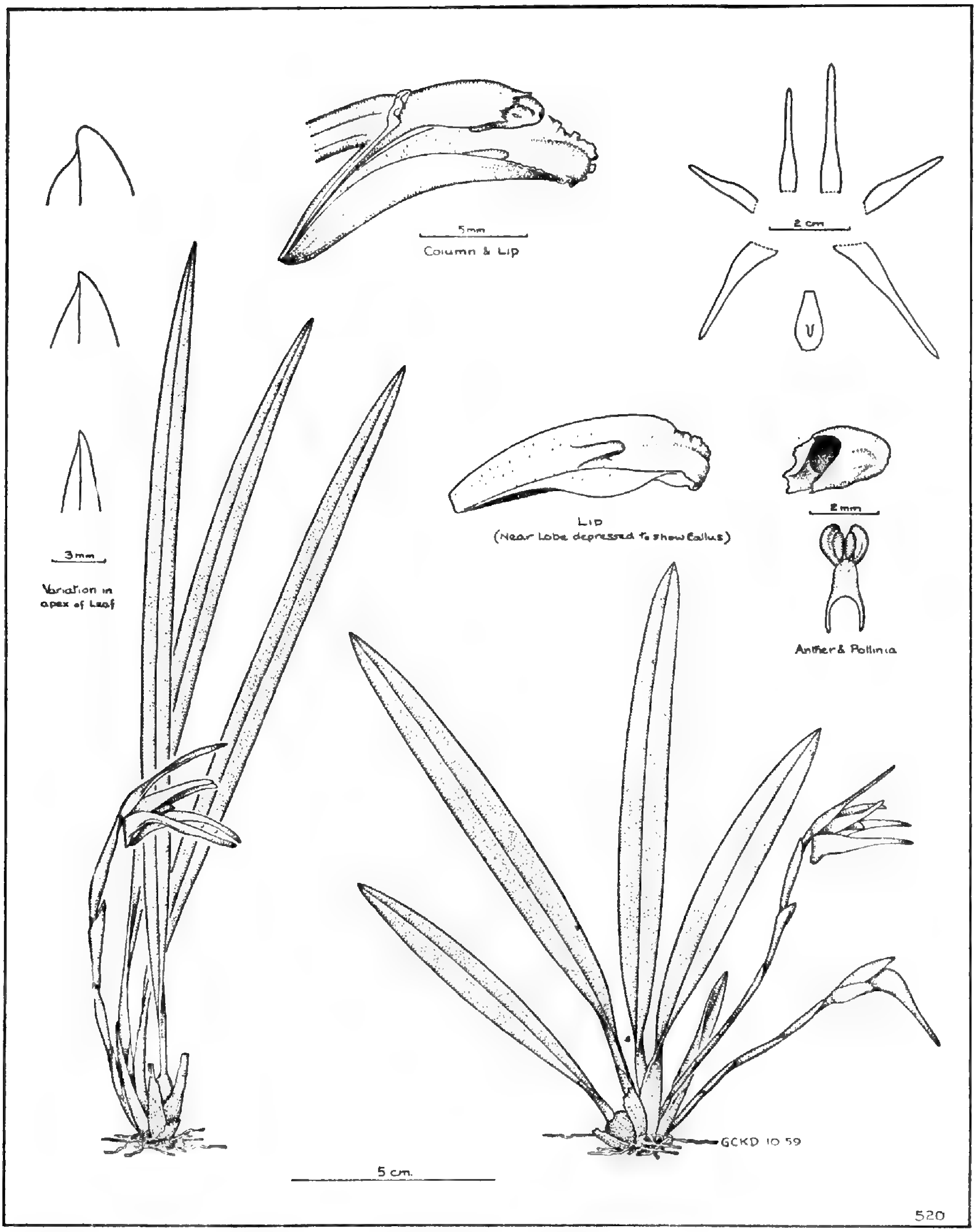
EPIDENDRUM REMOTIFLORUM *C. Schweinfurth.* 1, plant (with stem severed to show entire height), one half natural size. 2, flower from front, expanded, one and one quarter times natural size. 3, lip, expanded, two and one quarter times natural size. *Drawn by* ELMER W. SMITH

Venezuela: Territory of Amazonas, occasional along Caño Tama-Tamá (a black water caño on right bank of Río Orinoco just above Tama-Tamá), at 150 meters altitude, epiphyte, "tepals old gold; lip basally old gold, apically white, the central lobe rose-streaked," June 23, 1959, *J. J. Wurdack & L. S. Adderley 43155* (Type in Herb. Ames No. 69472.—Territory of Amazonas, occasional along Río Atabapo between Manacal and Guarinumo, at 125 meters altitude, epiphyte, "tepals externally dull red-brown, internally olive; lip white, longitudinally rose-streaked," June 12, 1959, *Wurdack & Adderley 42998* (smaller flowers than those of the type).

Maxillaria bolivarensis *C. Schweinfurth sp. nov.*

Herba parvula, epiphytica, usque ad 24 cm. alta. Radices numerosae, fibrosae, glabrae. Pseudobulbi approximati, oblongo-ellipsoidei, valde complanati, unifoliati, usque ad 1.3 cm. alti, vaginis distichis foliiferis evanidis suffulti. Folia linearia, ad apicem acutum vel mucronatum plusminusve angustata, ad basim sessilem conduplicatam attenuata, circiter 6.5–23 cm. longa, 6.5–14 mm. lata. Scapi singuli vel plures, quam folia multo breviores, suberecti vel patentes, vaginis 3–6 anguste tubulatis maculatis celati. Flos pro planta magnus, segmentis paulo patentibus, viridis vel ochroleucus. Sepalum dorsale lineari-lanceolatum, apice acutum, basi valde concavum, circiter 2.5–3.5 cm. longum et 5–6 mm. latum. Sepala lateralia triangulari-linearia, obliqua, ad apicem acutum angustata, 2.7–3.5 cm. longa, cum columnae pede mentum conicum usque ad 7 mm. longum formantia. Petala sepalis multo breviora, oblique et anguste lanceolata, ad apicem abrupte subacutum longe angustata, 2–2.3 cm. longa, basi 4–4.5 mm. lata. Labellum segmentis ceteris multo minus, in positu naturali leviter recurvum, tubulari-involutum et circiter 15 mm. longum, expansum obovato-oblongum et supra medium 5.5–7 mm. latum, apice rotundato-subtruncatum cum marginibus undulatis, prope apicem utrinque leviter constrictum, basim versus longe angustatum; discus callo

PLATE VIII



MAXILLARIA BOLIVARENSIS *C. Schweinfurth.* Plants one half natural size. Flower parts (separated) about one half natural size. Apices of the leaves, two lips, anther and pollinia much enlarged. *Drawn by* G. C. K. DUNSTERVILLE quadrato sulcato apice rotundato vel retuso supra medium ornatus. Columna brevis, crassa, leviter arcuata, circiter 5.5 mm. alta, in pedem longiorem producta.

This species appears to be allied to the Peruvian *Maxillaria tenuis* C. Schweinf., but it differs in having much longer scapes and larger flowers with a very prominent mentum and a subentire lip.

VENEZUELA: State of Bolívar, Region of Urimán, forest mesa of Aprada-tepuí, at 950 m. altitude, August 13, 1953, *Bernardi 780* (TYPE in Herb. Univ. de los Andes, Mérida; ISOTYPE in Herb. Ames No. 69561).—Between El Dorado and Sta. Elena, epiphyte in forest, flowers white, April 24, 1957, *Brother Hermano Antonio 714.*—110 km. south of El Dorado. *G. C. K. Dunsterville 520.* A large collection from Altiplanicie de Nuria (Bolívar), *Julian A. Steyermark 87197* and *89045*, appears to represent this orchid.

Maxillaria sulcata *C. Schweinfurth nom. nov.*

Maxillaria rugosa Schltr., in Notizbl. Bot. Gart. u. Mus. Berlin-Dahlem 6 (1914) 125, non Scheidw., 1843.

The above new name is proposed to replace the homonym, *Maxillaria rugosa* Schltr. The specific epithet, meaning furrowed, was selected to describe the rugose sheaths which suggested the original name of this taxon. No record of this concept was available.

VENEZUELA: State of Bolívar, Mt. Roraima, at about 2000 meters altitude, in the lower woods, *E. Ule 8572*, blooming in December 1909.

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THE HALLUCINOGENIC MUSHROOMS OF MEXICO AND PSILOCYBIN: A BIBLIOGRAPHY

R. Gordon Wasson[*]

THE past six years have seen unprecedented activity in the study of the hallucinogenic mushrooms of Mexico. So diverse and extensive has this activity been, and so numerous are the publications about these mushrooms and their derivatives, that we believe a bibliography on the subject is timely. It will prove useful, we hope, in mobilizing our knowledge about them and in facilitating further research.

This interest—scientific, cultural, popular—flows directly from the writings of Roger Heim and the Wassons. On February 13, 1956, Professor Heim submitted his first *Note* about these mushrooms to the Académie des Sciences, Paris, based on the discoveries that my wife, Dr. Valentina P. Wasson, and I had made in the Sierra Mazateca, Oaxaca, in the summer of 1953. This initial *Note*, published in the *Compte rendu* of February 20, has been followed at intervals by others.

In the spring of 1957 my wife and I brought out our book, *Mushrooms Russia and History*, the fruit of almost thirty years of intermittent research. Timed to coincide with its appearance, we published articles of *haute vulgarisation* on our Mexican mushrooms in *Life* (illustrated with reproductions of water-colors of the mushrooms by Professor Heim) and in *This Week*.

Meanwhile Professor Heim was enlisting teams of scientists to work on the mushrooms. He himself has naturally coped with the mycological problems, ably assisted by his technician, Roger Cailleux. The scientists of the Swiss pharmaceutical house of Sandoz A. G. were quick to help. Drs. Arthur Brack and Hans Kobel succeeded in developing mass production of the fungal material in

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the laboratory. Dr. Albert Hofmann (discoverer of LSD-25, a substance kindred to the active principles found in the hallucinogenic mushrooms) isolated the two active agents, *psilocybin* and *psilocin*, and with his colleagues defined their molecular structure and succeeded in synthesizing them. Dr. A. Cerletti with his colleagues studied their pharmacological and physiological properties. Professor Jean Delay, the eminent French psychiatrist, was the first to head up a team to experiment clinically with psilocybin and psilocin at the Hôpital Ste. Anne in Paris.

All of this activity culminated in the appearance of a book, *Les Champignons Hallucinogènes du Mexique*, large in format and richly illustrated, in the writing and editing of which Professor Heim was the prime mover. I contributed the historical and anthropological chapters, and Professor Heim did me the honor of joining my name to his as co-author on the title page; the Sandoz and Delay teams also made their several contributions. My wife and collaborator died at the end of 1958, and, when the book appeared a few weeks later, it was dedicated to her memory.

It is appropriate, even inevitable, that, because of their number and broad scope and the quality of Professor Heim's contributions, his publications and ours be listed together in the first section of our bibliography. The second section, divided into three parts, deals with THE PAST: *a*) *Primary Sources*, *b*) *Later References*, and *c*) *Archeological*. Under *a*) *Primary Sources* we give the citations for all references to the sacred mushrooms known to us in the early Mexican writings. As time goes on, more will certainly be uncovered. A promising area to explore lies in the body of surviving Nahuatl literature, largely in manuscript and mostly unread; Nahuatl is the language spoken by the Aztecs and many other peoples of Middle America at the time of the Conquest. Our *b*) *Later References* includes such citations as we have found in writers who are posterior to the *Primary Sources* (the last of these being Bishop Lanciego in 1726) and down to and including William E. Safford in 1915. During these two centuries the record shows no first-hand contact by white men with the sacred mushrooms, no field trips, no curiosity about them. The sacred mushrooms of Mexico had never arrested the attention of the great outside world. Now they were known only to a few scholars poring over dusty tomes and records, who occasionally would mention them perfunctorily in their own obscure publications. Then finally Safford appeared on the scene and delivered, as he thought, the *coup de grâce* by declaring in an elaborate paper read before a distinguished society in Washington (later published with photographs and footnotes in a learned journal) that the vision-producing mushrooms had never existed. They had been, it would seem, an hallucination of the Spanish *padres*. The entries under *c*) *Archeological* are contributed by Dr. Stephan F. de Borhegyi, Director of the Milwaukee Public Museum, who for more than ten years has studied the "mushroom stones" of Middle America, those artifacts long considered enigmatic that we interpret as the symbol of the religious cult of our sacred mushrooms. Following each entry in this sub-section Dr. de Borhegyi has added his illuminating comment.

The third section in our Bibliography is ANTHROPOLOGICAL, reflecting the revivified interest in the ways of the Indians leading their own lives today in the mountains of Oaxaca, Puebla, Vera Cruz, and the vicinity of Mexico City. The fourth section is MYCOLOGICAL. The fifth CHEMICAL, the sixth PHARMACOLOGICAL, and the seventh PSYCHOLOGICAL, PSYCHIATRIC, AND CLINICAL. The entries in these sections five, six, and seven often overlap, and therefore we have made them into a single list, but we have indicated in brackets to which sections each entry belongs.

The eighth section covers PARAPSYCHOLOGICAL items; the ninth, CASES OF ACCIDENTAL INGESTION OF HALLUCINOGENIC MUSHROOMS; and finally BOOK REVIEWS are listed in the tenth section.

Much has been published on our mushrooms and psilocybin in the lay press, in many countries. Our bibliography does not attempt to cover these articles: perhaps they will be the subject of a brief paper on a future occasion. We have tried to make our entries complete to July 1, 1962.

The basic papers of Professor Heim that originally appeared in the *Comptes rendus* of the Académie des Sciences, Paris, were reprinted, except the most recent ones, in the *Revue de Mycologie*, complemented by specific definitions in Latin and certain other articles; and finally these pieces were gathered together in three recapitulations:

(1) *Notes préliminaires sur les Agarics hallucinogènes du Mexique*, 1957, hereafter called *Notes prélim* . . . ;
(2) *Nouvelles Observations sur les Agarics hallucinogènes du Mexique*, 1958, hereafter called *Nouv Observ* . . . ; and
(3) *Deuxième Supplément aux Observations sur les Agarics hallucinogènes du Mexique*, 1962, hereafter called *Deux Supplé* . . . .

These were published by the Laboratoire de Cryptogamie, of the Muséum National d'Histoire Naturelle, 12, Rue de Buffon, Paris, V^{e}. The successive publication of these basic documents will be made clear by the key on the next page:

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Feb. 20, 1956 tome 242:965–8	May 15, 1957 XXII(1) 58–62	*Notes prélim . . .*
Mar. 12, 1956 242:1389–95	,, ,, 62–70	
Feb. 4, 1957 244:695–700	,, ,, 70–76	
June 24, 1957 244:3109–14 (*Note* of Roger Heim and Roger Cailleux)	Sept. 15, 1957 XXII(2) 183–9	
Aug. 5, 1957 245:597–603	,, ,, 189–197	
Nov. 18, 1957 245:1761–5 (Presented at session of Nov. 13)	Dec. 31, 1957 XXII(3) 300–5	*Nouv Observ . . .*
Mar. 3, 1958 246:1346–51 (*Note* of Roger Heim, Arthur Brack, Hans Kobel, Albert Hofmann and Roger Cailleux)	Apr. 15, 1958 XXIII(1)106–13	
Aug. 4, 1958 247:557–61 (*Note* of Roger Heim and Albert Hofmann)	Oct. 15, 1958 XXIII(3)347–51	
Oct. 20, 1958 247:1235–8 (Presented by R. Heim on behalf of Jean Delay, Pierre Pichot, Thérèse Lemperière, and Pierre Nicolas-Charles)		
Nov. 9, 1959 249:1842–5 (*Note* of Roger Heim and Roger Cailleux)	Dec. 31, 1959 XXIV(5)437–441	*Deux Supplé . . .*
Dec. 15, 1960 250:1155–60 (*Note* of Guy Stresser-Péan and Roger Heim)		
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Compiled by R. Gordon Wasson and Sylvia Pau

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39. ———. Moving picture with sound track of mushroom ceremony, accompanied by commentary, photographed and recorded in Sierra Mazateca, Mexico, in 1961. Muséum National d'Histoire Naturelle, Paris. In preparation.

40. Wasson, R. Gordon. "Lightning-bolt and mushrooms: An essay in early cultural exploration." For Roman Jakobson: Essays on the occasion of his sixtieth birthday, Oct 11 1956. The Hague: Mouton & Co, 1956. pp 605–12. Reprinted in revised and amplified version, with illustrations, in *Antiquity and Survival*, The Hague, Vol III, No 1, 1960, pp 59–73. In Dutch. English edition promised for 1962.

41. ———. "Seeking the magic mushroom." Water colors by Roger Heim. *Life Magazine*, May 13 1957, New York. Letters to the Editor, June 3. (International edition, June 10; "En busca de los hongos mágicos," *Life en Español*, June 3.)

42. Wasson, Valentina Pavlovna. "I ate the sacred mushroom." *This Week Magazine*, New York, May 19 1957.

The two foregoing articles, timed to coincide with the publication of Mushrooms Russia and History, drew world-wide attention, and started diverse activities in many circles, lay, scientific, and cultural, all centered in the hallucinogenic mushrooms of Mexico. r.g.w.

43. ———, and R. Gordon Wasson. "The hallucinogenic mushrooms". The New York Botanical Garden. *The Garden Journal*, Jan-Feb 1958.

An historical article summarizing the world's knowledge of and attitude toward the hallucinogenic mushrooms of Mexico during four centuries, from the 16th down to the 20th. r.g.w.

44. Wasson, R. Gordon, and Valentina P. Wasson. Mushroom Ceremony of the Mazatec Indians of Mexico. Recorded by R. Gordon Wasson. With translations and commentary by Eunice V. Pike and Sarah C. Gudschinsky. Folkways Record and Service Corporation, 121 West 47th St, New York 36 N Y. Record listing No FR 8975.

Extracts of a recording made in 1956 in Huautla de Jiménez of a midnight mushroom ceremony. r.g.w.

45. Wasson, R. Gordon, with others. Tape recording of mushroom ceremony held in Sierra Mazateca in 1958, with album of records, transcription

in Mazatec of entire text, annotated translations into Spanish and English, and commentary anthropological, musicological, and linquistic. In preparation.

46. ———. "The divine mushroom: Primitive religion and hallucinatory agents." *Proc Am phil soc,* Philadelphia, Vol 102, No 3, June 24 1958, pp 221–223.

47. ———. "Wild mushrooms: A world of wonder and adventure." *Herbarist* Herb Soc Amer, Boston, Mass, No 25, 1959.

Three cases of accidental ingestion of hallucinogenic mushrooms are here published for the first time. The article in *Life* (*vide* 41) elicited them in letters to the author. They report experiences in Poland, Colorado, and the Fiji Islands. R.G.W.

48. WASSON, R. GORDON. "The hallucinogenic mushrooms of Mexico: An adventure in ethnomycological exploration." *Trans N Y Acad Sci,* Ser II, Vol 21, No 4, Feb 1959, pp 325–339. Reprinted in Drug Experience: First-person accounts of addicts, writers, scientists and others, edited by David Ebin. New York: Orion Press, 1961, pp 311–324.

49. ——— "The hallucinogenic fungi of Mexico: An inquiry into the origins of the religious idea among primitive peoples." *Annual Lecture* of the Mycological Society of America, delivered in Stillwater, Oklahoma, Aug 30 1960. Revised. *Bot Mus Leafl* HARV, Cambridge, Mass., Vol 19, No 7, Feb 1961, pp 137–162.

Appended to this paper is a list of the hallucinogenic fungi of Mexico, both those that truly possess psychotomimetic properties and those others to which the Indians also attribute divinatory powers. To the latter class should be added the puffballs reported in Entry 15, published only in 1962. R.G.W.

50. WASSON, R. GORDON, AND SYLVIA PAU, compiled by. "The hallucinogenic mushrooms of Mexico and psilocybin: A bibliography." *Bot Mus Leafl* HARV, Cambridge, Mass. Vol 20, No 2, Sept 1962, pp 25 *et seq.*

II. THE PAST

a. Primary Sources

COMPILED BY R. G. WASSON AND IRMGARD WEITLANER JOHNSON

51. ANONYMOUS. "Coloquio de la Nueua Conberción y Bautismo de los Quatro Vltimos Reyes de Tlaxcala en la Nueua España." El Teatro de Nueva España en el Siglo XVI, ed by José J. Rojas Garcidueñas. Mexico City, 1935, pp 181–221.

In this religious play a principal character is "Hongol demonio ydolo," a name obviously derived from the Sacred Mushroom, the object of *odium theologicum* among Spaniards of the 16th century. R.G.W.

52. BASALENQUE, DIEGO. Ms lexicon: Vocabulario . . . Español-Matlatzinca and Matlatzinca-Español. See entries under *hongo que emborracha* and *chohui.* Biblioteca Nacional de Mexico, 1642; also in John Carter Brown Library, Providence, R. I.

    This dictionary securely places the use of the Sacred Mushroom among the Matlatzinca Indians, to the west of Mexico City. R.G.W.

—. BENAVENTE, FRAY TORIBIO DE. See MOTOLINÍA.

53. CÓRDOVA, JUAN DE. Vocabulario en Lengua Çapoteca. Mexico City, 1578. See entries under *honguillo* and *xetas.*

    This dictionary shows that the Sacred Mushrooms were known among the Zapotecs. R.G.W.

54. COVARRUBIAS, GASPAR DE. "Relación de las Minas de Temazcaltepec". (1579) Papeles de Nueva España, Geografía y Estadística. Madrid: Francisco del Paso y Troncoso, 1906. Ser 2, Vol VII, p 20.

    In the annual tribute paid by these Matlatzinca-speaking people to their overlord there is included a shipment of the Sacred Mushrooms. R.G.W.

55. DURÁN, DIEGO. Historia de las Indias de Nueva-España y Islas de Tierra Firme. México: J. M. Andrade y F. Escalante, 1867–1880. 2v. See Vol I, Chap liv, p 431.

    The Sacred Mushrooms were consumed at the celebrations attending the inauguration of Moctezuma, years before the Conquest of Mexico by Cortés in 1519. R.G.W.

56. GILBERTI, MATURINO. Tarascan lexicon. 1559. See entry under *hongo.*

    This lexicon places the use of the Sacred Mushroom in Tarascan country, in Michoacan. R.G.W.

57. Hearing before the Holy Office of the Inquisition in the case of Gonzalo Pérez. (1629) Ms. *Archivos Generales de la Nación,* Mexico City. Vol 340, pp 354–359.

    An episode that takes place in Tarascan country involving the use of mushrooms. R.G.W.

58. HERNÁNDEZ, FRANCISCO. Opera: Historia Plantarum Novae Hispaniae. (Ms written before 1577) Madrid: Ibarra, 1790. 3v. See Vol II, Bk IX, Chap 95.

    This 16th-century Spanish botanist describes the sacred mushrooms but unfortunately his picture of them, which he mentions in his text, is lost. R.G.W.

59. Kakchiquels, Annals of the. Anonymous Kakchiquel Text. English version translated by Delia Goetz (from Spanish version translated by Adrián Recinos). Oklahoma: University of Oklahoma Press, 1953. Also see Annals

of the Cakchiquels, Quiché and English text, edited by Daniel G. Brinton. In Library of Aboriginal American Literature, No VI, Philadelphia, 1885, pp 114–5.

Mushrooms are mentioned in a context that, although obscure, is certainly religious. Today no trace of the use of Sacred Mushrooms has been found in Guatemala, where the Kakchiquel Maya live. For discussion of this text see Entry 1, p 282. R.G.W.

60. LANCIEGO, JOSÉ. Letter to the clergy of the Huasteca. (1726) Extract published in La Parroquia de Tancanhuitz: Datos para su Historia. Univ Autónoma de San Luis Potosí, 1954, p 14.

The good bishop deplores the use of mushrooms among his people. This is the only indication of the use of Sacred Mushrooms in the Huasteca, and unfortunately it is not clear whether Hausteco Indians were using them or Nahuatl-speaking immigrants. R.G.W.

61. Magliabechiano Codex. Loubat edition, Rome, 1904. See p 90. Also published by the University of California, Berkeley, 1903. Reproduced in Entries 1, p 235, and 2, p 33.

One of two illustrations of the Sacred Mushrooms coming down to us from the 16th century. This one, painted probably by an Indian under strong Spanish influence, expresses nevertheless the Indian's awe before the miracle of the mushrooms. R.G.W.

62. Mixe lexicon. (?1800) See entries under *el honguillo con que se emborrachan.* Ms. found by Walter Miller in San Lucas Camotlán and given to Museo National de México.

The only documentary evidence for the use in former times of the Sacred Mushrooms among the Mixe Indians. R.G.W.

63. MOTOLINÍA (TORIBIO DE BENAVENTE). "Ritos antiguos, sacrificios e idolatrías de los Indios de Nueva España, y de su conversión a la fe . . ." (Before 1569) Colección de Documentos para la Historia de México, ed. by Joaquín García Icazbalceta. Mexico City, 1858. See Vol 1, p 23.

A horrifying (and, as we know, fanciful) description, by a devout son of the Church, of the effects of taking the Sacred Mushrooms. He states that their name in Nahuatl, *teonanácatl*, means in that language "God's flesh", and ends his disquisition with the observation that the Indians served the mushrooms in Holy Communion. R.G.W.

64. MOLINA, ALONSO DE. Vocabulario en Lengua Castellana y Mexicana. 1571. See entries under *hongo que emborracha* and *xochinanacatl.*

This 16th-century Nahuatl dictionary securely places the use of the Sacred Mushrooms among the Nahua of the Valley of Mexico. R.G.W.

65. NÁGERA (NÁJERA) YANGUAS, DIEGO DE. Doctrina y Enseñança en la Lengua Maçahua de Cosas muy Utiles, y Provechosas para los Ministros de Doctrina. Mexico City, 1637. Fol 27–29.

A manual for the clergy in which they are told how to ask, in the Mazahua language, when confessing their penitents, whether these persist in using the Sacred Mushrooms. R.G.W.

66. Nahuatl poem. "Dolor en la Amistad." (c. 1600) Anonymous. Translated by Angel María Garibay. No 37 in Xochimapictli, colección de Poemas nahuas. Mexico City, 1959.

One of the poems in this Nahuatl anthology mentions expressly the Sacred Mushrooms. Others in the same collection use *xochi*, "flowers", in a sense that suggests it was a metaphor used for the mushrooms. This possibility is reenforced by Molina's lexicon, where *xochinanacatl* is translated by *honguillos que embeodan*, "little mushrooms that inebriate". R.G.W.

67. Otomí lexicon. 1640 Ms., copied from 16th-century ms. now lost. See entries under *hongo que emborracha* and *hongos que enbelezan*. Biblioteca Nacional de México.

This lexicon places the use of the Sacred Mushrooms among the Otomí Indians. R.G.W.

68. PÉREZ DE ZÁMORA ABARCA, PEDRO. "Relación de Teticpac." (1580) Papeles de Nueva España, Geografía y Estadística. Madrid: Franscisco del Paso y Troncoso, 1905. Vol IV, p 111.

This report places the use of the Sacred Mushrooms in the Valley of Oaxaca, among the Zapotecs. R.G.W.

69. POPOL VUH. Anonymous Quiché Text. English version translated by Delia Goetz and Sylvanus Griswold Morley. Oklahoma: University of Oklahoma Press, 1950. See p 192, reference to mushrooms.

The context is enigmatic, but at least the mushroom citation occurs in a passage that unmistakably relates it to a religious use. R.G.W.

70. SAHAGÚN, BERNARDINO DE.
    (1) Historia General de las Cosas de Nueva España. (16th century)
        (a) Bk IX, Chap viii; Flor Codex, fol 31r-31v.
        (b) Bk X, Chap xxix, Sec 2; Flor Codex, fol 122v.
        (c) Bk XI, Chap vii, Sec 1, par 70 in Nahuatl text; Flor Codex, fol 129v-130r.
        (d) Bk XI, Chap vii, Sec 1, par 74; Flor Codex, fol 130v-131r.
        (e) Flor Codex, illus 516, in Paso y Troncoso; also in Entry 1, fig 14, p 234; and in Entry 2, fig 1, p 32.
    (2) Paralipómenos de Sahagún, translated by Angel María Garibay. Published in Tlalocan, Vol II, No 3, 1947, pp 239, 247.
    (3) Schultze-Jena, Leonard. Gliederung des altaztekischen Volks in Familie, Stand, und Beruf. Stuttgart: W. Kohlhammer, 1952. pp 26–27, 36–37, 58–59, 242–243, 243–244.

Our most important source for the use of the Sacred Mushrooms is the great Franciscan ethnographer Sahagún. The first four citations survive in Spanish and in Nahuatl, the latter presumably being the very words of Sahagún's informant. R.G.W.

71. SERNA, JACINTO DE LA. Manual de Ministros de Indios para el Conocimiento de sus Idolatrías y Extirpación de Ellas. Published in Mexico City, 1892. See Chap IV, Sec 3. Also included in *Anales del Museo Nacional de México*, Vol VI, Mexico City, 1900.

Like Motolinía, this author draws the analogy between the Christian Eucharist and the eating of the mushrooms; he suggests that the Indians regard the flesh of the mushrooms as divine, or as he considers it diabolic. R.G.W.

72. TEZOZÓMOC, FERNANDO DE ALVARADO. Crónica Mexicana. Mexico City, 1958. See Chap 87.

Briefly Tezozómoc tells of the same episode as Diego Durán. See Entry 55. R.G.W.

73. THÉVET, ANDRÉ. "Histoyre du Mechique." (Before 1574) Ms. (Rendered lost work by Andrés de Olmos, Antiqüedades Mexicanas, c. 1543.) Edited by Ed. de Jonghe. *J Soc Amér de Paris*, n. s., Vol. II, 1905, p 18.

This historian recounts an episode dating from the middle of the 15th century, long before the Conquest, in which the Sacred Mushrooms were eaten in Otomí country in a religious context. R.G.W.

74. Trial before the Holy Office of Inquisition, in the case of Mixcoatl and Papalotl. (1537) Ms. Published in Publicaciones del Archivo General de la Nación, Procesos de Indios, Idólatras, y Hechiceros. Mexico City, 1912. Vol III, pp 55 *et seq*.

In this trial the analogy between the Christian Eucharist and the mushroom agape is strikingly brought out, as in Motolinía and de la Serna. R.G.W.

75. YANHUITLAN, CÓDICE DE. (1544) Edited by Wigberto Jiménez Moreno and Salvador Mateos Higuera. Mexico: Instituto Nacional de Antropología e Historia, 1940. See Appendix, p 38.

This source places the Sacred Mushrooms in Mixtec country. R.G.W.

b. Later References

76. BANCROFT, HUBERT HOWE. The Native Races. Vol II, 1874–1876. See p 360.

77. BOURKE, JOHN GREGORY. Scatologic Rites of all Nations. 1891. See pp 89–91.

78. CAIRNS, HUNTINGTON. "A divine intoxicant." *Atlantic Monthly*. Vol 144, No 5. Nov 1929, pp 638–645.

In this article the Safford thesis, denying the existence of hallucinogenic mushrooms in Mexico, received its final expression. R.G.W.

79. Flores, Francisco A. Historia de la Medicina en México. México: Oficina Tipográfica de la Secretaría de Fomento, 1886–1888. 3v. See Vol I, pp 55, 258.

80. Orozco y Berra, Manuel. Historia Antigua y de la Conquista de México. México: G. A. Esteva, 1880. 4v. in 2, See Vol I, p 274; Vol III, pp 375, 437.

81. Safford, William E. "An Aztec narcotic." *J Hered*, Vol 6, July 1915, pp 291–311.

The economic botanist, renowned in his day, in a full-dress study here adumbrated the thesis that the hallucinogenic mushrooms had never existed, and that early Spanish *padres* had confused *peyote* with fungi. R.G.W.

82. ———. "Peyote, the narcotic mescal button of the Indians." *J Am med Assoc*, Vol 77, No 16, Oct 15 1921, pp 1278–1279.

This article, published shortly before Safford's death, shows that he still persisted in his mistaken belief. R.G.W.

83. Siméon, Rémi. Dictionnaire de la Langue nahuatl. 1885. See entries under *nanacatl* and *teonanacatl*.

c. Archeological

COMPILED BY STEPHAN F. DE BORHEGYI

—. Borhegyi, Stephan F. de. "Mushroom stones of Middle America. A geographically and chronologically arranged distributional chart." See Entry 1, chart, in pocket at end of Vol II. Hereinafter referred to as Borhegyi's chart, of which a revised version is in Entry 85.

A geographic and chronologic distributional chart of Pre-Columbian mushroom stones and pottery mushroom forms found at various archeological sites in Mexico, Guatemala, and El Salvador published as an *Appendix* in end-pocket form to Vol II of the Wassons' book. Borhegyi distinguishes 5 types (A to E) of stone and pottery mushrooms and illustrates with 48 specimens. (Average height 30cm)

Types:		*Approx. Chronology (revised as of 1962)*
Type A	Anthropomorphic stone sculptures with plain or circularly grooved mushroom caps.	Early or Mid-Pre-Classic (1000 B.C. to 300 B.C.)
Type B	Effigy mushroom stones with circularly grooved caps and square or tripod bases.	Early and Mid-Pre-Classic (1000 B.C. to 300 B.C.)

Type C	Effigy or plain mushroom stones with square or rounded bases without circularly grooved caps.	Late Pre-Classic (300 B.C. to 200 A.D.) and Proto-Classic(?) (200 to 300 A.D.)
Type D	Tripod mushroom stones with plain or carved stems and with clubby or sharp angled feet.	Late Classic (600 to 900 A.D.)
Type E	Miscellaneous and possibly related stone and pottery objects.	Chronological position uncertain. Late Pre-Classic (300 B.C. to 200 A.D.) & Proto-Classic(?) (200 to 300 A.D.)

84. ———. "Mushroom Stone Discoveries." Amatitlán Field Report. Mimeographed, 1960. Milwaukee.

Reports (p 4) the finding of a square based anthropomorphic (Type C) mushroom stone from the shores of Lake Ayarza (Dept Santa Rosa) in Eastern Guatemala. The Specimen was found by a group of Guatemalan skin-divers who have been engaged in a systematic investigation of the inland lakes of Guatemala since 1954, seeking possible Pre-Columbian lake offerings. To date six mushroom stones (Types C and D) have been found in the waters of Lake Amatitlán in the Central Guatemalan Highlands. The specimen from Lake Ayarza is in the private collection of Manfred Töpke, while the others are in the private collections of Dr. Guillermo Mata-Amado and Jorge Castillo, of Guatemala City.

Paper includes (p 7) a preliminary report on the (Type B) miniature mushroom stones found in a cache at Kaminaljuyu, now in the collection of Karl Heinz Nottebohm of Guatemala City (for final report see next Entry). Also reports the finding of a (Type C) mushroom stone fragment (in the shape of an owl) from the recent excavation of the Post-Classic period (1000–1500 A.D.) at the Kakchiquel Maya capital of Iximché, in the Central Guatemalan Highlands.

85. ———. "Miniature mushroom stones from Guatemala." *Amer Antiq*, Vol XXVI, No 4, April 1961, Salt Lake City, Utah, pp 498–504.

Offertory cache of nine miniature mushroom stones and nine miniature *metates* with *manos* from the Verbena cemetery at Kaminaljuyu in Highland Guatemala, dating from the Late Pre-Classic Miraflores phase, 300 B.C. to 200 A.D. All of the mushroom stones are of the Type B variety with a circular groove around the base of the cap (average height 16cm).

A similar but larger Type B mushroom stone, in the shape of a jaguar, has been found in a Miraflores tomb in Mound E-III-3 at the same site (see Shook and Kidder, Entry 103). The cache of nine miniatures demonstrates considerable antiquity for the "mushroom-stone cult," and suggests a possible ceremonial association with the nine Lords-of-the-night and gods of the underworld, as well as the possible existence among the Highland Maya of a nine-day cycle and nocturnal count in Pre-Classic times. The association of the miniature mushroom stones with the miniature *metates* and *manos* greatly strengthens the possibility that, at least in some areas in Pre-Columbian Mesoamerica, *metates* were used to grind the sacred hallucinatory mushrooms to prepare them for ceremonial consumption. The article includes, as Fig 2 and Table 1, a revised chart of Borhegyi's 1957 chronologic distributional table, and brings up to date the mushroom stone and pottery mushroom finds in Mesoamerica. About 50 archeological sites are listed from Mexico, Guatemala, and El Salvador where mushroom stones and pottery mushrooms have been found during archeological excavations, or in private collections and museums.

All miniature mushroom stones and *metates* with *manos* described in this article are in the private collection of Karl Heinz Nottebohm, of Guatemala City. The large Type B mushroom stone (Fig 3), representing a kneeling young woman (a virgin?) with a *metate*, is from the Hans Namuth collection in New York.

To date this is the only comprehensive article on mushroom stones and pottery mushrooms, and the first report on the existence of miniature mushroom stones.

86. ———. "The Enigmatic Mushroom Stones of Meso-America." Ms. (In preparation) Tulane University, New Orleans. Middle American Research Institute, Middle American Research Records.

Manuscript in preparation that will present an up-to-date distribution and typology of these enigmatic objects. It will contain photographs and line drawings of over 100 specimens, as well as distributional maps and chronological charts.

87. Brigham, William T. Guatemala, the Land of the Quetzal. New York: Scribner, 1887, see p 280, illustration.

Illustrates a zoomorphic mushroom stone-like object representing a rabbit or *pisote*, with rounded base (Type E) from the National Museum of Guatemala. Brigham refers to it as a stone seat, implying that these sculptures were so used. It represents the first mushroom stone-like object from Mesoamerica to be described and illustrated. For a similar specimen in the Chicago Natural History Museum (Cat no 48650) see No 44 on Borhegyi's chart. The whereabouts of the piece illustrated by Brigham is unknown.

88. Brinton, Daniel G. "Mushroom-shaped images." *Science*, n.s., Vol 8, No 187, July 29 1898, New York, pp 126–127. See p 127.

Reply by the noted American ethno-linguist to Sapper's suggestion in *Globus* (1898), Entry 100, that an anthropomorphic mushroom stone illustrated from El Salvador was a phallic symbol. Brinton suggests that since the stone resembles a mushroom or toadstool, it may have been intended by its maker to represent just that. Brinton further suggests that, since the Tseltal-Maya word for mushroom is *hu* and is sufficiently similar to the word used for moon *uh* or *yuh* to recall it in sound, the mushroom stones may have been emblematic of the lunar and nocturnal divinity. According to him the night growth of the fungus would strengthen this mythical alliance. The Type C specimen referred to is now in the Rietberg Museum collection in Zürich. (Cf no 19 in Borhegyi's chart, above cited.) Historically, this is the first known, published reference to mushroom stones as mushroom representations. The next published reference is in Wasson & Wasson, 1957, herein entered as Entry 1.

89. Canals Frau, Salvador. Las Civilizaciones Pre-hispánicas de América. Buenos Aires, Editorial Sudamericana, 1955, p 147. Fig 36.

Illustration and brief description (p 147) of two effigy mushroom stones with circularly grooved caps (Type B) from Kaminaljuyu, Guatemala, both of which represent jaguars. They are also illustrated in Borhegy's chart as nos 12 and 15. Figure 36 (left) (Cat no 2366; Lot no C-69) is probably of the Early Pre-Classic Las Charcas phase (1000 B.C. to 500 B.C.), and as such ranks among the earliest known effigy mushroom stones. Figure 36 (right) is from tomb 1 in Mound E-III-3 at Kaminaljuyu (Shook and Kidder, 1952, fig 78*f*) and is one of the first examples (Late Pre-Classic-Miraflores phase, 300 B.C.–300 A.D.) of this problematical sculpture to be excavated. Both specimens are now in the National Museum in Guatemala City (Cat no 2366 and 3450 respectively).

90. Foster, George M. "Some implications of modern Mexican mold-made pottery." *Sthwest J Anthrop*, Vol IV, No 4, 1948, pp 356–370.

According to Foster, some pre-Conquest Mexican pottery was made using convex mushroom-shaped pottery molds. These molds appear to have originated from the practice of molding pots over the upturned bottom of finished vessels. The same technique is still in use at several places in Mexico.

Owing to the fact that some modern mushroom-shaped pottery molds from Tzintzuntzan and Metepec in Mexico (see figs 2, 3) and some Pre-Columbian pottery anvils from North America (see fig 6) have a slight resemblance to the Pre-Columbian pottery-mushrooms from Mexico and El Salvador (see nos 46, 47, 48 in Borhegyi's chart), there exists the slight possibility that pottery-mushrooms were used, not in Pre-Columbian hallucinogenic mushroom rites, but to aid in the shaping and manufacturing of culinary pottery objects. (For publications referring to pottery-mushrooms see Longyear, Entry 94; Lothrop, Entry 95; Lowe, Entry 96; and Stirling, Entry 106).

91. Gann, Thomas. Glories of the Maya. London: Charles Scribner's Sons, 1939, pp 204–6.

Describes the discovery of a plain tripod mushroom stone (Type D) in association with a plain stone yoke, Tiquisate ware figurines, and cylindrical vases with human bones, in a Late Classic (600 to 900 A.D.) Pipil (?) burial ground at Patulul, near Cocales (Dept Suchitepequez) on the South Coast of Guatemala. No illustrations. Similar tripod mushroom stones were found and illustrated later from the same general area by Thompson, Entry 110. Gann mentions that mushroom stones are believed by some anthropologists to be phallic symbols because of their resemblance to the *lingam*. The whereabouts of the specimen excavated by Gann is unknown.

—. Heim, Roger, and R. Gordon Wasson. 1958. Paris. See Entry 2, chap III, pp 113–121, figs 22, 23, pls X, XI, XII.

Illustrates 9 crudely manufactured miniature clay cups (fig 23B) with mushroom-like appliqué designs collected by Marshall Saville between 1899–1900, from Xaaga, near Mitla, Oaxaca, Mexico. These curious cups are now in the collection of the American Museum of Natural History in New York.

Line drawings (figs 22–23) illustrate five Type B and C mushroom stones, reproduced from Borhegyi's charts, nos 31, 15, 32, 25 respectively. Plate X illustrates a Type D tripod mushroom stone with carved stem in the Wasson private collection in New York (cf Borhegyi, no 38). Plate XI illustrates the Type C effigy mushroom stone, first published by Sapper (1898) and now in the Rietberg Museum in Zürich (cf. Borhegyi, no 19). Plate XII illustrates a Type B effigy mushroom stone with circularly grooved cap from the Hans Namuth private collection in New York. The specimen represents a young woman (a virgin?) kneeling before a *metate*.

(Reproduced also as fig 3 in Borhegyi, Entry 85.) Figures 22 and 23, as well as plates XI and XII, are also illustrated by Wasson and Wasson, Entry 1, Vol II, as figs 18, 19, and plates XLIII, and XLIV respectively.

92. Kidder, A. V., with J. D. Jennings and E. M. Shook. "Excavations at Kaminaljuyu, Guatemala." Carnegie Institution of Washington. Publ 561, Washington, D. C., 1946. See pp 104, 142, figs 42, 58*c*, 160*a-h*.

This is the first publication reporting (pp 104 and 142) the discovery of mushroom stones in a scientifically controlled excavation. It describes and illustrates (fig 160*a-h*) ten mushroom-shaped stone objects from Guatemala and Mexico. Six of the specimens are plain or effigy mushroom stones (Type C), while three belong to the tripod (Type D) variety. Five have been reproduced in Borhegyi's chart as nos 32, 28, 38, 19, 18. The Type C effigy mushroom stones represent seated human figures, birds, and *pisotes*. Kidder briefly but concisely discusses their known distribution (p 142) in the Highlands and Pacific Slopes of Guatemala and Mexico, and that of similar pottery-mushrooms in El Salvador. He is non-committal as to their use, but refutes previous suggestions that they represent *phalli* or were used as seats. Of the specimens illustrated in the publication, five (fig 160*f,h,e,g* and fig 42) are in the collections of the Guatemala National Museum (Cat nos 2368 a; 2368 b; 4631, 1903, 2715), and two (fig 160*a, b*) in the Regional Museum, at Tuxtla Gutiérrez, in Mexico; the whereabouts of the remainder are unknown.

93. Kidder, Alfred (Editor). The Art of the Ancient Maya. New York: Thomas Y. Crowell Company, 1959. See figs 3, 4.

Illustrates two effigy mushroom stones with square bases from the Guatemalan National Museum collection, found in the vicinity of Kaminaljuyu in the Guatemalan Highlands. One represents a seated human figure, the other an anthropomorphic squatting toad. Both are of the Type C variety (without cricularly grooved caps), and are also reproduced in Borhegyi's chart as nos 17, 31. As to their use, Kidder mentions that they may represent the sacred hallucinogenic mushroom used to induce trances in some mushroom-rituals in modern Mexico. Both specimens are in the Guatemalan National Museum (Cat nos 2220 and 2209). The toad-shaped mushroom stone (fig 4, Cat no 2209) from Cerro Alux is also illustrated as fig 18 in Wasson and Wasson, Entry 1, and as fig 22 in Heim and Wasson, Entry 2.

94. Longyear, John M. "Archeological investigations in El Salvador." *Mem Peabody Mus*, Vol IX, No 2, Cambridge, 1944. See pottery 'mushrooms,' pl IX-no 26; stone 'mushrooms,' pl XII-no 16.

Illustrates a pottery mushroom (Type E) and a plain stone mushroom (Type C) from El Salvador (Plate IX, no 26, and Plate XII, no 16). They are reproduced in Borhegyi's chart as nos 48 and 37. Longyear has no comments as to their function or distribution. The specimens are in the private collection of Colonel Montalbo, in El Salvador.

95. Lothrop, Samuel Kirkland. "Atitlán: An Archeological Study of Ancient Remains on the Border of Lake Atitlán, Guatemala." Carnegie Institution of Washington, Publ 444, Washington, D. C., 1933. See p 29, figs 9*b*, 11*a-c*.

Illustrates two pottery mushrooms (Type E) from El Salvador (fig 11*b*, *c*) which are also reproduced in Borhegyi's chart, nos 46, 47. Also illustrates (based on Villacorta and Villacorta, Entry 111, p 123) anthropomorphic mushroom stone with a square base (Type C) from Majadas, a section of Kaminaljuyu; and a stone mushroom cap (Type A) from the archeological site of Chukumuk, on the Southeast shore of Lake Atitlán in Guatemala (reproduced as no 9 in Borhegyi's chart). Lothrop does not attempt to describe their distribution or their function. The stone mushroom cap illustrated by Lothrop as fig 9*b* is now in the collection of the Guatemalan National Museum (Cat no 1169). A similar stone mushroom cap from the archeological site of Xikomuk, also at Lake Atitlán (Guatemalan National Museum, Lot no E-194), is reproduced as no 11 in Borhegyi's chart. Lothrop's article is the first to mention and illustrate a stone mushroom cap and "pottery mushrooms." (For other publications referring to pottery mushrooms see Longyear, Entry 94; Stirling, Entry 106; and Lowe, Entry 96.)

96. Lowe, Gareth W. "Archeological exploration of the Upper Grijalva River, Chiapas, Mexico." *Papers of the New World Archeological Foundation,* No 2, Orinda, California, 1959. See pottery 'mushrooms,' pp 75–76, figs 29*f*, 50*a*; stone 'mushrooms,' pp 49, figs 60*c*, *d*.

Illustrates and describes a pottery mushroom (Type E) found at the archeological site of Guanacaste, near the Grijalva River, Chiapas, and two plain mushroom stones (Type C) from Chiapa de Corzo in Central Chiapas, Mexico. Lowe believes that the pottery mushrooms in Chiapas may have Salvadorean origin. The specimens now are in the Regional Museum at Tuxla Gutiérrez in Chiapas.

97. ———. "Mound 5 and minor excavations, Chiapa de Corzo, Chiapas, Mexico." *Papers of the New World Archaeological Foundation,* No 12 (Publication No 8). Brigham Young University, Provo, Utah. 1962, p 64, fig 40*j*.

Illustrates (fig 40*j*) and describes (p 64) a Type C mushroom stone reportedly found in a burial (burial no 1) located in a small mound group at Mango Seco, 800 m. east of Chiapa de Corzo. The burial also contained nine undecorated pottery vessels, and a jade necklace and earspools. The mushroom stone, discovered below the right foot of the skeleton of an adult, is of pecked and ground limestone. The burial and its contents are dated to the Mid-Pre-Classic (500–300 B.C.) Francesa phase. The specimen is now in the Regional Museum at Tuxtla Gutiérrez in Chiapas, (Mu no 61–LIV–34).

98. Puharich, Andrija. "Mushroom Icons." *Bull Mycol So San Francisco,* Vol IX, No 12, 1959, pp 8–10, 16.

Illustrates and comments on two (Type C) effigy mushroom stones from Highland Guatemala; reproduced as Nos 17 and 13 in Borhegyi 1958, 1961. For other items by this author see Entry 141 and sec viii.

—. Ravicz, Robert. 1961. See Entry 143, pp 91–92.

Ravicz renews the suggestion first made by the Wassons that mushroom stones may have been used in Mexico in Pre-Columbian times as part of the hallucinogenic sacred mushroom ceremony. Among the present day Mixtecs the sacred mushrooms are gathered by a virgin, ground on a *metate*, water added, and the beverage drunk by the person who wishes to consult the mushroom. The association of Pre-Columbian mushroom stones and their use for similar purposes with *metates* is discussed by

Borhegyi, Entry 85. For an anthropomorphic mushroom stone (Type B) representing a woman with a *metate*, see Heim and Wasson, Entry 2, Pl XII, and Borhegyi, Entry 85, fig 3.

99. SANDERS, WILLIAM T. "Ceramic stratigraphy at Santa Cruz, Chiapas, Mexico." *Papers of the New World Archaeological Foundation*, No 13 (Publication No 9). Brigham Young University, Provo, Utah, 1961, pp 16 and 28, fig 15*b*, pl 6*j*.

Illustrates (fig 15*b*, and pl. 6*j*.) and describes (p 16 and p 28) a Type E pottery mushroom fragment, found in the excavation of Trench 2, in level 4. The fragment is of a coarse-paste, unslipped, unburnished, thick-wall utility ware, subsequently named Chiapilla ware. Although only one fragment is illustrated (upside down), Sanders indicates (p 28) that there were several of these "mushroom" pots or "mushroom" vessels in Trench 2. The Chiapilla period at the Santa Cruz site is equated by Sanders with the Mid- or Late- Pre-Classic (500 B.C. –0 A.D.) Francesa and Guanacaste periods (IV–V) at the site of Chiapa de Corzo. Owing to the fact, however, that level 4, in Trench 2, was a disturbed level (see p 9), it is possible that the "mushroom" vessels are of the later Santa Cruz period, which is of late Pre-Classic or Proto-Classic (0 A.D. –200 A.D.) date. The specimens are now in the Regional Museum at Tuxtla Gutiérrez in Chiapas.

100. SAPPER, CARL. "Pilzförmige Götzenbilder aus Guatemala und San Salvador." *Globus*, Vol 73, No 20, 1898, p 327.

Illustrates and describes an anthropomorphic mushroom stone on a square base (Type C) from El Salvador, now in the Rietberg Museum in Zürich (see Wasson and Wasson, Entry 1, Pl XLIII; and Heim and Wasson, Entry 2, Pl XI). Sapper explores the function of these objects, citing Dr. Santiago F. Barbarena, then Director of the National Museum in San Salvador, who believes that mushroom stones represent *phalli*, and that the nine-pointed star, comprising the head-dress of the figure depicted on the mushroom stone, refers to the nine month pregnancy. (For a Type C effigy mushroom stone with a similar nine-pointed crown, found at Kaminaljuyu, see Kidder, Jennings, and Shook, Entry 92, fig 160*f*; reproduced as no 19 on Borhegyi's chart cited above.) Sapper refutes Barbarena's suggestion on the ground that the Pre-Columbian Maya Indians used a 20 month year, and that the wide cap of the stone in question does not resemble a phallus. He urges that comparative studies of these unusual objects be undertaken by archeologists. (See also Brinton's reply to this article, Entry 88.)

101. SELER-SACHS, CAECILIE. Auf alten Wegen in Mexico und Guatemala. 2nd ed. Stuttgart: Strecker and Schröder Verlag, 1925. See pp 182–183.

Illustrates (p 183) and describes (pp 182–183, 236–237) several plain and effigy tripod mushroom stones (Type D) located in private collections by Dr. Seler in the course of his famous reconnaissance trip to Guatemala and Mexico in 1895–96. These stones are reportedly from Chuchun and Los Diamantes on the Pacific Piedmont area of Guatemala, and from Tecpán, Los Pastores, Pompeya, and El Portal in the Central Highlands. They are referred to as "stone seats." Some of the specimens described were donated to the Berlin Museum in 1896, while others found their way to the American Museum of Natural History in New York (Cat nos 30/3122, 30/5448 and 30/50449).

102. Shook, Edwin M. "The present status of research on the Pre-Classic horizons in Guatemala." International Congress of Americanists, 29th Session. The Civilizations of Ancient America. Selected papers, ed by Sol Tax. Chicago: University of Chicago Press, 1951, pp 93–100. See pp 97–98.

Describes the chronological occurrences of the Pre-Classic mushroom stones in the Central Highland area of Guatemala. Asserts that simple stone sculpture probably begins during the Early Pre-Classic Las Charcas phase (1000 to 500 B.C.) in the Maya Highlands with the fashioning of effigy mushroom-like objects. Also mentions the finding of the jaguar-shaped tripod mushroom stone (Type B) in tomb 1, at Mound E-III-3 at Kaminaljuyu (cf Shook and Kidder, Entry 103, p 112, fig 78*f*, and no 15 in Borhegyi's chart, above cited). Shook's premise, that mushroom stones were manufactured during the Las Charcas phase, is not yet fully substantiated. However, mushroom caps (Type A) were discovered in Las Charcas deposits (Guatemala National Museum, Lot nos C-50, C-69, C-43) and are reproduced as nos 8, 10, in Borhegyi's chart. It is also possible that the jaguar mushroom stone (no 12 in Borhegyi's chart) is of Las Charcas date.

103. ———, and A. V. Kidder. "Mound E-III-3, Kaminaljuyu, Guatemala." Carnegie Institution of Washington. Contributions to American Anthropology and History, Publ 596, Vol XI, No 53, Washington, D. C., 1952, pp 33–128. See p 112, fig 78*f*, fig 13-no 193.

Shook and Kidder describe the finding of an exquisitely carved tripod effigy mushroom stone (Type B) in the rich Mid-Pre-Classic (Miraflores phase, 300 B.C. to 200 A.D.) tomb 1 at Kaminaljuyu. This jaguar-shaped mushroom stone is reproduced as no 15 in Borhegyi's chart. Kidder and Shook earlier contended (1946) that mushroom stones are products of the Classic period. The finding of this mushroom stone in a sealed Miraflores phase tomb (fig 13, no 193) establishes with finality that at least certain types of mushroom stones (Types A, B, C) are of Pre-Classic date, and that the mushroom stone cult among the Highland Maya was in vogue as early as 300 B.C. The specimen is now in the Guatemalan National Museum collection (Cat no 3450). This Pre-Columbian jaguar mushroom stone is the first reported from a tomb.

104. ———. "Lugares arqueológicos del Altiplano Meridional Central de Guatemala." *Revista del Instituto de Antropología e Historia de Guatemala,* Vol IV, No 2, 1952, pp 3–40. See pp 5, 7, 10, 11, 16, 19.

In his archeological survey of the Central Guatemalan Highlands, Shook describes 103 archeological sites, their location, architecture, and the specimens collected from each site. Seven sites yielded mushroom stones of the effigy (Type B and C) and tripod (Type D) variety. The seven sites are Aeropuerto, Agua Caliente, Alux, Aurora, Cementerio, Eucaliptus, and Kaminaljuyu. They are reproduced as nos 2, 3, 4, 8, 10, 12, 13, 15, 17, 18, 19, 20, 27, 28, 29, 31, 38, 39, 40 in Borhegyi's chart Shook's article represents the first attempt to survey the distribution of mushroom stones in the Central Guatemalan Highlands. Most of the specimens referred to in Shook's article are in the collections of the Guatemalan National Museum.

105. Sorenson, John L. "An archaeological reconnaissance of West-Central Chiapas, Mexico." *Papers of the New World Archaeological Foundation,* No 1, Orinda, California, 1956, pp 7–19. See p 13.

Mentions the finding of plain mushroom stones (Type C) near the Grijalva River at the archeological site called La Grandeza in Chiapas. Although Sorenson does not illustrate them, the stones appear to be similar to the ones reported by Kidder, Jennings, and Shook (Entry 92 fig 160*a*, *b*) from nearby Ococingo, Chiapas (now in the Regional Museum at Tuxla Gutiérrez), and reproduced as no 32 in Borhegyi's chart.

106. STIRLING, MATTHEW W. "An archaeological reconnaissance in Southeastern Mexico." *Bull No 164 Bur Amer Ethnol.* Anthropological Papers No 53; pp 213–40. Washington, D. C., 1957. Pottery mushrooms, Plates 59 *i*, *e*, *f*, *h*, and 65 a-3; pp 238–9.

Five pottery mushrooms (Type E) are illustrated upside down and described mistakenly as tall pottery jars with round "bottoms" expanded to bowl shape. The "bottoms" are roughened by textile imprints and by stamping them with crinkled edges of pecten shell. One specimen (fig 65 a-3) was found in a sealed tomb at the site of Isla (near Paraíso and Bellote) in association with typical Maya Proto-Classic (200 to 300 A.D.) pottery (unbridged spouted vessels, mammiform feet, etc.). Four similar pottery mushrooms were found in a shell mound at Ceiba, also near Bellote in the State of Tabasco, not far from the Atlantic. This find helps us to assign a tentative proto-Classic date to the pottery mushrooms found throughout Southern Mexico (Veracruz, Tabasco, Campeche, Oaxaca, Chiapas) and Eastern El Salvador. Similar (Type E) pottery mushrooms are reproduced as nos 46, 47, 48 in Borhegyi's chart. The specimens found by Stirling are in the Regional Museum at Villahermosa in Tabasco.

107. STROMSVIK, GUSTAV. "Exploration of the Cave of Dzab-Na, Tecoh, Yucatán." Carnegie Institution of Washington. Current Reports, Vol II, No 35, Cambridge, Mass., pp 463–470. See pp 466, 468, fig 2*g*.

Illustrates and describes the only possible mushroom stone fragment (stem and lower portion missing) ever reported from Yucatán where mushroom stones seem to be absent. Fragment was found by Stromsvik in the South East gallery of the Dzab-Na Cave, located near the village of Tecoh, south of Mérida. It was discovered in association with a slate-ware bowl, a wooden statuette, and six broken *metates* with short *manos*. The specimen consists only of a cap, so that it cannot be ascertained for sure whether it was a grinding implement or, less likely, the top portion of a mushroom stone. Similar doubt is expressed by Heim and Wasson, Entry 2 (p 117, foot 1). This is why it was omitted from the distributional list of Borhegyi. The fragment along with other material from the cave is in the Regional Museum at Mérida, in Yucatán.

108. TERMER, FRANZ. "Auf den Spuren rätselhafter Völker in Süd-Guatemala." *Die Umschau*, Frankfurt-a-M, No 26, 1942. pp 389–392. See fig 7.

Illustrates, as fig 7, a zoomorphic mushroom stone (Type C) representing a toad(?) from Guazacapan (Dept Santa Rosa) on the Southeastern Coast of Guatemala. Termer believes that the specimen may pertain to the Pipil culture, known to have influenced this area during the Classic period (300–900 A.D.), and that it represents a fertility idol, in the form of a phallus, attached to the back of this toad. The specimen is similar to a toad-shaped mushroom stone from Cerro Alux, near Mixco (Guatemala

Highlands), reproduced as no 31 in Borhegyi's chart. The whereabouts of the specimen illustrated by Termer is unknown. There are similar specimens in local private collections (Faustino Padilla Collection at Lake Ixpaco, Dept Santa Rosa).

109. THOMPSON, J. ERIC S. "A trial survey of the Southern Maya area." *Amer Antiq*, Vol IX, No 1, 1943, pp 106–134. See p 121, pl X*d*.

Illustrates an anthropomorphic mushroom stone representing a seated individual with a mushroom cap (Type A). The specimen (now in the Chicago Natural History Museum, Cat no 48649) comes from the Central Highlands of Guatemala, and is reproduced as no 5 in Borhegyi's chart. Thompson refers to the piece as a huge mushroom-like object and mentions that some anthropologists refer to them as stone stools, but asserts that they could hardly have been comfortable seats.

110. ———. "An Archeological Reconnaissance in the Cotzumalhuapa Region, Escuintla, Guatemala." Carnegie Institution of Washington. Contributions to American Anthropology and History, Publ 574, Vol IX, No 44, Washington, D. C., 1948, pp 1–95. See p 24, figs 19*f*, 20*b*.

Describes and illustrates the finding of tripod mushroom stones with plain stems (Type D) at Finca el Baúl (Dept Escuintla), a site on the Coastal Piedmont of Guatemala. Several fragments and one complete specimen (fig 20*b*) came from the excavation of an offertory cache-pit in front of the platform on which stood Monument 3, a huge boulder sculpture, representing an aquiline-nosed, bearded individual. Associated in this cache-pit with the mushroom stones were other small stone sculptures, such as yokes, vertically tenoned anthropomorphic and zoomorphic sculptures, and some pottery sherds. On the basis of the contents of the pit, Thompson was able to assign the tripod mushroom stones (Type D) to the Late Classic San Juan phase (600–900 A.D.). This chronological assignment is substantiated by the finds of Gann (1939) at Patulul where a plain tripod mushroom stone was found in association with a Late Classic burial. Thompson refers to the mushroom stones found at El Baúl as stone seats. They are reproduced as no 39 in Borhegyi's chart. The mushroom stones are in the private collection of Carlos Herrera at El Baúl.

Spanish version of same: "Tentativa de reconocimiento en el area Maya Meridional." *Revista del Instituto de Antropología e Historia de Guatemala*, Vol I, No 2, Guatemala, 1949, pp 23–48. See p 35, Pl IV*d*. Also published by Biblioteca Guatemalteca de Cultura Popular. *Arqueología Guatemalteca*, Vol XX, Guatemala, 1957, pp 23–64. See p 43, Pl IV*d*.

111. VILLACORTA, ANTONIO J. C., AND CARLOS A. VILLACORTA. Arqueología Guatemalteca. Guatemala, 1927. See pp 123–125.

Illustrates and describes two anthropomorphic mushroom stones (Types A and C) with square bases, found in the vicinity of Kaminaljuyu (La Majada) in the Central Guatemalan Highlands, and forming part of the local private collection of Don Carlos Galluser. The specimen (p 125) with the mushroom cap (Type A) is reproduced as no 4 in Borhegyi's chart, while the other (p 123, Type C) is illustrated as fig 11*a* in Lothrop, Entry 95, and fig 23*d* in Heim and Wasson, Entry 2. They are described by the Villacortas as fantastic and humorous stone sculptures with mushroom-like hats. The present whereabouts of the specimens is unknown.

112. VILLACORTA, CARLOS A. "Sitio arqueológico de origen Maya-tolteca entre Guatemala y Mixco; su exploración, y últimas piezas del tipo arcaíco allí

encontradas, que ya figuran en la collección del Museo de Guatemala." *Revista del Museo Nacional de Guatemala,* No 2, Guatemala. 1932. See pp 31–32.

Illustrates and describes a zoomorphic mushroom stone with a square base (Type C) from Cerro Alux, a hill above the present Pokomam Indian town, Mixco, northwest of Guatemala City. The specimen represents a squatting anthropomorphic toad. It is reproduced as no 31 in Borhegyi's chart; as fig 22 in Heim and Wasson, Entry 2; and as fig 4 in Kidder, Entry 93. The piece is now in the National Museum in Guatemala City (Cat no 2209).

—. WASSON, VALENTINA PAVLOVNA, AND R. GORDON WASSON. Mushrooms Russia and History. New York: Pantheon Books, 1957. See pp 275–286, figs 18, 19, pls XLIII, XLIV. Entry 1 in this bibliography.

Illustrates and describes 7 mushroom stones from the Guatemalan Highlands and Chiapas Mexico. The line drawings (fig 18, 19) illustrate 5 Type B and C mushroom stones, reproduced by Borhegyi's chart as nos 31, 15, 32, 25 respectively. Plate XLIII illustrates the Type C effigy mushroom stone first published by Sapper and now in the possession of the Rietberg Museum in Zürich. Plate XLIV illustrates a Type B effigy mushroom stone with circularly grooved cap from the Hans Namuth private collection in New York, representing a young woman (a virgin?) kneeling before a *metate.* (Reproduced also as fig 3 in Borhegyi's chart.) The drawings and plates in this book are also illustrated as figs 22, 23 and plates XI, XII in Heim and Wasson, Entry 2. The Wassons describe in detail (pp 275–286) their research in Mexico and Guatemala, relative to the modern use of hallucinogenic mushroom by Indian groups in Mexico, and convincingly associate the use of mushroom stones with similar rites in Pre-Columbian Mesoamerica.

III. ANTHROPOLOGICAL

See also Entry 1, Chap V, sec 15; Entry 2, Chap II

113. AGUIRRE BELTRÁN, GONZALO. Medicina y Magia: El proceso de aculturación y el curanderismo en México. Mimeographed. Mexico City, 1955. See Chap 6, p 7.

This admirable work, which deserves publication, explores the early sources and poses a number of problems concerning the use of hallucinogenic agents including the Sacred Mushrooms that call for further study. R.G.W.

114. BURKE, OMAR M. "Tunisian caravan." *Blackwood's Magazine,* Vol 291, No 1756, Feb 1962, pp 123–140. See pp 132–3.

The author draws an analogy between the Arab dervishes and our discoveries in Mexico. R.G.W.

115. DE ROPP, ROBERT S. Drugs and the Mind. New York: St. Martin's Press, 1957. Chapter 7: Brews strange and brews familiar. Spanish edition: Las Drogas y la Mente; Mexico, Editorial Continental. 1959.

116. Fabing, Howard D. "On going berserk: A neurochemical inquiry." Read at the Annual Meeting of the American Psychiatric Association, 112th Session, Chicago, Spring, 1956. *Sci Mon* N. Y., Vol 83, No 5, Nov 1956, pp 232–237. Reprinted simultaneously in *Amer J Psychiat*, Vol 113 No 5, Nov 1956, pp 409–415.

117. ———. "Toads, mushrooms, and schizophrenia." *Harper's Magazine*, Vol 214, No 1284, May 1957, pp 50–55.

118. Fanchamps, A. "La psychopharmacologie moderne et les drogues magiques mexicaines." *Rev méd Suisse rom*, Vol 82, 1962, pp 15–31.

A survey of the whole subject, anthropological, mycological, chemical, and medicinal. R.G.W.

119. Gamio, Manuel. La Población del Valle de Teotihuacan. México: Talleres Gráficos, 1922. Vol II. See p 413.

120. Graves, Robert. "What food the Centaurs ate." Stories Talks Essays Poems Studies in History. London: Cassell, 1958. pp 319–343. Also published in Food for Centaurs. New York: Doubleday & Company, 1960. pp 257–282.

121. ———. "Mushrooms, food of the gods." *Atlantic Monthly*, Vol 200, No 2, August 1957, pp 73–77.

In this and the preceding entry Mr. Graves works out an ingenious hypothesis that the formulae for ambrosia and nectar in ancient Greece can be arrived at by writing down the insipid recipes given by the ancient writers and discovering that the initial letters spell "mushrooms" in Greek. R.G.W.

122. ———. "The poet's paradise". Address delivered to the Oxford University Humanist Group, 1961. Published in Oxford Addresses on Poetry. London: Cassell, 1962, pp 109–129.

123. ———. "How to avoid mycophobia." Also an editorial note by Martin Levine. *Saturday Review of Literature*, May 11 1957, pp 21–22, 47.

124. ———. "Diseases of scholarship, clinically considered." A lecture given on Feb 13 1957, at Yale University. Five Pens in Hand. New York: Doubleday & Company, 1958. pp 73–90. See pp 87–88.

125. ———. "A journey to paradise: Of toadstools and toxins, and a vivid tour of the Heaven (and Hell) that lies within us all." *Holiday*. Vol 32, No 2, Aug 1962, pp 36–7, 110–1.

126. Guerra, F., and H. Olivera. Las Plantas Fantásticas de México. Mexico: Imprenta del Diario Español, 1954. See pp 7–12.

An uncritical compilation from secondary sourses, some of them unreliable. R.G.W.

127. Heizer, Robert F. "Mixtum Compositum: The use of narcotic mushrooms by primitive peoples." *Ciba Symposia*, Vol 5, No 11, Feb 1944, pp 1713–1716.

This article, sent to us by Robert Graves in Sept 1952, first apprised us of the mushroom cult in Mexico and sparked our later investigations. At the same time Hans Mardersteig of Verona sent us a drawing of the mushroom stone on exhibit in the Rietberg Museum, Zurich, which we later discovered was the one described in Entry 100 and which we linked with the Mexican Sacred Mushrooms. R.G.W.

128. Hoogshagen, Searle. "Notes on the sacred (narcotic) mushroom from Coatlán, Oaxaca, Mexico." *Okla Anthrop Soc Bull*, Vol 7, 1959, pp 71–74.

An important contribution to contemporary anthropology for the light it sheds on the feelings toward the Sacred Mushrooms of the Mixe people. The author has a sound grasp of the Mixe language and is gifted with rare intuition. R.G.W.

129. Johnson, Jean Bassett. "The elements of Mazatec witchcraft." Gothenburg Ethnographical Museum. *Ethnological Studies* 9, 1939. pp 119–49.

130. ———. "Some notes on the Mazatec." Lecture before Sociedad Mexicana de Antropología, Mexico, Aug 4 1938. Later published by Editorial Cultura, México, 1939.

On the night of July 16–17 1938 the young anthropologist Jean Bassett Johnson, with three companions (Bernard Bevan, Irmgard Weitlaner, and Louise Lacaud), witnessed a mushroom ceremony in Huautla de Jiménez. They were the first white persons known to have had this experience, and in the two preceding entries Johnson gave his account of that event. Later he lost his life in the 1939–45 war, when the American forces landed in North Africa, in Nov 1942. R.G.W.

131. Kobayasi, Yoshio. "Questions about fungi, from Wasson." (In Japanese) An exchange of letters between Professor Kobayasi and R. Gordon Wasson. *Nat Sci & Mus*, Tokyo, Vol XXV, Nos 1–2, 1958, pp 41–43.

132. La Barre, Weston. "Native American beers." *Amer Anthrop*, n.s. Vol 40, April-June 1938, p 234, ftn 37.

133. ———. "The Peyote cult." *Yale Pub Anthrop*, No 19, 1938, p 7, appendix 3.

134. Martínez, Maximino. Plantas Utiles de la Flora Mexicana. México: Ediciones Botas, 1959. See pp 564–566.

135. Miller, Walter S. Cuentos Mixes. México: Instituto Nacional Indigenista, Biblioteca de Folklore Indígena, late 1956. See pp 37–47, 218–220.

In recording stories gathered among the Mixe Indians Miller reports two involving the Sacred Mushrooms. R.G.W.

136. Nelken-Terner, Antoinette. Les Champignons Hallucinogènes de Huautla de Jiménez. Ms. report submitted to Professor Javier Romero, Head of Departamento de Investigaciones, Instituto Nacional de Antropología e Historia, Mexico City, July 2 1959. 11 pages.

137. Pérez de Barradas, José. Plantas Mágicas Americanas. Madrid: Consejo Superior de Investigaciones Científicas Instituto 'Bernardino de Sahagún.' 1957. See pp 234, 238, 267.

138. Pike, Eunice V. Not Alone. Chicago: Moody Press, 1956. See pp 109–110.

139. ———. "Mazatec sexual impurity and Bible reading." *Practical Anthropology*, Tarrytown, N. Y. Vol VII, No 2, March-April 1960, pp 49–53.

140. ———, and Florence Cowan. "Mushroom ritual vs Christianity." *Practical Anthropology*, Vol VI, No 4, July-Aug 1959, pp 145–150.

—. ———, and Sarah C. Gudschinsky. See Entry 44.

—. ———. For letter to R. Gordon Wasson, see Entry 1, pp 242–5, and Entry 2, pp 47–8.

These valiant women, who have lived for years among the Mazatecs, have made an invaluable contribution to our knowledge of the role of the Sacred Mushrooms in the lives of the Indians. R.G.W.

141. Puharich, Andrija. "The mushroom in myth." *Bull Mycol Soc San Francisco*. Vol IX, No 12, 1959, pp 3–7.

For other entries by this author see Entry 98 and SEC VIII. R.G.W.

142. Ramsbottom, John. Mushrooms & Toadstools. London: Collins, 1953. See pp 49–51.

143. Ravicz, Robert. "La Mixteca en el estudio comparativo del hongo alucinante." *An Inst Nac Antrop Hist*, Mexico. Vol 13, 1960 (1961), pp 73–92.

An anthropological study of the role of the Sacred Mushrooms in one region of the Mixteca, based on observations made in 1960 in the company of R. Gordon Wasson. R.G.W.

144. Reko, Blas Pablo. "De los nombres botánicos Aztecos." *El México Antiguo*, Vol I, No 5, Feb 1919, pp 113–157. See entry under *nanacatl*.

145. ———. Letter to J. N. Rose, U. S. National Museum. U. S. National Herbarium. Herbarium Sheet No 1745713, Washington, D. C., 1923.

146. ———. Mitobotánica Zapoteca. Mexico: 1945. See pp 14, 44, 53, 95.

147. ———. "Nombres botánicos Chinantecos." *Boletín de la Sociedad Botánica de México*, No 8, 1949, pp 9–20; see p 12. See Entry 1, p 238n.

Reko was the modern precursor of all subsequent workers on the problem of the Sacred Mushrooms. An indefatigable field worker, his observations drew little attention at the time, but later they were fully recognized and his priority is now assured. R.G.W.

148. Reko, Victor A. Magische Gifte. Stuttgart: Ferdinand Enke, 1936 (1938, 1949). See pp 123–132.

149. SCHULTES, RICHARD EVANS. "Peyote and plants used in the Peyote ceremony." *Bot Mus Leafl* HARV, Cambridge, Vol IV, No 8, April 12 1937, pp 136–137.

150. ———. "Peyote (Lophophora Williamsi) and plants confused with it." *Bot Mus Leafl* HARV, Cambridge, Vol V, No 5, Nov 19 1937, pp 69–73.

151. ———. "The identification of Teonanacatl, a Narcotic Basidiomycete of the Aztecs." *Bot Mus Leafl* HARV, Cambridge, Vol VII, No 3, Feb 21 1939, pp 37–54.

This Leaflet drew considerable attention in scientific circles and laid the foundation for all subsequent serious work in the field. R.G.W.

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In 1941 or thereabouts Dr. Singer, working over mushroom collections in the Farlow at Harvard, came upon a specimen that R. E. Schultes had brought back in 1938 from Huautla de Jiménez and that, according to Schultes' field notes, the Mazatec Indians had said was vision-producing. Dr. Singer correctly identified it and he was the first person to associate the genus *Psilocybe* with the Mexican sacred mushrooms. His priority lies in this fungal identification in the Cambridge laboratory. Unfortunately his discovery proved to be stillborn. He did not disclose what he had found even to Dr. Schultes, who would have been intensely interested. He published nothing on the subject until about a decade had elapsed, when in the first edition of his work on the systematics of the *Agaricales*, more than 800 pages long, he dropped in casually two brief, enigmatic allusions, lost in the expanse of that vast work, to the use of *Psilocybe* sp. by Mexican Indians. He cited no source or authority. Those of us who later became interested in the identification of the species so used would have been helped by Dr. Singer's discovery, had we known of it, and would have been delighted to give him full credit. When we published our book, some 15 years had elapsed from the date of this identification. He had done nothing with it. We were ignorant of it. We owed him nothing. He revealed to me his prior identification of the mushroom specimen when we met him, on the one and only occasion, at Huautla de Jiménez and at the nearby airstrip, on Monday, July 15, 1957, during his hurried passage through an area that we had been studying for some years. By this time we had done much of our work and had brought out our book, here listed as Entry 1. It is understandable that the circumstances should have caused Dr. Singer disappointment, but I must disclaim responsibility for them.

In the second edition of his *Agaricales*, on pp 543–4, Dr. Singer greatly expands his comment on the use and properties of these mushrooms. His cultural observations must be read with caution. He asserts that the Guatemala Indians use the mushrooms as a drug. Until our book came out in 1957 this had never been reported by any student of the indigenous cultures. Since our book appeared no one has reported from Guatemala the use of these mushrooms. In our book we advanced the bold surmise that there had once been a mushroom cult in Guatemala of which the symbols—the archeological artifacts known as "mushroom stones" and pottery "mushrooms"—are occasionally found today. According to our hypothesis, the ritualistic use had prevailed for centuries, even millennia, but had died out in the Maya country in Pre-Columbian times, for reasons unknown. The resolution of this problem hangs on evidence that is being slowly accumulated. That Dr. Singer should link the present-day Maya with the use of the Sacred Mushrooms shows how alien to him are the problems of Indian culture. He made a like assertion before, in the *Bull* of the Chicago Nat His Museum (see Entry 171), whereupon we drew his attention by private communication to his error. He now persists in it. R.G.W.

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The American mycologist in this review criticized sharply the Wassons and incidentally his confrère Roger Heim for certain alleged inaccuracies in *Mushrooms Russia & History*, alleged inaccuracies that had no bearing on their general argument. We decided to ignore what we considered his untoward remarks, but in France they aroused lively comment and inspired three replies showing, in my opinion, that Dr. Smith had himself been largely mistaken in his strictures: see Entries 27, 326, and 331. R.G.W.

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1962

BOTANICAL MUSEUM LEAFLETS
HARVARD UNIVERSITY

Cambridge, Massachusetts, December 28, 1962 Vol. 20, No. 3

A NEW SPECIES OF SALVIA FROM MEXICO

BY

Carl Epling[1] and Carlos D. Játiva-M.[1]

In the course of his studies of narcotic plants in southern Mexico, Mr. R. Gordon Wasson became interested in a member of the Labiatae which is employed by the Mazatec Indians of Oaxaca as a psychotropic drug.

An examination of material from the Mazatec country indicates that the plant in question is an undescribed species of Salvia:

Salvia divinorum (Dusenostachys) *Epling & Játiva sp. nov.*

Herba perennis altitudine 1 m. et ultra, caulibus pilis plus minusve articulatis pubescentibus; foliorum laminis plus minusve ovatis, 12–15 cm. longis, in apice acuminatis, in basi plus minusve rotundatis et ad petiolos 2–3 cm. longis attenuatis, ad margines crenato-serratis et in sinibus hirtellis, paginis ambabus glabratis nisi inferiore ad venas hirtella; floribus in verticillastris sat distantibus ut videtur in paniculis amplis, ramis 30–40 cm. longis cyaneo-puberulis; pedicellis gracilibus 8–9 mm. longis; calycum cyaneorum glabrorum tubo in maturitate 15 mm. longorum labia superiore 1.5 mm. longa, imprimis 3-venia; corollarum cyanearum sigmoidearum tubo 22 mm. longo,

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[1] Herbarium, Department of Botany, University of California, Los Angeles, California.

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intus nudo, labia superiore 6 mm. alta, inferiore ut videtur breviore et incurva; staminibus ad fauces positis, inclusis, gubernaculo integro; stylo hirtello, ramo postico paulo longiore obtuso plano, antico ut videtur carinato.

Mexico. Estado de Oaxaco. San José Tenango, in the Sierra Mazateca; in ravines with black soil marginal to the wet forest. September 8, 1962, *A. Hofmann & R. G. Wasson s.n.* (Type in Herb. Univ. Cal., Los Angeles; Duplicate type in Econ. Herb. Oakes Ames).

Salvia divinorum is allied to *S. cyanea* Lamb. ex Benth., which is found in central Mexico. The former differs from the latter principally in respect to leaf shape (the attenuation of the blade) and the flattened upper style branch. The bracts of *Salvia divinorum* appear to be tardily deciduous. The species is doubtless striking in its habitat and might possibly be valuable if introduced into horticulture.

The specific name, which means "of the seers," refers to the curious use to which the plant is put by the Mazatec Indians and which Mr. Wasson describes in the following pages.

A NEW MEXICAN PSYCHOTROPIC DRUG FROM THE MINT FAMILY[1]

BY

R. Gordon Wasson[2]

For a number of years we have been exploring the highlands of southern Mexico in a study of the role played by hallucinogenic mushrooms in the religious life of the Indians. We began by visiting the Sierra Mazateca in 1953, in the northernmost part of the state of Oaxaca, returning there in 1955 and every year thereafter through 1962. At an early date we learned of a psychotropic plant that the Mazatecs consume when mushrooms are not available. But as we and our collaborator Roger Heim were concentrating on the difficult task of locating and identifying the various species of hallucinogenic mushrooms, we had to neglect for some time this plant that the Indians employ as a less desirable substitute. In 1960 and 1961, we brought back specimens and submitted them for determination to Schultes and to Epling. All of the specimens available proved to be unsatisfactory for specific identification. Finally, in September and October of 1962, satisfactory herbarium material reached us, when we were in San José Tenango, on which Dr. Epling could base his specific description. Tenango, at

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[1] Submitted for publication October 24, 1962.

[2] Research Fellow, Botanical Museum of Harvard University.

about 1200 meters altitude, is close to and above the *tierra caliente* of Vera Cruz.

We now identify a species of Salvia new to botanists, *S. divinorum* Epling & Játiva, as a psychotropic drug used traditionally by the Mazatec Indians of Oaxaca, Mexico, in their divination rites. To the ever growing family of Mexican *phantastica* a new member is thus added, and for the first time a species of the Labiatae joins this interesting group.

The plant is familiar to virtually all Mazatecs. In Huautla de Jiménez (1800 meters) we saw two or three plants growing, and a specimen taken to Mexico City is still alive there in the open air; but these plants do not flower. We have never seen the seeds, and no Indian has been able to tell us about them. The plant is reproduced vegetatively from a shoot stuck into the ground. It requires black soil, rather than clay, and for the plant to prosper moisture must be steady. Many, perhaps most, Mazatec families possess a private supply of the plants, but almost invariably they are not near the home nor near trails where passers-by might see them. We were on the watch for *Salvia divinorum* as we criss-crossed the Sierra Mazateca on horseback in September and October of 1962, but never once did we see it. The Indians choose some remote ravine for the planting of it and they are loath to reveal the spots. No Indian in San José Tenango was willing to take us to the plants whence they brought back specimens to us. *Salvia divinorum* seems to be a cultigen; whether it occurs in a wild state (except for plants that have been abandoned or have escaped) we do not know.

In former times the proprietors of land paid no attention to growths of hallucinogenic mushrooms and *Salvia divinorum;* but in the last four or five years the market for the mushrooms and the possibility of a market for the Salvia have made them conscious of a potential value here. Several episodes have recently taken place in the vicinity of Huautla in which the owner has enforced his right to the plants.

The Mazatecs who speak Spanish refer to *Salvia divinorum* as *hojas de la Pastora*, or *hojas de María Pastora* ("leaves of the Shepherdess" or "leaves of Mary the Shepherdess"), and this is also the translation of the name in Mazatec[3]: *ška*^{4} *Pastora.*

The Mazatec name is curious. In Christian tradition the Virgin Mary is not thought of as a shepherdess. Is the "Pastora" concept a survival of the pre-Christian *dueño de los animales*, "the Lord of the animals," that figures large in the folk tradition of the Middle American Indians? A pagan association would thus be sanctified by the addition of the Virgin's name.

Salvia divinorum is, in the minds of the Mazatecs, only the most important of several plants, all Labiatae, that they regard as members of the same "family." *Salvia divinorum* is known as *la hembra*, "the female." *El macho*, or "the male," is *Coleus pumila*, of European origin. Then there is *el nene*, "the child," and *el ahijado*, "the godson," which are both forms of *Coleus Blumei.* Some Indians insist that these others are likewise psychotropic, but we have not tried them; others say these are merely medicinal.

We have found no reference to the use of the leaves of *Salvia divinorum* in the 16th and 17th Century writers. We have found only two passages that may refer to them in modern writers. Dr. Blas Pablo Reko, a pioneer in Mexican ethnobotanical field work, discussing the hallucinogenic mushrooms, adds (*Mitobotánica zapo-*

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[3] The superscript digit indicates the tone of the syllable, which is the lowest of four tones in Mazatec.

teca, Mexico, 1945, p. 17) a sentence that, translated, says:

> We cannot fail to mention here another magic plant whose leaves produce visions and which the Cuicatecs and Mazatecs (in the districts of Cuicatlán and Teotitlán) call "divination leaf." The loose leaves that I have received do not permit their scientific identification.

This refers probably to the *Salvia divinorum* of the Mazatecs. There is a longer reference in a paper by Ing. Robert J. Weitlaner ("Curaciones Mazatecas" in An. Inst. Nac. Anthrop. Hist. 4, No. 32 (1952) 283). While Weitlaner was in Ojitlán, a Chinantec village, he encountered a native of Jalapa de Díaz, a neighboring Mazatec town, who told him of the use among his fellow-townsmen of a plant known as *Yerba de María.* This informant's account, in a shortened paraphrased translation, follows:

> *Yerba María* resembles somewhat the *yerba mora,* but it has slightly wider leaves. Only the leaves are used, putting them in water. First the leaves are rubbed together in the hands, the water is not boiled, and they are used for very specific purposes. When the *curandero* goes to the forest in search of this plant, before cutting it he must kneel and pray to it. They are not witch-doctors; but the leaves are cut only when they are needed, after praying.
>
> For example, if someone is suffering from a sickness, and the doctors do not know what is the matter, then with this plant they divine the disease. The *curandero* who brings the leaves first asks the sick person if he is addicted to taking alcohol, because, when a man does not take alcohol, fifty leaves are prescribed; when he takes alcohol, then 100 leaves are prescribed. The sick person drinks the water in which the leaves have been rubbed. At midnight, the curandero goes with him and another person to a place where there is no noise, as for example an isolated house, where the patient takes the potion. They wait 15 minutes for the drug to take effect, and the patient himself begins to state the kind of sickness from which he suffers. The patient finds himself in a semi-delirious state, he speaks as in a trance, and the others listen attentively to what he says. He shakes his clothes, as though with the aid of the plant he would free himself from the little beasties [presumed cause, in the Indian mind, of the illness]. At dawn the *curandero* bathes the patient with the water of which he has drunk, and thereupon the patient is cured.

> People say that with this bath goes away the drunken state produced by the plant that the patient has taken.
>
> When it is a question of a theft, or a thing lost, the *curandero* listens to what is said by the man who has taken the plant, and thus the facts are disclosed.
>
> There is in Jalapa de Díaz an individual named Felipe Miranda, who every three or six months goes to the mountains to gather the plant. He makes wonderful cures and finds himself in a good economic situation. They say he cultivates and tends to the plant, but he does not reveal the kind of plant that it is.

The identification of *Salvia divinorum* is long overdue. The plant is present the whole year round, and the Mazatecs do not hesitate to discuss it, since they are much less inhibited with respect to this plant than they used to be when talking about the sacred mushrooms. In recent years Huautla has changed greatly, the highway having reached there in 1958–9 and the new-born traffic in the psychotropic mushrooms having its focus there. Among the visitors to Huautla there have been a number of botanists and mycologists. In Mexico City the *hojas de la Pastora* are a frequent theme of discussion in botanical circles. It is hard to understand how the plant has avoided classification until now.

So far as our information goes, the area of diffusion of the *hojas de la Pastora* is confined to the Mazatec country and possibly the immediately contiguous Cuicatec and Chinantec areas. But it may well be known and used elsewhere. We shall await with curiosity the reports of informants from other regions following the publication of this article. *Ololiuqui* (*Rivea corymbosa* (L.) Hallier filius) is known among the Mazatecs, but they seem to prefer for divinition the *hojas de la Pastora* to the *semilla de la Flor de la Virgen,* "seed of the Flower of the Virgin," as the Mazatecs call *ololiuqui.*

On Wednesday, July 12, 1961, I ate the "hojas de la Pastora" and experienced their effects. I was in Ayautla, stopping in the home of Doña Donata Sosa de García. She introduced me to a number of *curanderas:* Augustina Borja, Clementina Unda, María Sebastiana Carrera, and Sara Unda de la Hoz.

On the evening of that day, the first two came to the house shortly before 11 o'clock, and Augustina Borja performed the ceremony in a large spare room. Those present were Irmgard Weitlaner Johnson, my daughter Mary X. Britten ('Masha'), Doña Donata, and her daughter Consuelo ('Chelo'). Augustina Borja was the daughter of a *curandero* who had died about ten years before. Her own daughters often accompany her on her healing visits and are themselves budding *curanderas.* On the evening that we spent with her, she came along with Clementina Unda. They were careful to orient themselves to the east as they set the stage for the ceremony. In the Mazatec country the rites are always so oriented or as near as possible in that direction; never to the west, which is considered sinister. Augustina was performing—she took mushrooms, rather than the *hojas;* these I had requested especially, as I had never taken them. Both mushrooms and leaves are counted in pairs. The leaves are paired off, care being exercised to assemble leaves that are flawless, without parasitic growths. In preparation for the ceremony, the leaves are placed on top of each other, each pair being face to face. It is customary for the Indians to consume the leaves by nibbling at the dose with their incisor teeth. This proved to be impossible for me, owing to the taste; and I was treated as a toothless person. There being no *metate* (stone grinding board) handy, Augustina squeezed the leaves with her hands and collected the juice in a glass. This was certainly an inefficient method. Some water was added. I drank the dark fluid, about half a glass full, the result of squeezing 34 pairs or 68 leaves in all. I was told that frequently Indians vomit on eating the leaves, which is easy to believe. It was possible for me, however, to retain the fluid.

After having eaten her mushrooms, without more ado our *curandera* launched into singing, intoning in Mazatec with vigor. She kept this up for two hours, in a rather monotonous voice. I tape-recorded her singing but have yet to find someone who will give a rendering in English or Spanish.

The effect of the leaves came sooner than would have been the case with the mushrooms, was less sweeping, and lasted a shorter time. There was not the slightest doubt about the effect, but it did not go beyond the initial effect of the mushrooms—dancing colors in elaborate, three-dimensional designs. Whether a larger dose would have produced a greater effect, I do not know.

A day or two before the events that I have narrated, the curandera María Sebastiana Carrera had supplied us with many details about the use of the leaves and had even chanted the words of the ceremony after her usage. She had declined to admit us to an actual ceremony because her neighbors (and doubtless she herself) would have considered the performance before outsiders a desecration and scandalous. Even as it was, when her session with us was drawing to a close, she burst into uncontrollable tears, fell on her knees, and begged forgiveness for what she had done. She had also given us valuable cosmological legends that are still believed in among the villagers, which I hope to publish elsewhere.

On October 9, 1962, our party was in San José Tenango. This time it consisted of Dr. Albert Hofmann, his wife Anita, Irmgard Weitlaner Johnson, Herlinda Martínez Cid (who served as Mazatec interpreter), and me. Through the good offices of Roberto Carrera, the son of Aurelio Carrera of Huautla, we were introduced to Consuelo García, about 35 years old, a vigorous, good-looking curandera, who that night performed for us a divinatory rite. She used only the leaves, not mushrooms. She ground them on her *metate*, after passing them through the smoke of *copal*, and she did a thorough job of it. Water is added to the mass that comes off the metate, the whole is put through a strainer, and then we drank the liquor. I took the juice of five pair and Mrs. Hofmann of three pair. We both felt the effects, which were as I described them in the ceremony in Ayautla the year before.

It would seem, in summary, that we are on the threshold of the discovery of a complex of psychotropic plants in the Labiatae or Mint Family. We know that *Salvia divinorum* is so employed in the Sierra Mazateca, and *Coleus pumila* and two "forms" of *C. Blumei* are said by some of the Indians to be similarly used.

RESIA — A NEW GENUS OF GESNERIACEAE

BY

Harold E. Moore, Jr.[1]

Several years ago, Dr. Richard Evans Schultes sent two collections of a gesneriaceous plant from Colombia for study in conjunction with material then on loan from the Gray Herbarium. The specimens were annotated with a manuscript name, but comparison suggested that they belonged in a genus other than that to which they were tentatively attributed and a genus related probably to *Napeanthus*. Thanks to the kindness of Mr. C. V. Morton, additional Colombian collections from the United States National Herbarium have been made available for study.

The recent paper by Leeuwenberg on Gesneriaceae of Guiana (*Acta Botanica Neerlandica* 7 (1958) 291–444), with its revision of *Napeanthus*, stimulated a fresh study of the materials mentioned above. Closer study showed them to be representatives of a new monotypic genus which is here proposed with the name ***Resia***, adopting the initials of Dr. Schultes for the generic epithet. The specific epithet *nimbicola* was that suggested by Schultes and Idrobo.

Anetanthus, ***Cremosperma***, ***Klugia***, ***Lembocarpus*** and *Napeanthus* are the only American genera of Cyrtan-

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[1] L. H. Bailey Hortorium, Cornell University, Ithaca, New York.

droideae thus far described with capsular fruits (fruit unknown in *Pterobesleria*, which has a distinctive calyx) and an annular disk (or the disk lacking). *Klugia* is abundantly distinct in its racemose inflorescence, strongly bilabiate flowers, alternate leaves and succulent herbaceous habit; *Anetanthus* differs in its presumed scaly rhizomes, habit and septicidal capsule; *Cremosperma* has a tubular, 10-ribbed calyx and irregularly rupturing capsule as well as different leaves; *Lembocarpus* differs in having a small tuber, palmately nerved leaves, nearly campanulate corolla and non-confluent locules in the anthers. *Napeanthus*, however, appears to be more closely related to *Resia*. The two genera share several characters: habit, leaf shape, anthers with confluent cells, thickened and conspicuously nerved calyx in fruit, bivalved loculicidal capsule. There are, however, differences so marked that to include *Resia* within the limits of *Napeanthus*, now a relatively homogeneous group as defined by Leeuwenberg, would drastically alter its homogeneity. The two may be separated as follows:

RESIA	NAPEANTHUS
Inflorescence ebracteate	Inflorescence bracteate when several-flowered
Sepals distinct	Sepals united up to half their length
Corolla vestite, yellow, the tube cylindric and longer than the calyx	Corolla glabrous or nearly so, white or lilac with or without white at the base, campanulate, cup-shaped or rotate, the tube shorter than the calyx
Stamens with filaments adnate to the corolla-tube below, becoming free about the middle and geniculate above	Stamens inserted at the base of the corolla, the filaments straight
Anthers coherent in a square	Anthers distinct
Disk prominent, annular	Disk absent
Ovary vestite	Ovary glabrous
Capsule laterally compressed	Capsule not compressed (?)

It was at first suggested that the species here described belonged to one of the genera of Columneae. That tribe as now constituted is rather well and uniformly characterized by the disk of discrete glands. There are superficial resemblances between *Resia* and some Columneae, perhaps more to the recently described *Tylosperma* from the slopes of Mt. Duida in the Guiana highlands than to any other. Despite these similarities, *Tylosperma* is distinct in the structure of its inflorescence, in its disk of one large and four small discrete glands and in its pustulate seeds.

Resia *H. E. Moore gen. nov.* [Gesneriaceae–Cyrtandroideae].

Plantae perennes, suffruticosae, caulescentes, radicibus fibrosis foliis brevipetiolatis congestis. Cymae axillares pedunculatae, floribus luteis pluribus. Corollae tubus cylindricus, limbo quinquelobato bilabiato. Stamina 4 filamentis inferne ad tubum adnatis superne liberis, geniculatis, antheris coherentibus, loculis confluentibus. Discus annulatus. Ovarium superius, vestitum. Capsula in calyce inclusa, bivalvata, lateraliter compressa, vestita, seminibus striatis, granulosis.

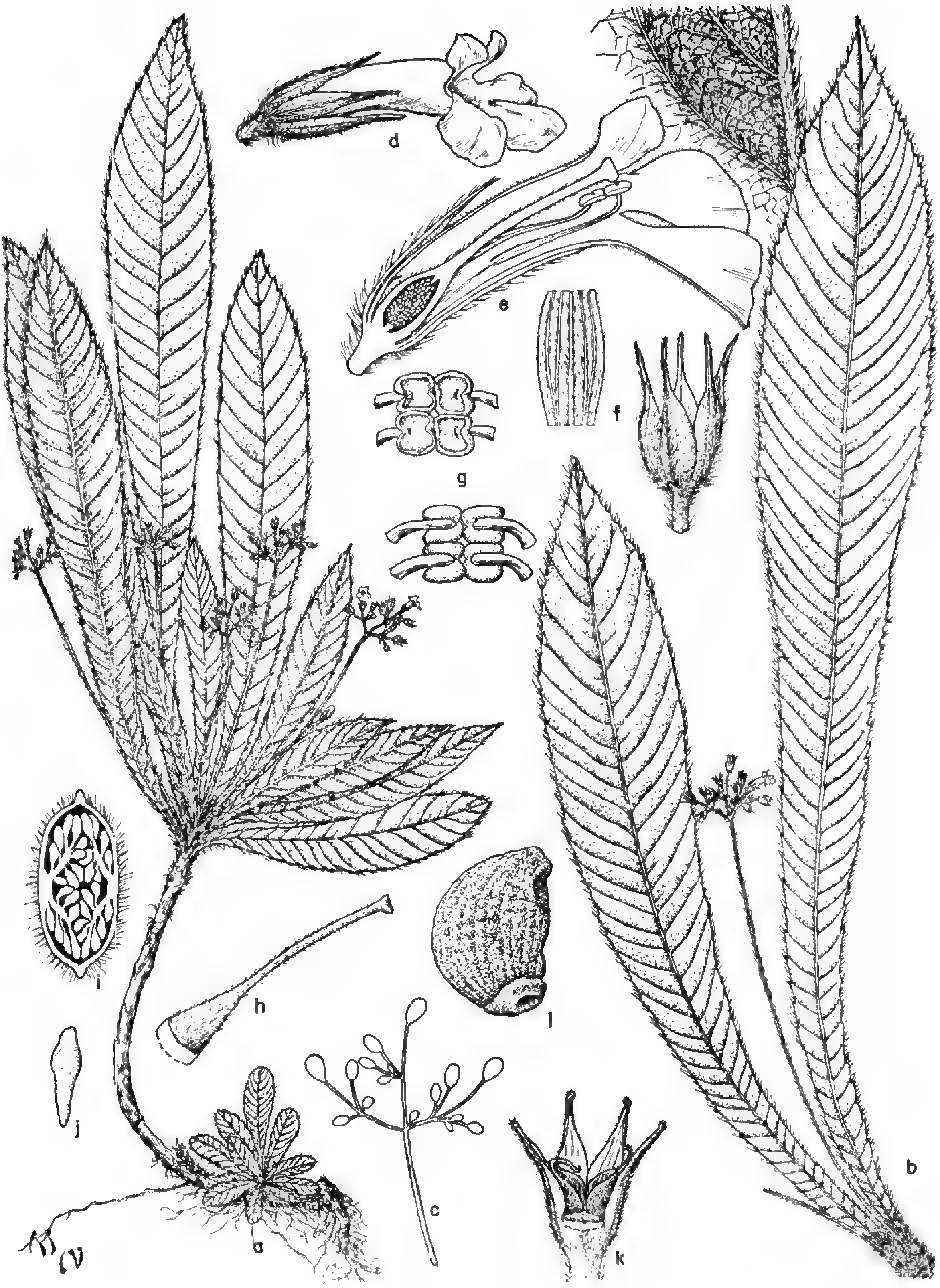
Terrestrial perennial sub-shrubs with fibrous roots and short to elongate, sometimes branched woody stems. Leaves subsessile or shortly petiolate, congested in a terminal crown. Inflorescence cymose, axillary, pedunculate, ebracteate. Flowers zygomorphic, calyx of 5 distinct sepals inconspicuously nerved in flower, thickened and conspicuously 5–7-nerved in fruit, corolla tubular with bilabiate limb of 5 spreading lobes, acute upper 2 lobes shorter than rounded lower 3. Stamens 4, filaments adnate to the corolla-tube to middle, then free, glabrous, geniculate, with anthers coherent in a square by their tips, cells of each anther confluent and dehiscing longitudinally, staminode 1. Disk prominent, annular. Ovary superior, laterally compressed, densely pilose, ovoid, with branched placentas ovuliferous on both surfaces, style elongate, stigma briefly bilobed-stomatomorphic. Fruit a laterally compressed loculicidal capsule shorter than calyx with 2 apiculate pilose valves and minute brown granular-striate seeds.

Resia nimbicola *H. E. Moore sp. nov.*

Folia cuneato-oblanceolata, acuta, 5–31.5 cm. longa. Corollae tubus 7–11 mm. longus, extus pilosus, lobis superioribus 1.5–4 mm. longis, inferioribus 3–5 mm. longis. Fructus valvae 2.5 mm. longae.

Stems to 20 cm. long or more, 10–18 mm. thick, with corky pale bark. Leaves cuneate-oblanceolate, acute, petiole brown-villous, 2–12 mm. long, blades drying papyraceous, 5–31.5 cm. long, 1.2–5.6 cm. wide, green and glabrous above, paler and densely pale or rufous-appressed-pilose or villous below, especially along prominent mid-nerve and 15–50 lateral nerves and pilose to hispidulous on prominently reticulate secondary nerves, margin serrulate to serrate. Inflorescences shorter than leaves, slender peduncles rufous-villous, to 12.5 cm. long, flowers to 16 in an irregularly cymose arrangement. Pedicels 8–20 mm. long, or, in fruit, to 25 mm. long and thickened apically, sparsely to very densely rufous-villous or more rarely merely pilose and sometimes glandular. Sepals lanceolate-acuminate, 5–8 mm. long, 1 mm. wide at anthesis, becoming 7–14 mm. long in fruit, 3 nerves slender at anthesis, becoming much thickened and usually branched to 5 or 7 in fruit, these thickened nerves persisting as skeletonized remains in age, surface hispidulous and densely rufous-villous at least along mid-nerve. Corolla-tube 7–11 mm. long at anthesis, pilose toward limb outside, glabrous within, limb pilose outside and

PLATE IX



RESIA NIMBICOLA *H. E. Moore.* a, habit ×$\frac{1}{3}$. b, leaves and inflorescence ×$\frac{1}{2}$ with portion of undersurface of leaf ×5. c, inflorescence (diagrammatic). d, flower ×3. e, flower in vertical section ×5. f, calyx ×3 with portion of sepal in fruit ×5. g, anthers ×10. h, disc and pistil ×4. i, ovary in cross section ×24. j, ovule ×40. k, capsule (sepal removed) ×3. l, seed ×42. All from *Idrobo & Schultes 1082*, except fruiting sepal in f from *Köie 4602*.

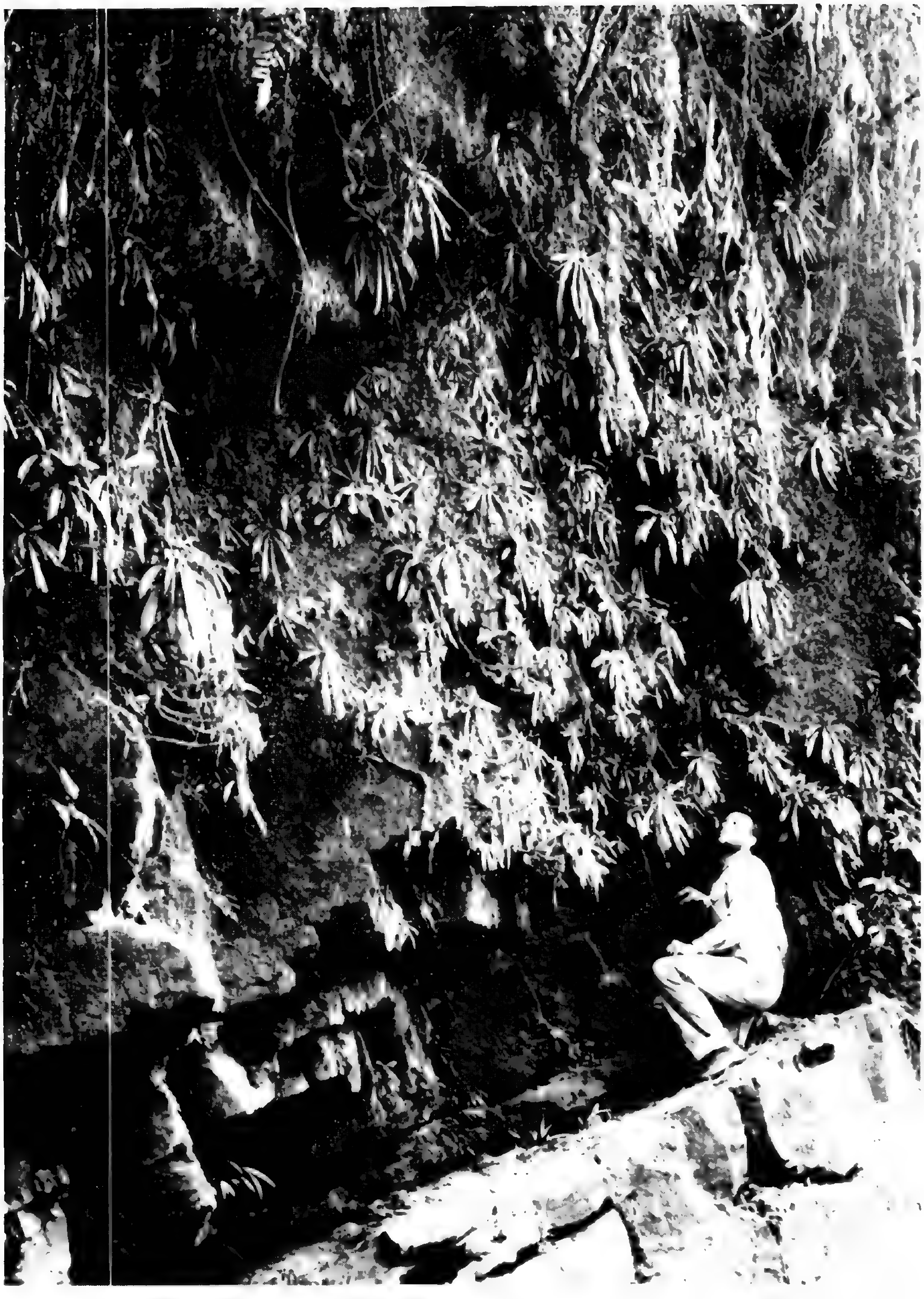
ciliolate with 2 acute upper lobes 1.5–4 mm. long and broad, 3 rounded lower lobes 3–5 mm. long and broad, lower lobes often puberulent inside, at least toward throat. Stamen-filaments glabrous, staminode ca. 1 mm. long or more, anthers glabrous, pale. Ovary and style densely short-pilose. Capsule ca. 2.5 mm. long, dark brown, laterally compressed before dehiscence, pilose, valves divaricate, usually apiculate with persistent halves of style. Seeds shining brown, ca. 0.5 mm. long.

COLOMBIA: Meta; Cordillera La Macarena (extremo nordeste), Macizo Renjifo, cumbre y alrededores, alt. 1,300–1,900 m., Enero 6–20, 1951, *Jesús M. Idrobo & Richard Evans Schultes 1082* (BH, TYPE; US, GH, COL, DUPLICATE TYPES); *1059A* (BH, US, GH, COL). Caquetá; Florencia, Quebrada de las Perdices, matorrales entre peñas, 400 m. alt., Mar. 29, 1940, *J. Cuatrecasas 8849* (US). Cundinamarca; Paraíso (near Sumapáz), 1,400 m. alt., June 5, 1952, *M. Köie 4602* (C).

Collectors' notes indicate that this species is essentially saxicolous, growing from rocks or cliffs or in humus in dark, damp locations. The four collections studied agree very well in general aspect but differ in particulars which, though essentially quantitative, are sufficient to deserve comment. The Idrobo and Schultes collections from the isolated Cordillera La Macarena have the smallest flowers, with sepals 4–5 mm. long at anthesis and corolla-tube about 7 mm. long. The Köie collection from the Cordillera Oriental agrees in respect to indument, but the pedicels are longer, and the flowers are nearly twice as large with sepals 8 mm. long at anthesis (attaining a length of 14 mm. in fruit), corolla-tube 11 mm. long and correspondingly larger lobes.

A fourth collection from a much lower altitude (400 m.) has flowers about as in the Idrobo and Schultes material. A first glance at the indument of leaf pedicels and especially the sepals suggested that this specimen might represent a variant warranting infra-specific recognition.

PLATE X



The colony of *Resia nimbicola* from which the collection *Idrobo & Schultes 1082* (the type) was taken. *Photograph by* RICHARD EVANS SCHULTES

The sepals mostly lack the red-brown multicellular hairs so prominent in other collections, but some have a less dense but nonetheless characteristic cover of these hairs along the mid-nerve and toward the base. The lower surface of the leaves has a less prominent indument. I am constrained from recognizing the material separately at this time by experience with variation in size and indument within the limits of what I consider definable and "defendable" species elsewhere in the Gesneriaceae, especially in *Achimenes*. For the moment, let it suffice to point out in synoptic form the differences noted in the too few collections seen from three rather well separated areas.

Pedicels and sepals with few or no red-brown multicellular hairs, sepals densely hispidulous, pedicels more or less sparsely pilose, sometimes with glandular hairs; lower surface of leaf villous on principal nerves, hispidulous to glabrescent elsewhere; sepals 6.5–8 mm. long, corolla-tube 6 mm. long. *Cuatrecasas 8849*

Pedicels and centre of sepals densely villous with red-brown multicellular hairs and hispidulous with pale short one- or few-celled rarely glandular hairs; lower surface of leaf villous on principal nerves, pilose on reticulate secondary nerves.

Sepals 8 mm. long at anthesis, becoming 13–14 mm. long in fruit; corolla-tube ca. 11 mm. long; pedicels to 2 or 2.5 cm. long. *Köie 4602*

Sepals 5–5.5 mm. long at anthesis, becoming 7 mm. long in fruit; corolla-tube 7 mm. long; pedicels ca. 8 mm. long. *Idrobo & Schultes 1059A, 1082*

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NEW ORCHIDS FROM CEYLON

BY

DON M. A. JAYAWEERA

THE present paper is the result of a detailed field investigation of the orchids growing in the Ceylon jungles, undertaken during 1958–60. Nine new species are proposed, six of them belonging to the genus *Oberonia* and one each to the genera *Cirrhopetalum*, *Saccolabium* and *Taeniophyllum*. The type specimens are deposited in the Herbarium Peradeniya. These new species have been checked with the extensive collections of the Ames Orchid Herbarium, and they form a part of my forthcoming treatment of the Orchids of Ceylon.

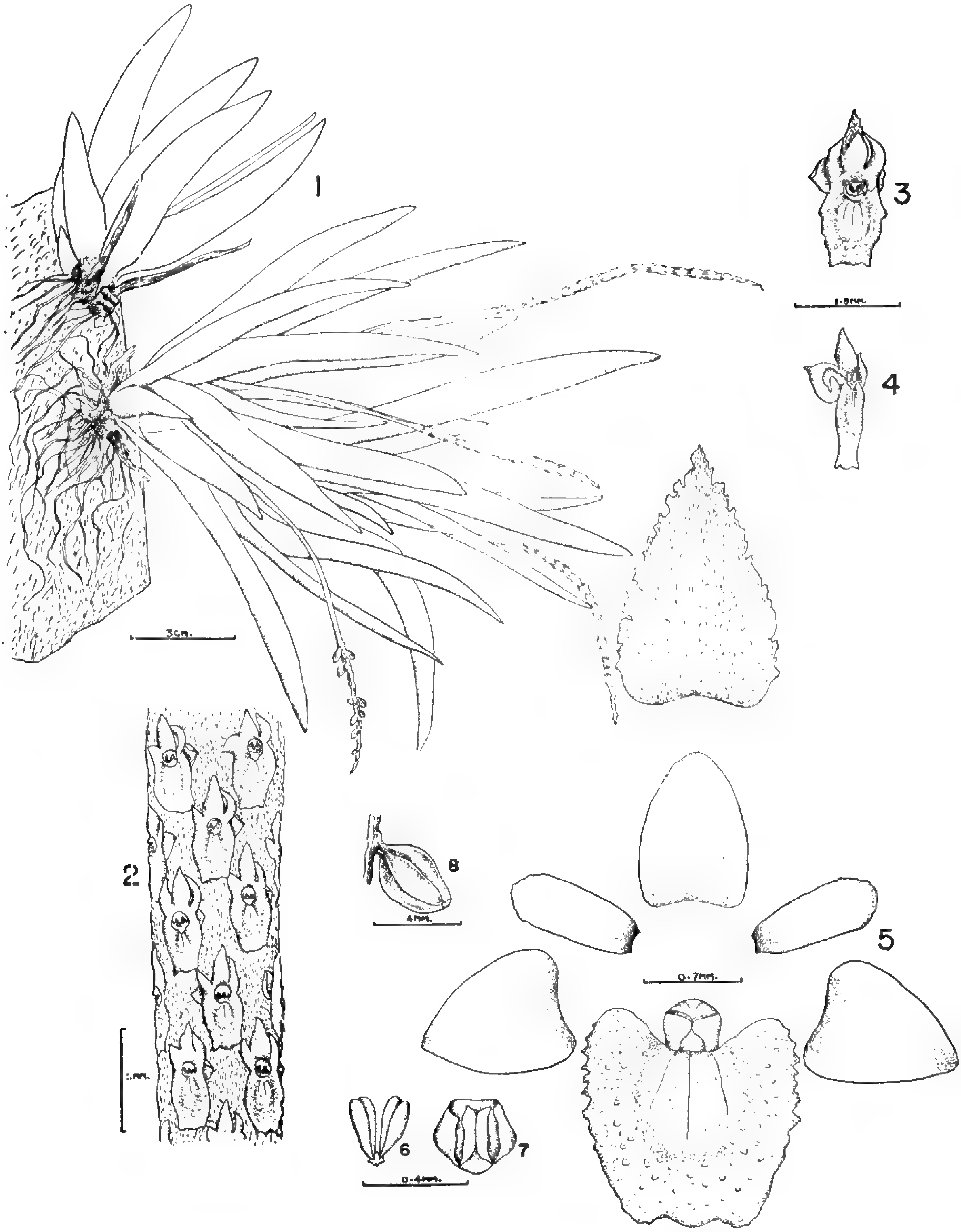
I wish to express my sincere gratitude and appreciation to Mr. Leslie A. Garay of the Oakes Ames Orchid Herbarium for his valuable suggestions and for rendering the descriptions into Latin.

Oberonia quadrilatera *Jayaweera sp. nov.*

Epiphytica, caespitosa, leviter pseudobulbosa. Foliis paucis, distichis, equitantibus carnosis, 4.5–17 cm. longis, 1–1.4 cm. latis, lineari-ensiformibus, apice obtusis, basi pseudobulbum amplectentibus. Inflorescentia cylindrica, spiciformi, erecta vel pendenti, perdense multiflora. Bracteis reflexis, ovatis, pilosis, acutis, margine crenatis, 2 mm. longis, 1.1–1.2 mm. latis. Floribus minutis, 2 mm. in diametiente. Sepalo postico reflexo, oblongo-ovato, apice obtuso vel rotundato, 0.9–1.1 mm. longo, 0.6–0.8 mm. lato; sepalis lateralibus reflexis, concavis, triangulari-ovatis, obtusis, 1.1 mm. longis, 0.5–0.9 mm. latis. Petalis lineari-oblongis, recurvis spiraliterque contortis, 0.1–1 mm. longis, 0.3–0.4 mm. latis. Labello carnoso superiori, sessili, concavo, quadrato, apice 3-lobo; basi subcordato, margine irregulariter dentato, disco obscure papilloso, 1–1.6 mm. longo, 1.5–1.6 mm. lato. Columna humili, crassa, 0.4 mm. alta, 0.3 mm. crassa. Capsula ellipsoidea, sessili, 4 mm. longa.

Tufted epiphyte with slightly pseudobulbous stems. Leaves few, distichous, equitant, fleshy, 4.5–17 cm. long, 1–1.4 cm. broad, linear ensiform or almost straight, obtuse, bases ensheathing the pseudobulb. Flowers minute, greenish yellow in cylindrical, straight or drooping, dense-flowered spiciform racemes. Peduncle 8–9.5 cm. long, flat, green or yellowish, the topmost leaf adnate to it and attaining $\frac{1}{3}$ to $\frac{1}{2}$ the length. Flower-bearing portion 6–7.5 cm. long and 3 mm. in diameter. The first flowers to open located in the middle of the raceme and subsequent ones opening progressively and simultaneously upwards and downwards, terminal flowers not opening (Plate XI). Flowers 2 mm. long from the tip of dorsal sepal to the lip and 1.16 mm. broad. Floral bracts 2 mm. long, 1.16–1.2 mm. broad, recurved, ovate, pilose, acute, margin broken up irregularly. Dorsal sepal 0.9–1.1 mm. long, 0.68–0.8 mm. broad, recurved, oblong-ovate, obtuse or rounded; lateral sepals 1.1 mm. long, 0.56–0.9 mm. broad, recurved, concave, triangular ovate, obtuse; petals 0.86–1 mm. long, 0.3–0.4 mm. broad, linear-oblong, much recurved and curling behind the dorsal sepal. Lip green or yellowish green, superior, sessile, thick, 1–1.6 mm. long, 1.5–1.6 mm. broad at the base, tapering to 0.9 mm., quadrate, 3-veined, concave; base subcordate, apex bluntly and obscurely trifid, margin

Plate XI



Oberonia quadrilatera *Jayaweera*. 1, plants with inflorescences. 2, part of the inflorescence showing the arrangement of the flowers on the rachis. 3, flower from front. 4, flower from side, three quarters view. 5, bract, sepals, petals, lip and column spread out from front. 6, pollinia with gland. 7, anther from front. 8, fruit.

thick, distantly and irregularly dentate. Column short, globular, 0.44 mm. high, 0.34 mm. broad. Anther terminal, incumbent, 2-loculed; pollinia 4, waxy, club-shaped, cohering in pairs to a small gland, 0.24 mm. long, 0.1 mm. broad. Fruit a sessile, ellipsoid, ridged capsule 4 mm. long and 2 mm. in diameter.

This species is allied to *Oberonia zeylanica* Hook.f. from which it differs in the linear-oblong petals and irregularly dentate lip, subcordate at the base.

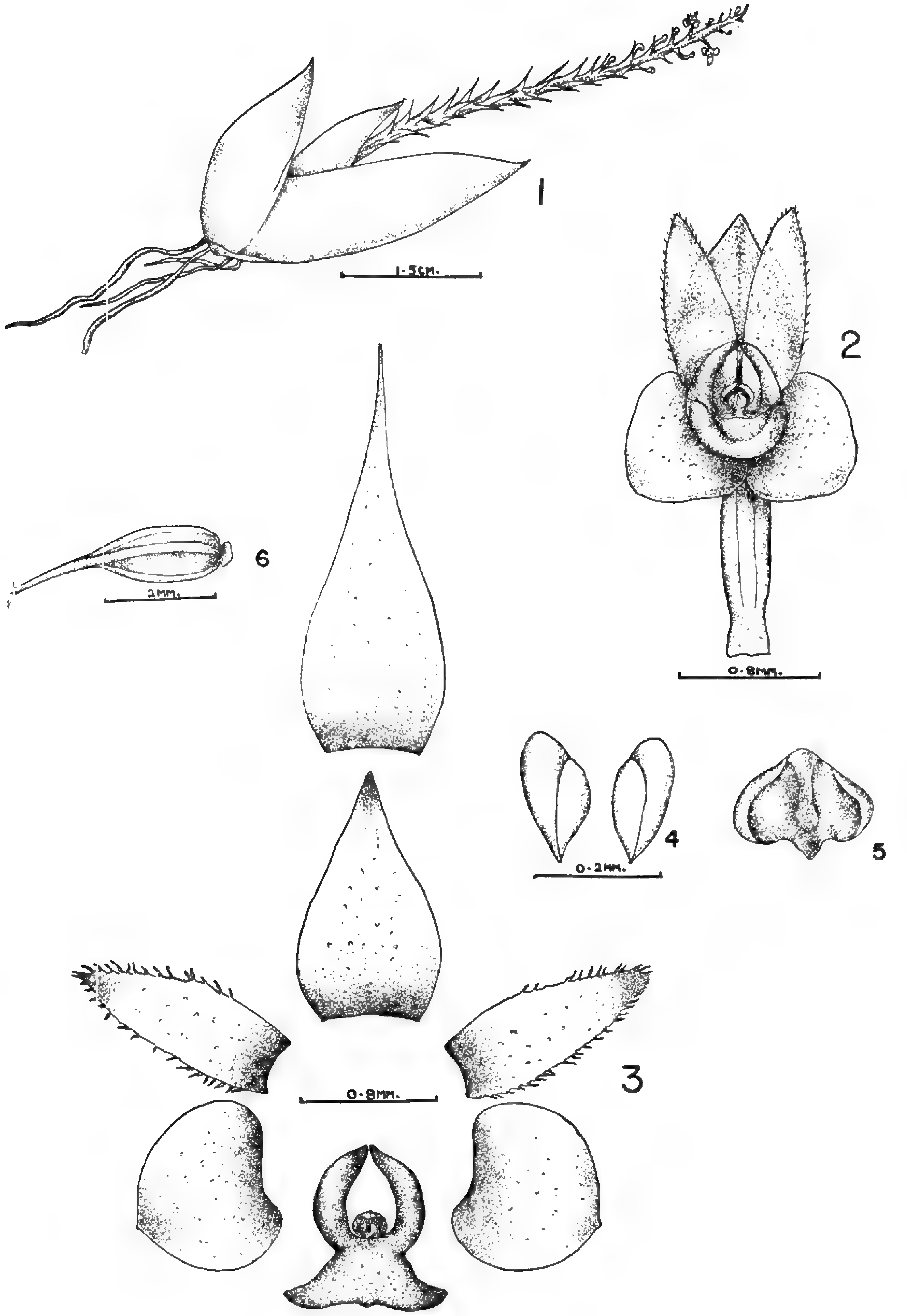
CEYLON: Rangala, in submontane or midcountry tropical wet evergreen forests at 1284 m. altitude, September 22, 1959, *Jayaweera 2001* (TYPE); Hunnasgiriya, at 1300 m. altitude, October 13, 1960, *Jayaweera 2191*. It flowers from August to October.

Oberonia dolabrata *Jayaweera sp. nov.*

Epiphytica, caespitosa, non pseudobulbosa. Caulibus lateraliter compressis, abbreviatis. Foliis distichis, equitantibus, oblongis vel oblongo-lanceolatis, acutis, 1.3–1.7 cm. longis, 0.3–0.5 cm. latis. Pedunculo abbreviato, bracteis non floriferis usque ad basin omnino obtectis. Racemo suberecto, 4 cm. longo. Bracteis ovatis, apice acuminatis, 1.8–2.3 mm. longis, 0.7–0.8 mm. latis. Floribus minimis, 1.3 mm. in diam. Sepalo postico ovato, 1–1.4 mm. longo, 0.5–0.8 mm. lato; sepalis lateralibus oblique late orbiculari-ovatis, obtusis, 0.6–0.8 mm. longis, 0.7–0.9 mm. latis. Petalis oblongo-lanceolatis, subacutis, margine ciliolatis, 1.2 mm. longis, 0.3–0.4 mm. latis. Labello superiori, sessili, carnoso, 3-lobo; lobis lateralibus subulatis, columnam circumdantibus, lobo terminali porrecto, dolabriformi, toto labello 0.6 mm. longo, 0.7 mm. lato. Columna abbreviata, crassa, 0.2 mm. alta crassaque. Ovario pedicellato 1.6 mm. longo. Capsula cum pedicello 2.3 mm. longo.

Small tufted epiphyte with compressed, non-pseudobulbous stems. Leaves 3, fleshy, distichous, laterally compressed, 1.3–1.7 cm. long, 0.3–0.5 cm. broad, oblong

PLATE XII



OBERONIA DOLABRATA *Jayaweera*. 1, plant with inflorescences. 2, flower from front. 3, bract, sepals, petals, lip and column spread out from the front; lip, 4, pollinia. 5, anther from inside magnified. 6, fruit.

or oblong-lanceolate, acute, bases confluent with the stem (Plate XII). Flowers reddish brown, 1.3 mm. across, in suberect racemes 4 cm. long. Peduncle very short, covered with sterile bracts right down to the base and adnate to the topmost leaf. Floral bracts 1.8–2.3 mm. long, 0.7–0.8 mm. broad, ovate, acuminate, acute. Dorsal sepal 1–1.4 mm. long, 0.56 0.8 mm. broad, ovate, acute; lateral sepals 0.6–0.8 mm. long, 0.7–0.9 mm. broad, broadly and obliquely orbicular-ovate, obtuse; petals 1.2 mm. long, 0.36–0.4 mm. broad, oblong-lanceolate, subacute, ciliate, appressed to the dorsal sepal and lying within it. Lip superior, sessile, 0.6 mm. long, 0.72 mm. broad, fleshy, 3-lobed: lateral lobes cylindrical-subulate and arched behind the column: mid-lobe trifid, hatchet-shaped, lateral lobules diverging. Column globular, 0.2 mm. high and 0.26 mm. broad. Anther terminal, incumbent, 2-loculed; pollinia 4, in two pairs, individual pollinum of each pair unequal, appressed and club-shaped, larger pollinia 0.2 mm. long, 0.1 mm. broad and the smaller ones 0.14 mm. by 0.06 mm. Ovary with pedicel 1.6 mm. long. Fruit stalked, 2.3 mm.long, 0.9 mm. in diameter.

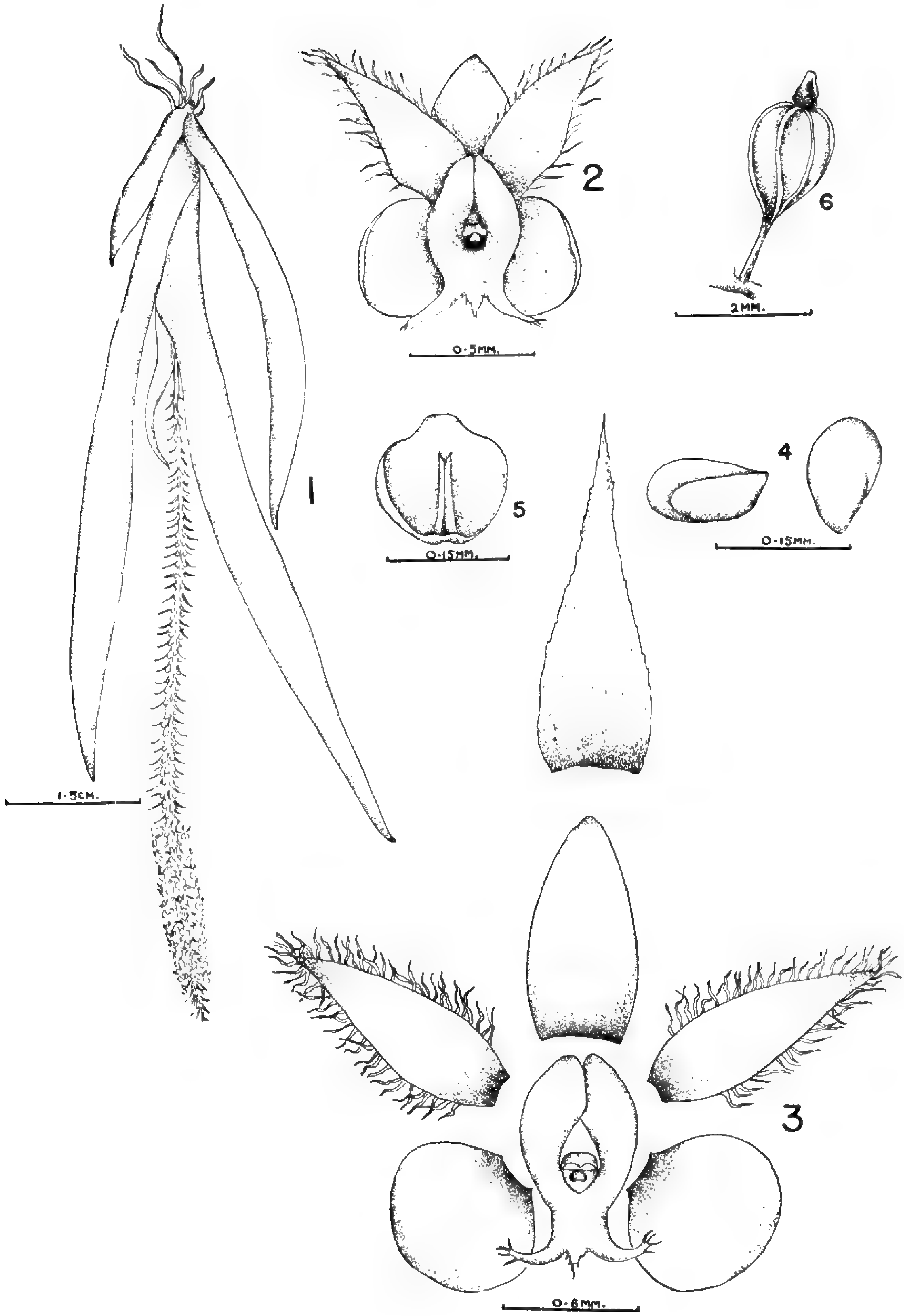
This species is allied to *Oberonia tenuis* Lindl. from which it differs in the small size of the plant, ovate dorsal sepal and ciliated petals which are subacute at their apices.

CEYLON: Rangala (Corbet's Gap), in submontane or midcountry tropical wet evergreen forests at 1285 m. altitude, March 14, 1960. *Jayaweera 2142*.—Same locality, April 4, 1960, *Jayaweera 2160* (TYPE). It flowers from January to April.

Oberonia claviloba *Jayaweera sp. nov.*

Epiphytica, caespitosa. Caule abbreviato, compresso. Foliis paucis, distichis, equitantibus, rectis vel subfalcatis, 4–6.5 cm. longis, 0.3–0.6 cm. latis. Inflorescentia spiciformi, erecta, 6.8 cm. longa; pedunculo 2 cm. longo.

Plate XIII



Oberonia claviloba *Jayaweera*. 1, plant with inflorescence. 2, flower from front. 3, bract, sepals, petals and lip spread out from front. 4, pollinia from side and back. 5, anther from inside. 6, fruit.

Bracteis ovato-lanceolatis, acuminatis, margine remote obscureque serrulatis, 1.2–1.6 mm. longis, 0.4–0.5 mm. latis. Floribus minutis, 1.1 mm. in diam. Sepalo postico oblongo-ovato vel oblongo-lanceolato, obtuso, 1 mm. longo, 0.4–0.5 mm. lato; sepalis lateralibus orbicularibus, 0.6 mm. longis, 0.7 mm. latis. Petalis patentibus, lanceolatis, acutis, margine ciliolatis, 1.1–1.2 mm. longis, 0.3 mm. latis. Labello carnoso, 3-lobo: lobis lateralibus clavatis, columnam involventibus, 0.8 mm. longis, lobo intermedio 3-partito, partitionibus lateralibus divergentibus, apice ciliolatis, 0.3 mm. longis, partitione media triangulari, acuta, 0.1 mm. longa; toto labello 1.2 mm. longo. Columna humili, crassa. Ovario pedicellato 0.6 mm. longo.

Tufted epiphyte with very short, compressed, non-pseudobulbous stems. Leaves few, 4 or 5, distichous, laterally compressed, not fleshy, 4–6.5 cm. long, 0.3–0.6 cm. broad, straight or subfalcate, acute, veins obscure, bases confluent with the stem (Plate XIII). Flowers brown in obscurely whorled, spiciform, erect racemes, 6.8 cm. long. Apical flowers opening first followed by the lower flowers progressively downwards, buds at the very top not opening. Peduncle 2 cm. long, adnate to the uppermost, linear, acuminate, arched leaf, lower bracts sterile. Flowers 1.1 mm. across. Floral bracts 1.2–1.6 mm. long, 0.4–0.5 mm. broad, ovate, acuminate, acute, margin slightly and distantly serrate. Dorsal sepal 1 mm. long, 0.46–0.54 mm. broad, oblong-ovate or oblong-lanceolate, obtuse; lateral sepals 0.6 mm. long, 0.76 mm. broad, orbicular, rounded; petals 1.1–1.2 mm. long, 0.36 mm. broad, lanceolate, spreading, acute, ciliate, almost shaggy; lip 1.2 mm. long, fleshy: lateral lobes 0.8 mm. long, clavate, overlapping each other behind the rostrum, mid-lobe trifid and ciliated at their apices, lateral lobules 0.3 mm. long, curving outwards, acuminate, mid-lobule 0.1 mm. long triangular, acute. Column very small, 0.2 mm. high, 0.16 mm. broad. Anther terminal, incumbent, 2-loculed; pollinia 4, cohering in two pyriform pairs, each pair 0.14 mm. long, 0.08 mm. broad, consisting of a larger pollinium and a smaller one appressed laterally. Ovary with pedicel 0.5 mm. long. Fruit a minute globular or obovate, stalked capsule, 1.6 mm. long, 1.2 mm. in diameter.

This species differs from others in the thin, subfalcate leaves, ciliated petals, club-shaped arching lateral lobes of the lip and the ciliated apices of the trifid mid-lobe.

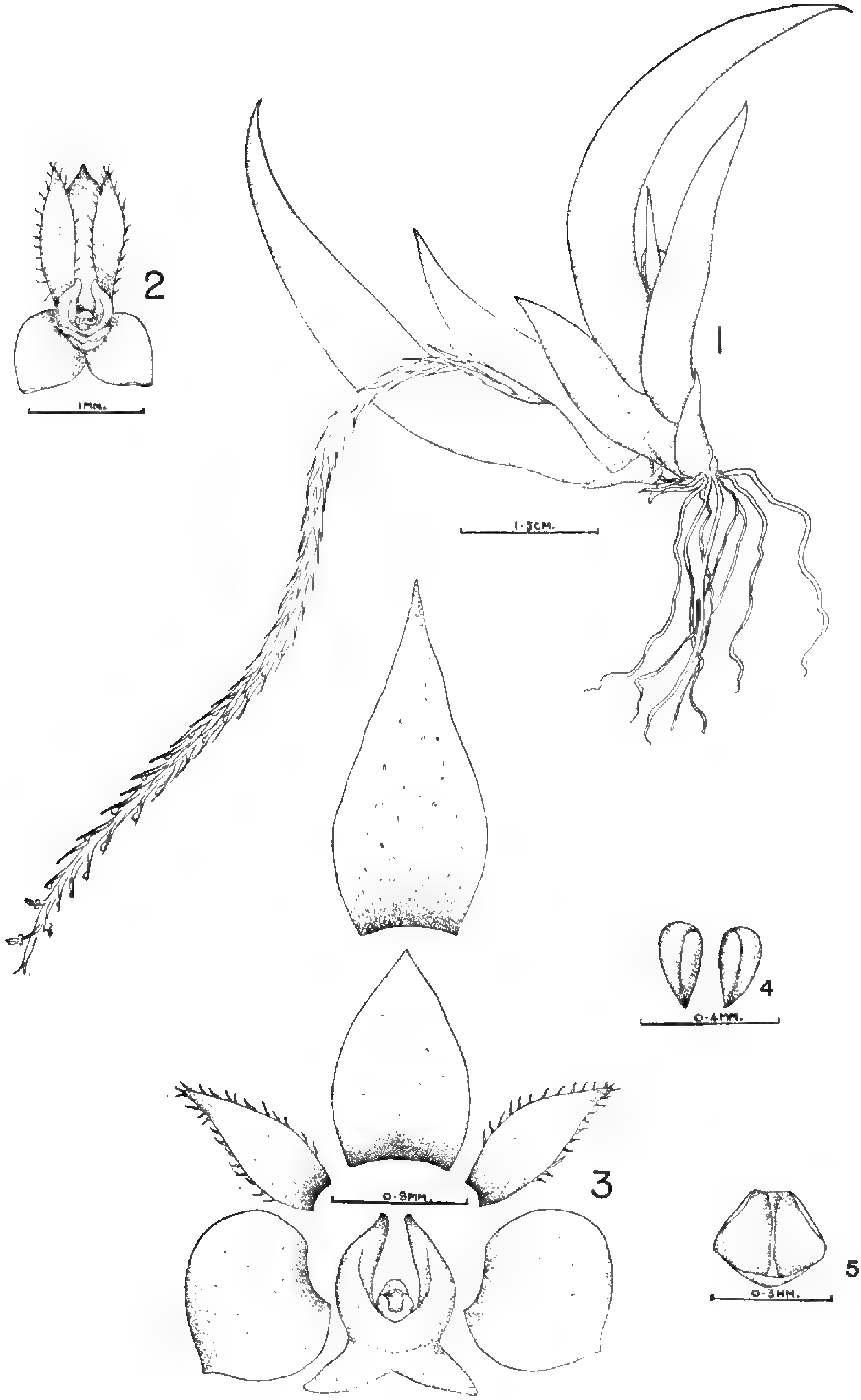
CEYLON: Ambagamuwa at 577 m. altitude in the transitional jungle between the tropical wet evergreen forests and the submontane or midcountry tropical wet evergreen forests, December 30, 1959, *Jayaweera 2144* (TYPE). It flowers in December.

Oberonia Wallie-Silvae *Jayaweera sp. nov.*

Epiphytica, caespitosa, non pseudobulbosa. Foliis distichis, carnosis, equitantibus, ensiformibus, apice acuminatis, 2–5.2 cm. longis, 0.4–0.7 cm. latis. Inflorescentia spiciformi, usque ad 10 cm. longa; pedunculo usque ad 10 cm. longo, et usque ad basin bracteis non floriferis omnino obtecto. Bracteis ovatis, acuminatis, 2 mm. longis, 0.9 mm. latis. Floribus minutissimis, 1.2 mm. in diam. Sepalo postico ovato, acuto, 1.2 mm. longo, 0.7 mm. lato; sepalis lateralibus oblique suborbicularibus, obtusis, 0.8 mm. longis, 1 mm. latis. Petalis lanceolatis, acutis, margine ciliatis, 1 mm. longis, 0.3 mm. latis. Labello 3-lobo, carnoso; lobis lateralibus lineari falcatis, crescentiformibus, lobo intermedio bifido, partitionibus inter se divaricatis, toto labello 1 mm. longo. Columna minutissima, globosa. Ovario pedicellato 1.4 mm. longo.

Tufted epiphyte with compressed non-pseudobulbous stems. Leaves distichous, fleshy, laterally compressed, 2–5.2 cm. long, 0.4–0.7 cm. broad, ensiform, decurved,

PLATE XIV



OBERONIA WALLIE-SILVAE *Jayaweera.* 1, plant with inflorescence. 2, flower from front. 3, bract, sepals, petals, lip and column spread out from front. 4, pollinia. 5, anther from inside.

acuminate, acute, bases confluent with the stem, veins obscure (Plate XIV). Flowers very small, reddish brown, 1.2 mm. across in spiciform racemes measuring about 10 cm. in length. Peduncle closely covered with sterile bracts right down to the base. Floral bracts 2 mm. long, 0.9 mm. broad, ovate, acuminate, acute. Dorsal sepal 1.2 mm. long, 0.74 mm. broad, ovate, acute; lateral sepals 0.8 mm. long, 1 mm. broad, obliquely suborbicular, obtuse; petals lanceolate, 1 mm. long, 0.36 mm. broad, acute, ciliate; lip 1 mm. long, thick: lateral lobes linear, falcate, horseshoe-shaped around the column: mid-lobe thick, 1 mm. broad, bifid, sometimes trifid, lateral lobules bluntly subulate and diverging. Column very small, globular, at the base of the lateral lobs. Anther terminal, incumbent, 2-loculed; pollinia 4, waxy, in two pairs, individuals of each pair unequal: each pair of pollinia 0.24 mm. long, 0.1 mm. broad, pyriform. Ovary with pedicel 1.4 mm. long.

This species does not appear to have any close allies. It is distinguished from others in its ensiform, decurved, acuminate leaves; lanceolate and ciliated petals; linear-falcate lateral lobes and the bifurcated, diverging mid-lobe of the lip.

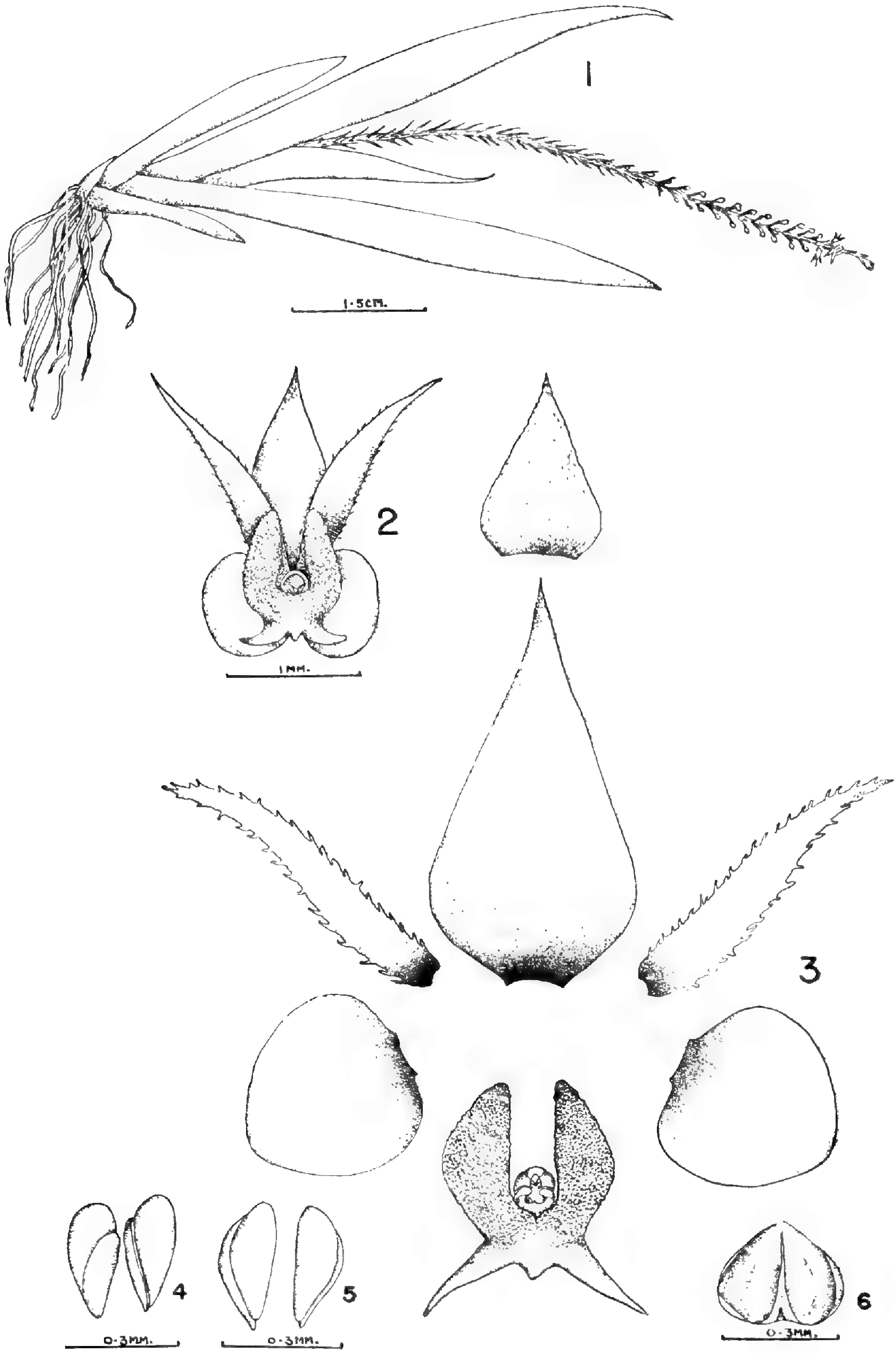
CEYLON: Rangala, in submontane or midcountry tropical wet evergreen forests at 1285 meters altitude, March 14, 1960, *Jayaweera 2143* (TYPE). It flowers in February and March.

Oberonia weragamaensis *Jayaweera sp.. nov.*

Epiphytica, caespitosa, ebulbosa. Foliis 4–5, distichis, equitantibus, carnosis, lanceolatis vel ensiformibus, acutis, 2–8 cm. longis, 0.3–0.6 cm. latis. Inflorescentia racemosa, erecta, perdense multiflora. Bracteis ovatis (triangulari-ovatis), acutis, 1 mm. longis, 0.5 mm. latis. Floribus minutis, 2 mm. longis. Sepalo postico ovato, acuminato, 1.2 mm. longo, 0.5 mm. lato; sepalis lateralibus suborbicularibus, apice rotundatis, 0.6 mm. longis, 0.7 mm. latis. Petalis lineari-lanceolatis, acuminatis, margine ciliolatis seu potius denticulatis, 1.4 mm. longis, 0.2 mm. latis. Labello 3-lobo, lobis lateralibus subtriangularibus, erectis, carnosis, papillosis, lobo intermedio 3-fido, partitionibus lateralibus divaricatis, subulatis, partitione intermedia dentiformi, triangulari, toto labello 1.2 mm. longo, 0.8 mm. lato. Columna abbreviata, crassa, 0.4 mm. alta. Ovario cum pedicello 0.8 mm. longo.

Tufted epiphyte with very short, compressed non-pseudobulbous stems. Leaves 4 or 5, distichous, laterally compressed, fleshy, 2–8 cm. long, 0.3–0.6 cm. broad, lanceolate or ensiform, acute, bases confluent with the stem and veins obscure (Plate XV). Flowers reddish brown, in whorled racemes 5–6 cm. long, first flowers to open located a little way below the terminal end and then progressively downwards, terminal flowers not opening. Flowers 2 mm. long, from the tip of the dorsal sepal to the apex of the lip and 1.2 mm. across. Floral bracts 1 mm. long, 0.52 mm. broad, ovate, acute, margin slightly irregular. Dorsal sepal 1.2 mm. long, 0.52 mm. broad, ovate, acuminate, acute; lateral sepals 0.6 mm. long, 0.74 mm. broad, suborbicular, rounded; petals longer than sepals, 1.4 mm. long, 0.28 mm. broad, linear-lanceolate, acuminate, ciliate or denticulate; lip 1.2 mm. long, 0.8 mm. broad: lateral lobes 0.7 mm. long, subtriangular, erect, fleshy, parallel, papillose, blunt at the apex, broadening towards the middle: mid-lobe trifid, the lateral lobules subulate, acuminate diverging and looped back posteriorly in the open flower, the mid lobule triangular and much shorter. Column short, 0.4 mm. high, 0.36 mm. broad. Anther terminal, incumbent, 2-loculed; pollinia 4, waxy, cohering in two pyriform pairs; larger pollinia 0.3 mm. long, 0.12 mm. broad, oblong, smaller ones 0.24 mm. long, 0.08 mm. broad and disk-shaped. Ovary with pedicel 0.8 mm. long, 0.3 mm. in diameter.

Plate XV



Oberonia weragamaensis *Jayaweera*. 1, plant with inflorescence. 2, flower from front. 3, bract, sepals, petals, lip and column spread out from front; bract, dorsal sepal, lateral sepals, petals, lip and column. 4, young pollinia. 5, older pollinia. 6, anther from inside.

This species differs from others in the linear-lanceolate, denticulate petals, subtriangular, erect, parallel lateral lobes of the lip and diverging, subulate, lateral lobules of the mid-lobe.

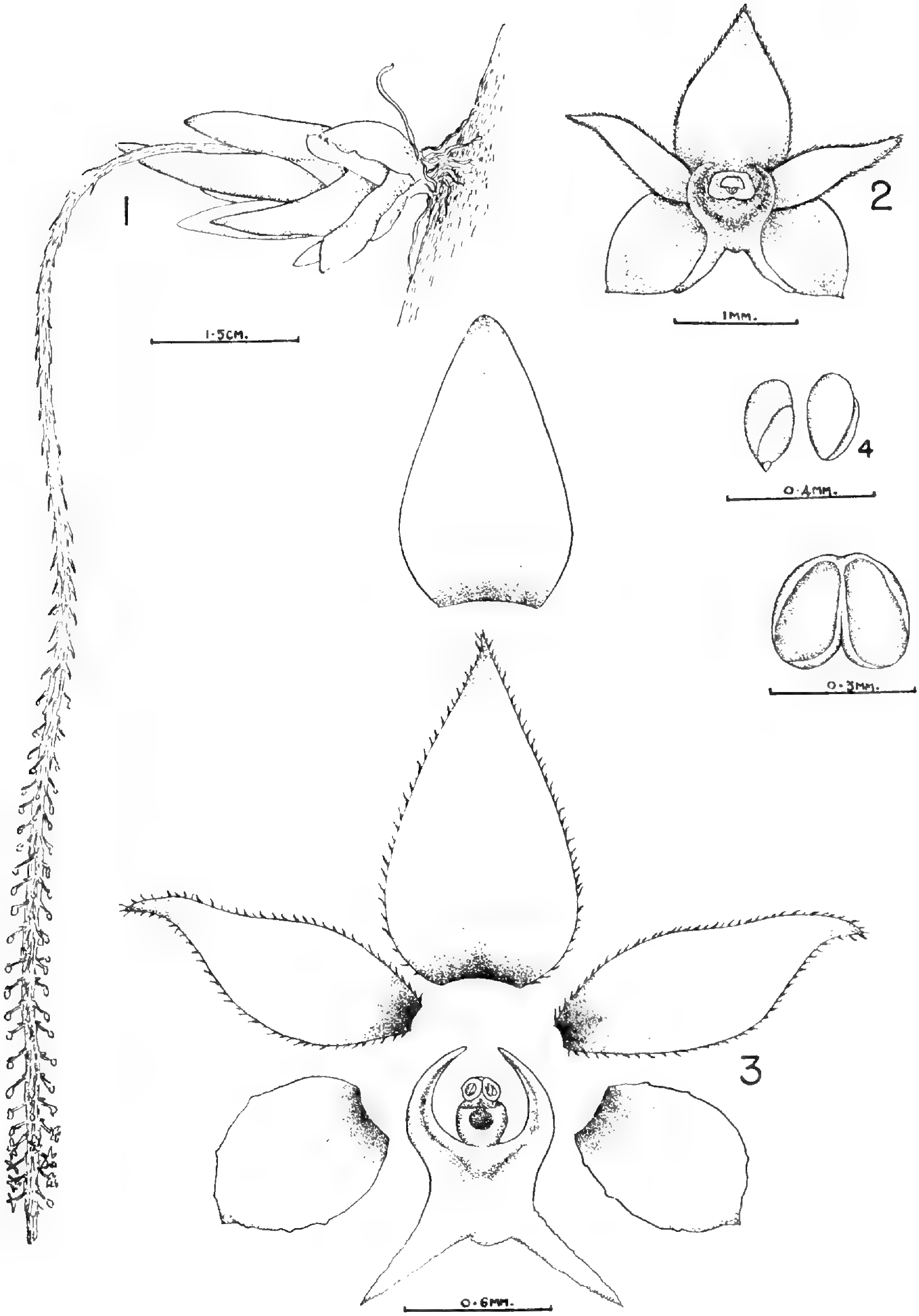
CEYLON: Ratnapura District, Weragama, in tropical wet evergreen forests at 220 meters altitude, November 30, 1959, *Jayaweera 2037* (TYPE), flowers reddish brown, epiphytic on *Wormia triquetra* Rottb., *Celtis Wightii* Planch., etc. It flowers in October and November.

Oberonia fornicata *Jayaweera sp. nov.*

Epiphytica, caespitosa, inflorescentia inclusa usque ad 20 cm. alta. Foliis paucis, carnosis distichis, equitantibus, ensiformibus, apice acutis, basi non articulatis, 1.5–2.5 cm. longis, 0.5–0.7 cm. latis. Inflorescentia satis dense multiflora, pendenti, pedunculo 1.5 cm. longo incluso usque ad 14 cm. longa. Bracteis ovatis, obtusis, 1.2 mm. longis, 0.5–0.7 mm. latis. Sepalo postico, ovato, acuto, margine ciliato, 1.4 mm. longo, 0.8 mm. lato; sepalis lateralibus suborbicularibus, obtusis, margine integris vel remote irregulariterque subdenticulatis, 1 mm. longis, 0.9 mm. latis. Petalis lanceolatis vel ovato-lanceolatis, acuminatis, margine ciliatis, 1.4 mm. longis, 0.5 mm. latis. Labello sepalis lateralibus aequilongo, 3-lobo, lobis lateralibus lineari-falcatis, columnam involventibus lobo intermedio 3-fido, partitionibus lateralibus subulatis, divergentibus, partitione intermedia abbreviata, dentiformi, obtusa. Columna globosa, 0.3 mm. alta. Ovario pedicellato 1.7 mm. longo.

Tufted epiphyte with compressed, non-pseudobulbous stems. Whole plant 3–3.5 cm. high. Leaves few, reddish green, fleshy, distichous, laterally compressed, short, oblong-ensiform, 1.5–2.5 cm. long, 0.5–0.7 cm. broad, acute, bases confluent with the stem (Plate XVI). Flowers greenish brown with a very pale coral lip; drooping racemes 14 cm. long, with sterile basal bracts. Peduncle 1.5 cm. long, bracteate almost to the base. Flowers in

PLATE XVI



OBERONIA FORNICATA *Jayaweera*. 1, plant with inflorescence. 2, flower from front. 3, bract, sepals, petals, lip and column with the anther flapped over from front: lateral sepals; lip magnified. 4, pollinia. 5, anther from inside.

distant, whorled fascicles on a very slender rachis. Floral bracts ovate, 1.2–1.26 mm. long, 0.56–0.7 mm. broad, obtuse and entire. Dorsal sepal 1.4 mm. long, 0.8 mm. broad, ovate, acute, margin ciliate; lateral sepals 1 mm. long, 0.9 mm. broad, orbicular-oblong, margin entire or slightly denticulate; petals lanceolate, 1.4 mm. long, 0.54 mm. broad, acuminate, acute, ciliate; lip shorter than sepals or about the same length as lateral sepals, 3-lobed; lateral lobes linear, falcate, ascending forming an arc round the column: mid-lobe trifid, the two lateral lobules subulate, diverging, mid-lobule short and blunt. Column globular, 0.36 mm. high, 0.3 mm. broad. Anther terminal, incumbent, 2-loculed; pollinia 4 in two pairs, one in each pair larger than the other; larger pollinia 0.24 mm. long, 0.14 mm. broad, one phase flattened fitting in the smaller ones: smaller pollinia 0.2 mm. long, 0.8 mm. broad and disk-shaped. Ovary with pedicel 1.7 mm. long.

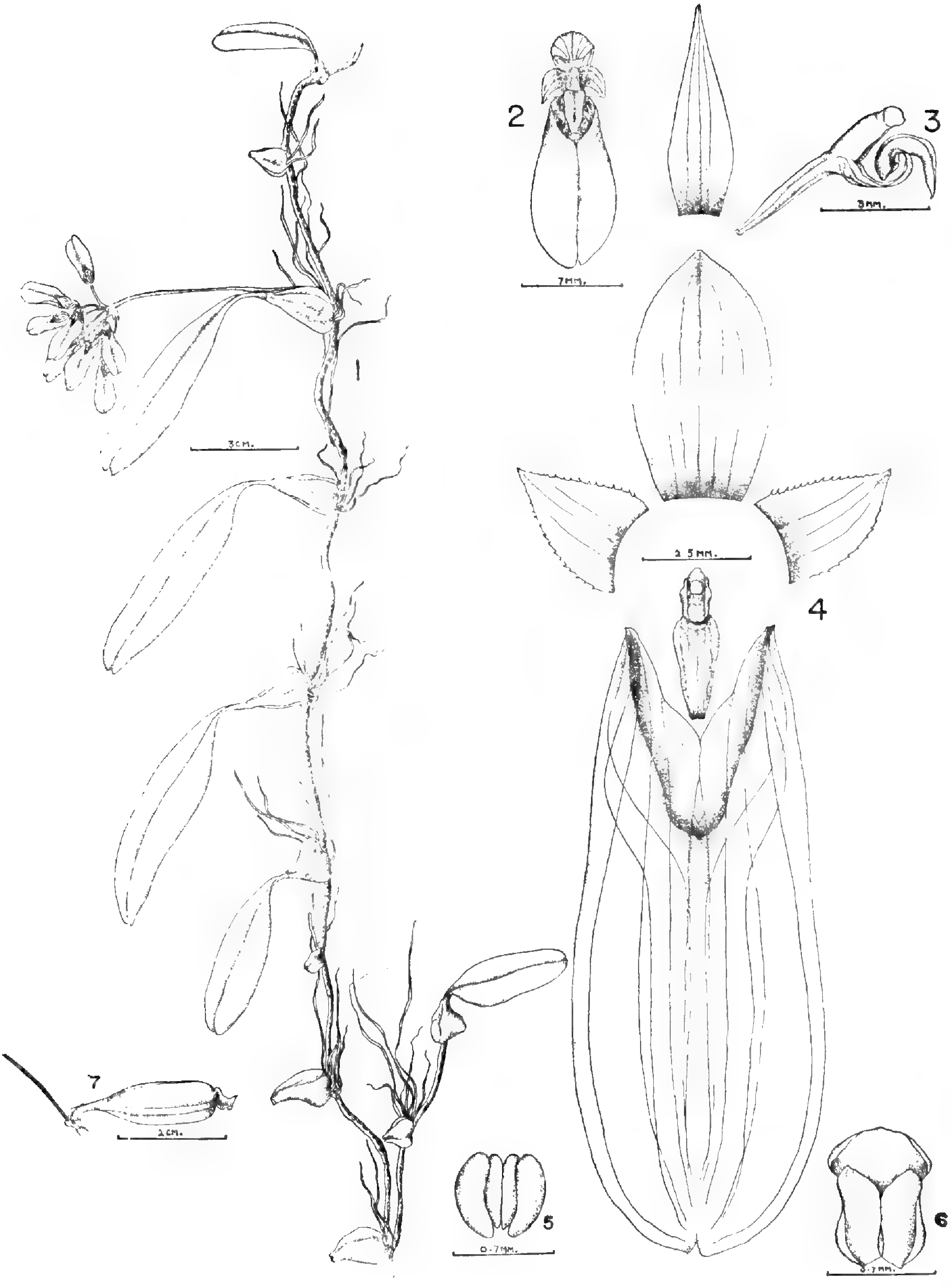
This species does not appear to have any close allies. It is distinguished by the ciliated dorsal sepal and petals, and the lip partly resembling *Oberonia Wallie-Silvae* and partly *O. weregamaensis*.

Ceylon: Rangala (Corbet's Gap), in submontane or midcountry tropical wet evergreen forests at 1285 meters altitude, *Jayaweera 2025* (Type) with no date of collection. It flowers in October.

Cirrhopetalum roseum *Jayaweera sp. nov.*

Epiphytica, pseudobulbosa, repente. Radicibus filiformibus, leviter flexuosis, glabris. Rhizomate prorepenti, elongato remote pseudobulbifero. Pseudobulbis ovoideis, vaginis scariosis protectis, unifoliatis, 1–1.5 cm. altis. Folio oblongo vel oblanceolato, interdum lineari-oblongo, valde coriaceo, apice emarginato, basi in petiolum brevem producto, 3.2–10.8 cm. longo, 1–1.5 cm. lato. Inflorescentia laterali, erecta, umbellata, 3.8–4.3 cm. longa. Bracteis lanceolatis, acuminatis, 3-nervatis,

Plate XVII



Cirrhopetalum roseum *Jayaweera.* 1, plant with inflorescence. 2, flower from front. 3, lip, column and mentum from side. 4, bract, dorsal sepal, petals, lip and column spread out from front; lateral sepals natural position. 5, pollinia. 6, anther from inside. 7, fruit.

4.8 mm. longis, 1.4 mm. latis. Floribus in umbello paucis (6-8), purpurascentibus, 1.2 cm. longis. Sepalo postico, elliptico, concavo, apice acuto, 5-nervato, 5.5 mm. longo, 3 mm. lato; sepalis lateralibus inter se usque ad apicem connatis, elliptico oblongis, concavis, apice bifidis, basi leviter saccatis, 13 mm. longis, 5 mm. latis. Petalis triangularibus vel triangulari-ovatis, acutis, 3-nervatis, margine serrulatis, 2.9 mm. longis, 2 mm. latis. Labello carnoso, valde recurvo versatili, apice truncato, basi ad pedem columnae adnato, 7-nervato, 4.6 mm. longo, 1.9 mm. lato. Columna cylindrica, ebrachiata, basi in pedem longum producta. Ovario pedicellato 7.2 mm. longo.

Epiphyte with pseudobulbous stems on a creeping rootstock. Pseudobulbs 1–1.5 cm. long, 0.8–1.2 cm. in diameter at the base, ovoid, tapering to the apex, ribbed, green, enveloped in old, brown, papery sheaths; internodes on rootstock 2.5–5 cm. long, ensheathed in dark brown scaly leaves; roots filiform, branched, tufted at the bases of pseudobulbs. Leaves solitary, 3.2–10.8 cm. long, 1–1.5 cm. broad, oblong, oblanceolate or linear-oblong, thickly coriaceous, emarginate, shortly petioled at the summit of pseudobulbs; petioles 3–4 mm. long, grooved (Plate XVII). Flowers purplish pink, 1.2 cm. long, 0.4 cm. broad in 6–8 flowered umbels, arising from the bases of the pseudobulbs. Peduncle 3.8–4.3 cm. long, red streaked with papery scaly bracts. Floral bracts 4.8 mm. long, 1.4 mm. broad, lanceolate, acuminate, acute, 3-veined. Dorsal sepal 5.5 mm. long, 3 mm. broad, elliptic, concave, obtuse, 5-veined bending over to form a hood over the rostrum and petals; lateral sepals 13 mm. long, 5 mm. broad, curving inwards and cohering in the mid-line along their outer edges, obtuse, adnate to the foot of the column at their bases, 5-veined; petals triangular-ovate, 2.9 mm. long, 2 mm. broad, acute, serrate, 3-veined; lip 4.6 mm. long, 1.9 mm. broad, oblong-ovate, thick, fleshy, strongly recurved, joining the foot, versatile, 7-veined, the two extreme pairs of veins intertwined forming a network. Column 1.8 mm. high, 1.3 mm. broad, the base extending into an upcurved foot. Anther terminal, 2-loculed; pollinia 4, waxy, collateral in two pairs, oblong, the inner ones of each pair smaller: outer pollinia 0.6 mm. long, 0.26 mm. in diameter and the inner ones 0.46 mm. long, 0.1 mm. in diameter. Ovary with pedicel 7.2 mm. long. Fruit a short pedicelled, oblong, cylindrical capsule, 2 cm. long, 0.7 cm. in diameter.

This species is allied to *Cirrhopetalum Wightii* Thw. from which it differs in the smaller flowers, elliptic dorsal sepal, smaller lateral sepals and petals, oblong-ovate lip and larger pollinia.

Ceylon: Ambagamuwa at 578 meters in the transitional jungle between the tropical wet evergreen forests of the low country and the submontane or midcountry tropical wet evergreen forests, January 22, 1960, *Jayaweera 2120* (Type).—Same locality, February 23, 1960, *Jayaweera 2128*. It flowers from January to March.

Saccolabium tortifolium *Jayaweera sp. nov.*

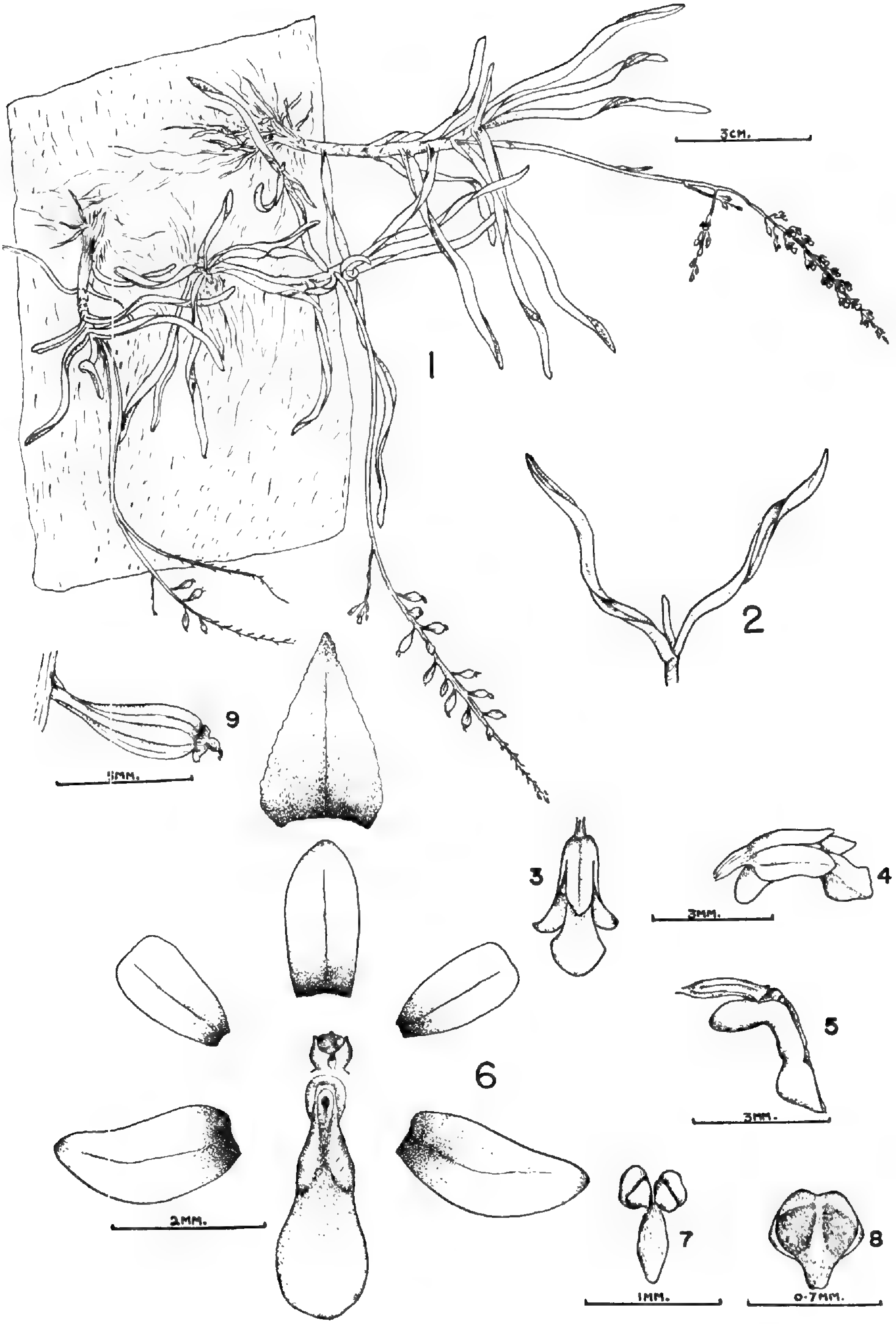
Epiphytica, caespitosa, non pseudobulbosa. Caulibus erectis, demum denudatis, deinde foliis 7–18, distichis tortis, semiteretibus obtectis. Foliis linearibus, carnosis 4–6 cm. longis, 0.3 cm. latis. Inflorescentia ex axillis foliorum superiorum nata, racemosa vel interdum pauciramosa, 13–14 cm. longa; pedunculo compresso, 6.5–7 cm. longo, rachide simplici, spiciformi, laxe pluriflora. Bracteis ovatis vel triangulari-ovatis, acutis, uninervis, 1.8–2.4 mm. longis, 1.4–1.6 mm. latis. Floribus minutis, albis. Sepalo postico oblongo, obtuso uninervato, 2 mm. longo, 1.1 mm. lato; sepalis lateralibus oblique ovato-oblongis, obtusis, uninervatis, 2.4–2.6 mm. longis, 1.2–1.4 mm. latis; petalis obovato-oblongis, truncatis vel vix emarginatis, uninervatis, 1.4–1.5 mm. longis, 0.7–0.8

mm. latis. Labello carnoso, spathulato, concavo, antice rotundato, basi in calcarem cylindricum producto, 3–3.4 mm. longo. Columna valde abbreviata, subglobosa, carnosa. Ovario cum pedicello 2.4–3.5 mm. longo.

Tufted epiphyte with simple non-pseudobulbous stems; stems 3–15 cm. long, 2 mm. in diameter, curving upwards in all directions, bases ensheathed in the remnants of old petiolar sheaths, the crowns carrying 7–18 ash-green, semiterete leaves, twisted clockwise or counterclockwise. Leaves 4–6 cm. long, 0.3 cm. broad, linear, fleshy, distichous, notched, bases sheathing the internodes above (Plate XVIII). Flowers minute, white, in leaf opposed racemose panicles, 13–14 cm. long. Peduncle 6.5–7 cm. long, flat, green with a number of short, membranous, sterile bracts; branches of the rachis few, 2.5–5.5 cm. long and spiciform. Floral bracts 1.8–2.4 mm. long, 1.4–1.6 mm. broad, triangular ovate, acute, faintly undulate, 1-veined. Dorsal sepal 2 mm. long, 1–1.1 mm. broad, oblong, obtuse, 1-veined; lateral sepals 2.4–2.6 mm. long, 1.2–1.4 mm. broad, obliquely oblong, rounded, 1-veined; petals 1.4–1.5 mm. long, 0.7–0.8 mm. broad, obovate-oblong, truncate or faintly emarginate, 1-veined; lip fleshy, white, 3–3.4 mm. long, notched halfway, concave and rounded dorsally, lateral lobes inconspicuous, mid-lobe 1.5 mm. long, fleshy, spathulate; spur short, cylindrical and rounded. Column 0.8 mm. high, 0.6 mm. broad, globular. Anther terminal, 2-loculed; pollinia 4, unequal, collateral in two pairs, large pollinia 0.34 mm. long, 0.16 mm. broad and the smaller ones 0.24 mm. long, 0.1 mm. broad attached to a lanceolate stipe 0.44 mm. long, 0.2 mm. broad, by short, flat caudicles. Ovary with pedicel 2.4–3.5 mm. long. Fruit a small, spreading, clavate, pedicelled capsule, 4 mm. long.

This species is allied to *Saccolabium niveum* Lindl. from which it differs in the linear twisted leaves, larger

PLATE XVIII



SACCOLABIUM TORTIFOLIUM *Jayaweera.* 1, plants with inflorescences. 2, apical portion of a shoot showing twisted leaves. 3, flower from top. 4, flower from side. 5, lip, column (hidden between the lateral lobes of the lip) and spur from side. 6, bract, sepals, petals, lip and column spread out from front. 7, pollinia with strap. 8, anther from inside.

sepals and petals, oblong lateral sepals, larger pollinia and the column taller than broad.

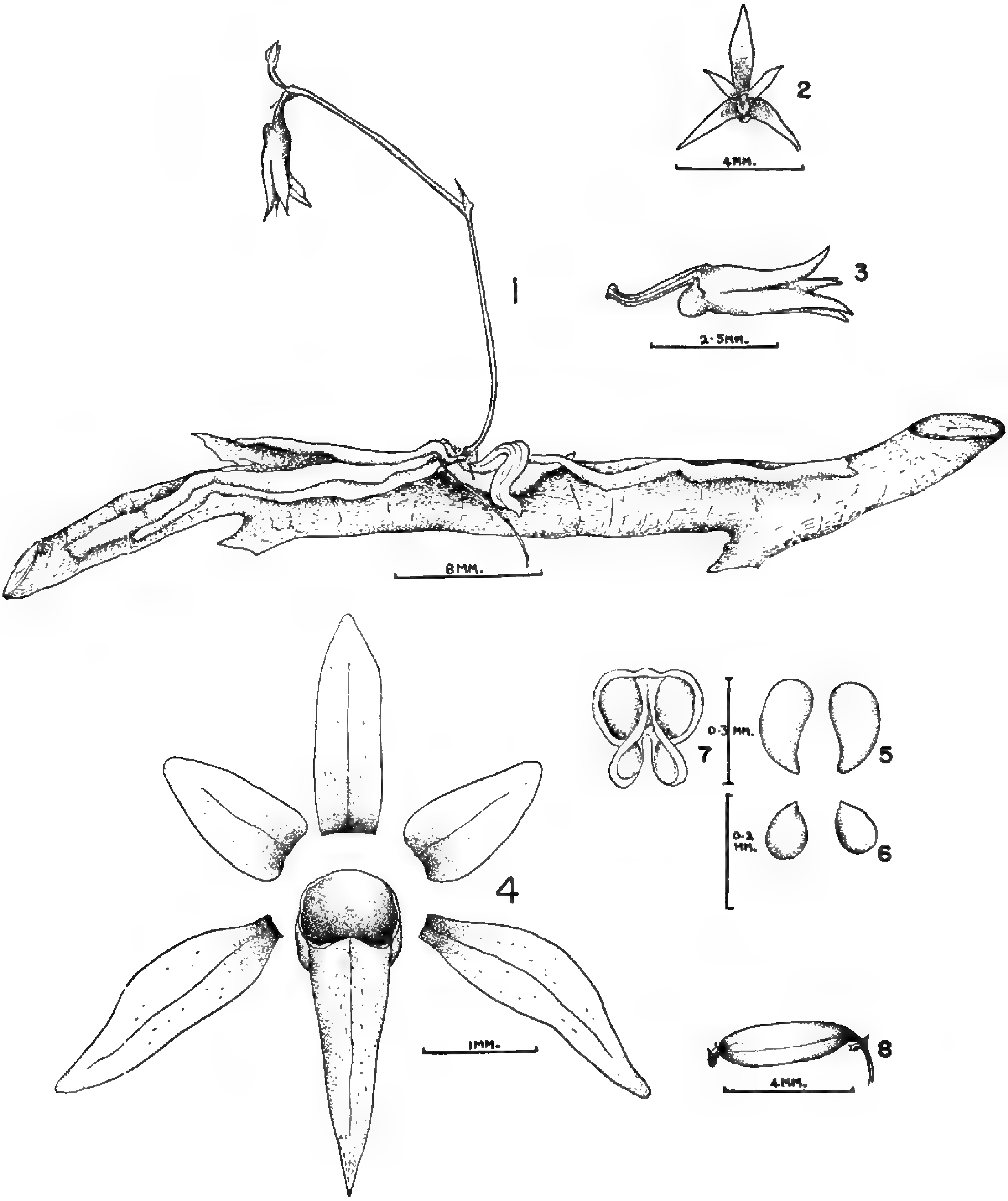
Ceylon: Hunnasgiriya, in submontane or midcountry tropical wet evergreen forests at 1150 meters altitude, August 21, 1959, *Jayaweera 1850* (Type).—Same locality and date, *Jayaweera 1851, 1852.*—Daulagala, July 25, 1960, *Jayaweera 2185.* It flowers from April to August. Two of its many host plants are *Schefflera stellata* (Gaertn.) Baill. and *Macaranga peltata* (Roxb.) Muell. Arg.

Taeniophyllum gilimalense *Jayaweera sp. nov.*

Epiphytica, ebulbosa, sine foliis et caule. Radicibus crasse carnosis, leviter flexuosis, glabris. Pedunculo filiformi, 2 cm. longo. Bracteis minutissimis, lanceolatis, acutis. Floribus minutis, succedaneis, viridi-luteis, 3.3 mm. longis. Sepalis petalisque inter se brevissime, i.e., supra basin connatis. Sepalo postico oblongo-lineari, acuto vel rotundato, uninervato, 1.9 mm. longo, 0.5 mm. lato; sepalis lateralibus ovato-lanceolatis, obtusis, uninervatis, 2.4 mm. longis, 0.6 mm. latis. Petalis ovatis, obtusis, uninervatis 1.3 mm. longis, 0.7 mm. latis; labello cymbiformi, acuto, uninervato, basi in sacculum subglobosum producto, 2.1 mm. longo, 0.7 mm. lato. Columna brevissima, globiformi, brachiis 2, porrectis in fronte. Ovario cylindrico, cum pedicello ca. 2 mm. longo.

Minute, non-pseudobulbous epiphyte without stems and leaves. Roots flattened, fleshy, dark green and tortuous, 2.5–4 cm. long, 3 mm. broad. Leaves, reduced to minute transparent scales (Plate XIX). Flowers minute, greenish yellow 3.3 mm. long in 2- or 3-flowered racemes, flowers opening one at a time. Peduncle jointed, slightly bent at the joint, 2 cm. long, with a single, sterile bract. Floral bracts, minute, lanceolate, acute. Sepals, petals and lip connate at the base only. Dorsal sepal 1.9 mm. long, 0.56 mm. broad, linear-oblong, acuminate, subacute or rounded, 1-veined; lateral sepals 2.4 mm. long, 0.64 mm. broad, lanceolate, rounded, 1-veined;

PLATE XIX



TAENIOPHYLLUM GILIMALENSE *Jayaweera.* 1, plant with inflorescence on a twig of the host plant. 2, flower from front spread out. 3, flower from side. 4, sepals, petals and lip spread out from front. 5, large pollinia. 6, smaller poliniar 7, anther from inside. 8, fruit.

petals 1.3 mm. long, 0.7 mm. broad, ovate, rounded, 1-veined; lip 2.1 mm. long, 0.7 mm. broad, cymbiform, subulate, acute, 1-veined, base produced into a rounded, saccate spur, 0.5 mm. long and 0.54 mm. in diameter. Column very short, globular, broad, with two projecting arms in front. Anther terminal, depressed, 4-loculed; pollinia 4, pyriform, sessile on a broad gland: large pollinia 0.26 mm. long, 0.14 mm. broad, slightly curved, and the smaller ones 0.1 mm. long, 0.06 mm. broad. Fruit a cylindric capsule, 4 mm. long. 1.3 mm. broad.

This species appears to be related to both *Taeniophyllum inconspicuum* Schltr. and *T. capillare* J.J.Smith from Celebes but differs from both in the ovate, rotund petals. *T. inconspicuum* has a longer spur while *T. capillare* is a larger plant bearing bigger flowers than this species. It differs from *T. Alwisii* Lind. in the larger size of the plant with longer and broader roots, larger flowers with 1-veined sepals and petals and smaller fruits.

CEYLON: Ratnapura District, Gilimale, in tropical wet evergreen forests at 175 meters altitude, July 6, 1960, *Jayaweera 2182* (TYPE). It flowers in July.

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SPREAD OF EIGHT-ROWED MAIZE FROM THE PREHISTORIC SOUTHWEST

BY

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THE origin and diffusion of maize (*Zea mays*) in the North American Southwest is of interest to both the maize breeder and the archaeologist. The interest of the maize breeder lies in his search for the sources of effective germplasm for use in the development of better maize hybrids. The archaeologist is interested in the history of maize because of its association with the growth and spread of those prehistoric cultures in which this cereal played a prime role.

BOTANICAL DATA

It is now apparent that most, if not all, of the races of Southwestern maize came from adjoining areas in Mexico, although, as will be discussed later, one race which was important to the evolution of this cereal may have come originally from South America. Both Mexico and the Southwest had the same ancient indigenous race, Chapalote, which underwent a slow evolutionary change for several thousands of years, until two separate and sudden evolutionary spurts were triggered by two new elements: first, teosinte, a wild relative of maize; and, later, an

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unrelated eight-rowed race of maize which survives in mixed form in a race called Harinoso de Ocho in northwestern Mexico (Mangelsdorf and Lister, 1956).

Chapalote reached the Bat Cave area in New Mexico apparently from central or southern Mexico perhaps as early as 3600 B.C. (Mangelsdorf, 1954), and, after a gradual evolutionary change leading to increased size of ear and increased number of kernel-rows, it became the Basketmaker maize which formed the subsistence base of the prehistoric Pueblo culture. The addition or introgression of teosinte germplasm into Chapalote occurred probably not later than 500 B.C. at Bat Cave (Mangelsdorf and Smith, 1949), and it seems to have spread as far north as Durango, Colorado by A.D. 46 to 330 (tree ring dates), as will be discussed later. The degree of such teosinte introgression can be estimated in archaeological cobs, and such estimates have been correlated with various changes in the morphology of the cob (Galinat *et al.*, 1956; Galinat and Ruppé, 1961). The effects of this teosinte germplasm include a tremendous increase in variability and an apparent heterotic effect on ear size as well as an increase in drought resistance which was necessary for an extension of maize culture into new and more arid regions.

Greater drought resistance in teosinte-contaminated maize may be of either a physiological or a morphological nature. The type of drought resistance derived from teosinte germplasm in maize reported by Reeves (1950) is apparently physiological. A morphological type of drought resistance in teosinte itself has been observed recently by Mr. Garrison Wilkes (personal communication), and this type may also be transferred to maize. After examining Mexican maize fields that showed serious drought damage and which contained Chalco teosinte, Mr. Wilkes concluded that the teosinte was more successful in producing seed than the maize. He attributed this ability of teosinte to ward off drought to the fact that it produces a succession of younger ears in clusters which eventually encounter the late season rains necessary for grain development. A situation in which this morphological type of resistance has been transferred to maize was observed this past summer at the Bussey Institution in the race Reventador, which seems to be a teosinte-contaminated descendant of Chapalote and has some similarities to the teosinte-contaminated form of Chapalote that was prevalent in the Southwest before A.D. 700.

Apparently at about A.D. 700, a third element, the race of eight-rowed maize, Harinoso de Ocho, entered upon the evolutionary scene and conferred new benefits in the form of higher yield, easier milling and adaptability to a far greater range of environments. A re-examination of the earlier eight-rowed cobs from the Durango Basketmaker site described by Jones and Fonner (1954), has now revealed that their eight-rowed condition is probably a result of teosinte introgression into the race Chapalote.

Some of the differences between eight-rowed cobs resulting from teosinte introgression into Chapalote, such as those from Durango, and this new eight-rowed race, Harinoso de Ocho, are apparent in Plate XX. The tripsacoid element in eight-rowed Chapalote (figs. 1–4) is revealed by a combination of slender cobs which may be curved and have slender shanks with narrow, triangular shaped cupules and hard up-curved glumes. The Harinoso de Ocho element (figs. 5–12) is manifest in thick straight cobs which are sometimes swollen at the base, thick shanks, wide cupules and wide, crescent-shaped kernels. In describing this race, Wellhausen *et al.* (1952), postulated that it was introduced into Mexico from South America in pre-Columbian times. Its South American progenitor was subsequently found in Colombia and identified by Roberts *et al.* (1957), as Cabuya, an eight-rowed race that is both tripsacoid and has nearly knobless chromosomes (average, 2.2 knobs). Grobman *et al.* (1961), suggested that these two features might result from indirect introgression, by way of Sabanero (1.5 knobs), from a South American species of *Tripsacum*, *T. australe*, which, as shown by Graner and Addison (1944), is unlike its knobby Central and North American relatives in having almost knobless chromosomes.

The blending of these three diverse germplasms from Chapalote, teosinte and Harinoso de Ocho produced, in Mexico and the American Southwest, new and more productive races of maize with increased adaptability sufficient to permit maize cultivation to spread north to northern Utah in the Great Basin. As this maize spread northward into the Dakotas in the Plains east of the Rocky Mountains and east across northern United States and on into New England, there was a filtering out of the eight-rowed element which became stabilized as the race called Northern Flint. Eventually, with the migrations of European farmers, these northern flints encountered the southern dents which had spread northward from eastern Mexico. The resulting hybridizations yielded the world's most productive race, our modern Corn Belt Dent, as shown by historical records (Wallace and Brown, 1956). The efficient use of these diverse germplasms which are now captured to various degrees in modern inbred lines of maize involves a knowledge of their origins and a recognition of their particular effects upon a spikelet-rachis relationship (Galinat, 1963).

There has been some confusion surrounding the origin and identity of this important eight-rowed race. This confusion seems to stem from the fact that pure forms of the eight-rowed race are either rare or hidden by the great diversity of maize in the Southwest, while eight-rowed maize was abundant and often the only archaeological maize in the North or Northeast. Accordingly, most references to this race follow Carter's (1945) early term of "Eastern Complex," a term which was coined to indicate an Eastern origin. Others (Brown and Anderson, 1947) have referred to the same race as Northern Flint, a term which seems to be better than that used by Carter, since it does, at least, indicate the "Life Zone" (Plate XXI) where this eight-rowed race attained its greatest distribution (Plate XXII). But if we examine both the prehistoric and historic evidence concerning the distribution of this eight-rowed race, as will be done later, we find that its origin can be traced back to the Southwest, as first suggested by Mangelsdorf and Reeves (1939), and southward to the race Harinoso de Ocho in Mexico. The Spanish term "harinoso" refers to the floury character of the kernels, while "ocho" refers to the eight-rowed condition of the ears. In the East and Northeast, this race has acquired "flinty" kernels instead of the original floury ones. We are here proposing a more general name, Maíz de Ocho, for this race in which we include both the Northern Flints and Harinoso de Ocho. The Spanish name was chosen to give recognition to its Mexican point of dispersal.

An excellent historical record of the geographic distribution of the eight-rowed flint (varieties Angel of Midnight, Canadian Eight-rowed Yellow, King Philip and Longfellow) was published by C. S. Plumb in 1898 as a bulletin of the United States Department of Agriculture. This record is the more significant because, at this early date, before the advent of extensive commercial maize hybridization, the races and their distribution more closely approximated the prehistoric condition. Since Plumb presented his distributional data only by states, the dots representing these occurrences on our Plate XXII are located arbitrarily within the states. Even so, his survey data revealed that Maíz de Ocho was best adapted, presumably because of suitable conditions of temperature and moisture, to the humid part (Alleghenian area) of the Transitional Life Zone; that is, especially to the Allegheny region, Ontario, New England, New York, Pennsylvania, Michigan, Wisconsin and Minnesota. This race also extended down through the arid part of the transition zone, where the soil was moistened by rivers, springs or sub-surface drainage from higher elevations or by intentional irrigation in parts of Nevada, Wyoming, Colorado, Utah, New Mexico and northwestern Mexico. But although this eight-rowed race was not well adapted to the Southwest, it became widespread there, which is in sharp contrast to its almost complete absence in the Lower Austral Zone in the Southeast (Plate XXI). These historical data suggest that Maíz de Ocho arrived in the Northeast by way of the Southwest.

Convincing evidence that Maíz de Ocho did indeed come from the Southwest becomes apparent when we extend the map of Brown and Anderson (1947) showing the prehistoric distribution of Maíz de Ocho to include all of the United States rather than just that part east of the Mississippi. With this archaeological data added to the historical data of Plumb, we find that Maíz de Ocho follows the Transition Life Zone from New England across the northern United States and down through the Southwest into Mexico (Plate XXII). Furthermore, the data on which this distribution is based (Table I) show that the closer one gets to Mexico, the earlier the dates for Maíz de Ocho. What at first appears to be the most serious exception to this sequence of dates is the Maíz de Ocho from Stalling's Island Mound, Georgia, where the major occupation probably pre-dates the Christian era. It is not possible, however, to determine, without radiocarbon dating, whether this eight-rowed maize is from this earlier occupation or from a later historic occupation (A.D. 1600–1700) which followed at the same site. The later occupation seems more likely.

If Maíz de Ocho did originate in the highlands of Colombia, then its poor adaptation to the lowlands in the southern part of the Southwest might be expected. But a flow of germplasm from local races such as Chapalote, Reventador and Tabloncillo has apparently tended to acclimatize it to this area. Thus, Harinoso de Ocho, as it lingers on, is extremely variable and mixed. Each ear from two collections of Harinoso de Ocho recently received from the Rockefeller Foundation in Mexico is different in size and shape and has thin dented kernels rather than thick floury kernels, as described for this race by Wellhausen *et al.* (1952). Although the kernels of Harinoso de Ocho are thinner (4.4 mm.) than those of Cabuya (6.36 mm.), they are still thicker than those of all other Mexican races except one, Cacahuacintle, which is thought to be also from South America and to be related to Cabuya (Wellhausen *et al.*, 1952 and Grobman *et al.*, 1961). The mixed nature of Harinoso de Ocho is also apparent in archaeological collections from northwestern Mexico (Mangelsdorf and Lister, 1956) and adjoining areas of the Southwest, as in a collection from several sites in southwestern New Mexico reported by Cosgrove (1947) and represented in Plate XXIII. This collection shows the distinct elements which were blended during the evolution of maize in the Southwest as follows: Chapalote (figs. 1, 2, 3), tripsacoid Chapalote (figs. 4, 5, 6) and Harinoso de Ocho (figs. 7, 8, 9) as well as their hybrid product, probably the Pima-Papago race, or Maíz Blando (figs. 10, 11, 12).

As Maíz de Ocho moved northward and eastward from the Southwest, it would have encountered colder soils and shorter growing seasons. As a result, natural selection, especially during germination, would have increased the frequency of the hard, flinty kernels and early maturing kernels. At the same time, natural selection would have filtered out any residual adaptation to the growing conditions which are found in the North and Northeast. Such germplasm might have been carried over through the poorly adapted Harinoso de Ocho in Sonora from the introduced highland race Cabuya of Colombia. Thus, during its northward migration from the Southwest we would have had the well-known substitution of latitude for altitude adaptation resulting in this reassertion of the original South American heritage.

This new eight-rowed race had certain advantages over the indigenous Chapalote race in that its larger and softer kernels were easier to grind for flour. When the problem of adaptability was overcome by hybridization with indigenous maize, the new superior type of grain must have spread rapidly, probably through trade and migration. The hybrid, called Maíz Blando de Sonora by Wellhausen *et al.* (1952), remained in Mexico. It has floury kernels approaching those of Harinoso de Ocho in size and a twelve-rowed ear approaching that of Chapalote. Just to the north, the counterpart of this hybrid is called Pima-Papago after the Indians who cultivated it (Anderson and Cutler, 1942). Teosinte introgression seems also to have played a role in the spread of this hybrid, especially in the Fremont area of Utah, where the kernels become strongly dented and the glumes indurated (Plate XXIV). The close similarities among the races Maíz

Blando de Sonora, Pima-Papago and Fremont Dent are seen in Plate XXV).

The denting of kernels in Pima-Papago to produce the Fremont Dent apparently allowed a more northerly extension of the culture of this hybrid race. The dent type of kernel has some of the advantages of both the hard, flinty kernels which are more resistant to decay in cool moist soils and the soft, floury kernels which are easier to grind for flour. The dent itself refers to a depression which develops in the crown of the kernel and extends toward the column of soft starch which occurs in the central region of the kernel. The sides of dent kernels are flinty and, thereby, provide protection against decay in the region most susceptible. During germination, the column of soft starch expands toward the crown, causing the dent to disappear.

The degree of denting is variable in different races of maize and appears to be one of the effects of teosinte introgression. Denting is correlated with the number of chromosome knobs, which in turn is related to tripsacoidness in the maize from western Guatemala (Mangelsdorf and Cameron, 1942) and in the maize from the United States (Brown, 1949). Since there is at most only slight denting in Chapalote even where there is extensive teosinte introgression, it was apparently the introduction of Maíz de Ocho germplasm combined with the tripsacoid Chapalote germplasm that made denting possible.

Although most collections of Fremont Dent appear to be merely a dented form of the Pima-Papago race, apparently some of its northernmost isolates have acquired slightly more pointed kernels and shorter ears than the Pima-Papago race and, consequently, have some superficial resemblance to the race called Zapalote Chico. In fact, it has been suggested that Zapalote Chico jumped about one thousand miles from central Mexico to the

Castle Park area in northwestern Colorado (Anderson, 1959), although the present distribution of this race is even farther south in the southernmost Mexican states of Oaxaca and Chiapas.

The most Zapalote Chico-like specimen which we were able to pick out of the Peabody Museum Collection from Fremont sites is from near Vernal, Utah, not far from Castle Park. This specimen matches very closely the ears from Castle Park which Anderson (1959) has called Zapalote Chico, but its resemblance to Zapalote Chico is not convincing when it is compared with actual specimens of this race obtained through Dr. E. J. Wellhausen of the Rockefeller Foundation in Mexico (Plate XXVI). Any similarities which exist between the Castle Park maize and Zapalote Chico may stem from the fact that Zapalote Chico and our candidate, the Pima-Papago race, have some similarities in their ancestry, as pointed out by Mangelsdorf (personal communication). That is, Nal Tel, one parent of Zapalote Chico, is either related to or else is the actual precursor of Chapalote, which is one parent of Maíz Blando (Pima-Papago). Furthermore, both hybrid races involve teosinte introgression, coming by way of the race Tepecintle in the case of Zapalote Chico and coming in more directly during the origin of Maíz Blando from Harinoso de Ocho and Chapalote (see Wellhausen *et al.*, 1952).

ARCHAEOLOGICAL IMPLICATIONS

This re-examination of the origin and spread of Maíz de Ocho has far-reaching implications for the archaeology of the Southwest, especially the Pueblo II expansion; for the beginnings of sedentary cultures in the Plains east of the Rocky Mountains; and for the development of cultures across the northern part of the United States as far as the Atlantic Ocean. Considering the very limited data with which we are dealing and the inherent imprecision of radiocarbon dating, which provides much of our chronological framework, it cannot be emphasized too strongly that the reconstructions here outlined, especially those concerning eastern United States, are of a tentative nature.

It has already been pointed out that pre-Chapalote, the maize introduced from Mexico into the American Southwest some 5000 years ago, developed quite slowly, until teosinte was introduced, also from Mexico, by about 500 B.C. Pre-Chapalote has been recovered from the earliest, but undated, levels at Swallow Cave in Chihuahua (Mangelsdorf and Lister, 1956) and from the earliest, perhaps 5000-year-old level, at Bat Cave in southwestern New Mexico (Johnson, 1951; Mangelsdorf, 1954).

More evolved, teosinte-contaminated, early Chapalote was recovered from a 2300-year-old level at Tularosa Cave in southwestern New Mexico not far from Bat Cave (Cutler, 1952; Johnson, 1951). The highly variable hybrids that resulted from the blending of Chapalote and teosinte provided the base for the Basketmaker and Pueblo development. By the beginning of the Christian era, the Basketmaker horticultural way of life had spread north into southern Utah and southwestern Colorado. A number of sites in this area that have yielded early and evolved types of Chapalote showing varying amounts of teosinte contamination have been dated by dendrochronology. Among these are Cave du Pont (A.D. 217) in south-central Utah (Collins, *in*: Nusbaum, 1922; Schulman, 1949); White Dog Cave (A.D. 312), as well as other sites in the Marsh Pass area of northeastern Arizona (Kidder and Guernsey, 1919; Guernsey and Kidder, 1921; Gladwin, 1957: 37); and the Durango Basketmaker site (A.D. 46–330) near Durango in southwestern Colorado (Morris and Burgh, 1954).

At about A.D. 700, the new race of maize that we have named Maíz de Ocho made its appearance in northern Mexico, where it survives in a race called Harinoso de Ocho. Our data are still too few to establish with certainty the routes by which Harinoso de Ocho traveled. No evidence of its influence has been noted between its postulated homeland in South America and northern Mexico. From the location of the few sites in the latter area where it has been found, the most likely route would have been up the west coast of Mexico. It seems probable that it was also introduced into Central America and southern Mexico, but since this race is especially well suited to high latitudes or altitudes, it is not surprising that no evidence of it can be seen in the maize of this tropical area. Once it reached northern Mexico, however, it apparently spread very rapidly throughout the Southwest, where it occurs at Tularosa Cave at about the same time that it appears in Chihuahua. Since it was crossing an area which had long contained other maize, some of the new germplasm probably spread in the form of a hybrid.

Our re-examination of some of the charred cobs from the Durango, Colorado Basketmaker site that were originally thought to show a significant amount of "Eastern" (Maíz de Ocho) influence, led to the conclusion that the traits in question were more probably the result of teosinte introgression. Thus, with the cancellation of this material as evidence of Maíz de Ocho in a Basketmaker context, we can probably rule out its occurrence in the Southwest prior to about A.D. 700, when it entered the Mogollón area.

The addition of this new race appears to have given a second and even more potent impetus to the development of the already well-adapted maize in the Southwest. By sometime between about A.D. 950 and 1100, the area occupied by the Pueblo cultures reached its maximum extent with what is known as the Pueblo II expansion; and throughout the Southwest, after about A.D. 950, the archaeological maize shows a blending of Chapalote, teosinte and Maíz de Ocho. The persistence until at least A.D. 1247 of essentially pure Maíz de Ocho, along with other strongly Chapalote-affiliated maize, is dramatically shown at Painted Cave, northeastern Arizona (Haury, 1945, Plate 36).

The reason for the Pueblo II expansion into areas not previously occupied by horticulturists has not been satisfactorily explained. A period of more favorable rainfall has generally been accepted as one factor. We are suggesting here that a more important factor was the introduction of the new race of maize, Maíz de Ocho, which, when blended with the previously cultivated maize, resulted in more abundant yields of a grain that was not only more easily milled, but also better suited to a wider range of environments, particularly higher elevations and latitudes. Thus, the introduction of Maíz de Ocho appears to have provided a food resource that contributed to a population increase, and a maize sufficiently adaptable to higher latitudes that it permitted this increased population to carry the Pueblo farming way of life an additional 250 miles farther north than had previously been possible. Although the Pueblo area spread limited distances both east and west during this period (ca. A.D. 900–1100), the most dramatic expansion was to the north, with the movement of the Fremont and Sevier (probably Plateau Shoshonean) peoples into the northern 85% of Utah (Gunnerson 1960, 1962).

This study started with an examination of maize remains collected by the Claflin-Emerson Expeditions to eastern Utah sponsored by Peabody Museum of Harvard between 1928 and 1931. The archaeology of some of these sites has been described previously by Morss (1931) and that of the remainder has been described recently by Gunnerson (n.d. b). This very interesting and important maize collection contains excellently preserved specimens from Fremont sites well distributed over that part of eastern Utah north of the Colorado River. The collection includes 226 ears, cobs and fragments of cobs in which a complete cross section is retained, plus other miscellaneous maize remains. A full tabulation and description of this material is in preparation, but only sites yielding definite evidence of Maíz de Ocho are included in Table I of this report. About 10% of the Fremont maize examined is eight-rowed, but some of these specimens show strong tripsacoidness. On the other hand, however, some ten- and twelve-rowed specimens show significant increcrements of Maíz de Ocho.

A few of the samples of Fremont maize were found in isolated rock shelters without associated diagnostic artifacts. However, since these sites are in areas where the Fremont Culture is the only horticultural archaeological complex, it is safe to assign these finds to Fremont. The finding at other sites of Maíz de Ocho specimens associated with diagnostic Fremont artifacts and with a wide range of other maize, mostly that here defined as Fremont Dent, helps substantiate the assignment of the isolated finds.

Other archaeological maize from the Southwest that has been examined or re-examined includes portions of the Peabody Museum Collections made by Guernsey and Kidder in northeastern Arizona and by Cosgrove in southwestern New Mexico. These two collections represent the Kayenta Anasazi and Mogollon cultures, respectively.

Certain changes that took place in the Pueblo II period, when considered along with the advent of Maíz de Ocho, raise questions such as the following: Did the greater ease with which the new maize could be milled cause changes in the design of *manos* and *metates*, such as the use of mealing bins and the graded coarseness of the metates? Did the increased yields provided by the new maize result in changes of settlement pattern and village plan, as well as changes in architectural styles, such as increased size of storage rooms? Did the increased yields make the Pueblo people overly dependent upon maize horticulture so that the occasional inevitable crop failures, especially when they occurred for several consecutive years, cause severe hardships and increased inter-village competition for the most desirable farm land, and even raids against villages which did harvest a successful crop by another village which did not? Was the moving of storage rooms into large multiroomed structures a device for protecting the surpluses that could now be amassed? These and many other questions can probably be answered by additional field work and a re-examination of data now available.

With regard to the area east of the Rocky Mountains, there are scattered bits of evidence (Caldwell, 1958) that maize was grown in various places in the southeastern quarter of the United States probably as early as the last few centuries B.C. It is uncertain, however, just how important maize was in the Hopewell Culture with which these scattered finds of maize have been most commonly associated. Very little maize has been recovered, but this could be due in part to poor conditions for preservation. The best description of Hopewell maize appears to be that by Cutler (*in:* McGregor, 1958: 169–170) based on 106 grains, but no cobs, from the Pool Site, a Hopewell village in west-central Illinois. These grains appeared to be from ears with 10 to 14 rows, mostly 12, and similar to maize from the upper prepottery and lower pottery levels at Tularosa Cave. Cutler states that "The ears probably resembled the Guatemalan Tropical Flints more than they resembled the historic ears of the region'' and that ''The grains probably were flint, but might have been flour. They were not sweet, pop, or dent.''

The only direct evidence of maize in Plains Woodland (ca. A.D. 0–900) consists of a few kernels found in eastern Nebraska at a site assignable to its latest phase (Kivett, 1952; Wedel, 1961). Of this maize, Mangelsdorf (*in:* Kivett, 1952: 58) said ''their size and shape is such as to indicate they are popcorn not too different from the primitive popcorn from Bat Cave dated at 1500 to 2000 B.C. This does not mean, of course, that this particular corn was grown at such an early date but there is no doubt that it represents a relatively primitive type of corn.''

Thus, there is no chance that either the Hopewell or the Woodland maize is closely related to Maíz de Ocho, nor is it likely that either was involved in any way with the spread of Maíz de Ocho prior to its appearance in the Southwest. The data are still too few to permit safe speculation on the relationship between Plains Woodland maize and Hopewell maize. Although Plains Woodland was contemporaneous with at least Late Hopewell and was apparently related to it both culturally and by trade, we can not be certain of even the relative chronological relationship between the maize described for each. Both races, however, appear to be derivable from the Chapalote maize occurring even earlier in the Southwest.

East of the Rocky Mountains, the earliest dated occurrence of something resembling Maíz de Ocho is at the Davis Site in eastern Texas, as described by Jones (1949). We borrowed samples of charred cobs taken from this site and concluded that they might have been from a small-eared type of Maíz de Ocho because of their eight-rowed condition and wide, glabrous cupules; but positive identification as such cannot be made. There is a possibility that they may be of a different origin. For example, specimens resembling these and derived from mixtures of early Nal Tel and Chapalote come from El Riego Cave, excavated by R. S. MacNeish in the state of Puebla (unpub.). Archaeological Nal Tel, which is eight-rowed with wide but hairy cupules and dated at about 4445 years ago, comes from much nearer Texas in the state of Tamaulipas in northeastern Mexico (Mangelsdorf *et al.*, 1956).

The Davis site maize was originally dated by radiocarbon, using the "carbon black" method, at A.D. 398 ±175 (Johnson, 1951). More recently, the University of Michigan laboratory arrived at a date of A.D. 1307 ±150 for this site, a date which is more in accord with archaeological evidence, although it is somewhat later than expected (Griffin and Yarnell, 1963). The actual age for the site may lie between these two dates; perhaps a conservative guess would put it at ca. A.D. 800–1000. In any case, the date would not be too early to preclude Maíz de Ocho from having spread to the Davis Site from northern Mexico via the Southwest, the interpretation most compatible with the available data. This spread could very easily be an extension of the ca. A.D. 700–1100 dispersal of Maíz de Ocho in the Southwest, but without Pueblo culture accompanying the maize to eastern Texas.

At about A.D. 1000, the first sedentary horticultural complexes appear, apparently full blown, in the Central Plains, extending as far north as northern Nebraska. The best known of these cultures are the Upper Republican Aspect of central and western Nebraska and western Kansas, the Nebraska Culture of eastern Nebraska and northeastern Kansas, and the Smoky Hill Aspect of central Kansas. These three complexes, which together form the Central Plains phase or tradition, persisted until sometime between ca. A.D. 1450 and 1550, ending probably earlier in the west and later in the east. South of the Central Plains phase, and at least partly contemporaneous with it, are similar and perhaps related complexes such as the Antelope Creek Focus of the Texas Panhandle and the Washita and Custer foci of Oklahoma. Wedel (1959: 628) states, "The origins of the Central Plains tradition remain to be worked out. That it is basically of eastern or southeastern derivation seems clear. The square earth lodge is well known from prehistoric cultures farther south, in eastern Oklahoma and Arkansas; and as we have seen, there is direct evidence of contacts between Smoky Hill valley sites and the lower Arkansas valley. More accurate determination of chronology in the two areas is needed before we can be certain of the significance of the contacts."

It is specifically with the Arkansas River area that Southwestern cultures apparently had contacts in the lower Mississippi drainage at about A.D. 700 (Jennings, ed., 1959: 84–86). With some sort of relationship already established between the Southwest and the Arkansas River area, it is reasonable to assume that Maíz de Ocho would have reached this area as soon as it did the Davis Site 275 miles straight south. The Arkansas River area, could, in fact, have served as a point from which Maíz de Ocho was dispersed north, south and east. The lack of Southwestern trade items at all of the numerous sites of the Central Plains phase, whereas such trade material is relatively abundant in later periods (Wedel, 1961), helps support the idea that Maíz de Ocho did not enter the Central Plains directly from the Southwest.

In the Central Plains, Kivett (1949, p. 280) reported maize cobs with six to twelve rows from Upper Republican sites in southwestern Nebraska. Our examination of charred cobs in the Peabody Museum Collection from Nebraska Culture sites in eastern Nebraska revealed a very strong Maíz de Ocho component with eight-rowed cobs present from about half of the sites.

Although the development from Upper Republican or Nebraska Culture through Lower Loup into Pawnee and Arikara, as suggested by Strong (1940, 382), has not been definitely established, it is generally thought probable; and no other equally plausible fate for the Upper Republican people or origin for the Pawnee and Arikara people has been advanced. In earliest historical times, Pawnee, along with the very closely related Arikara to the north and Wichita and Caddo to the south, formed a nearly solid Caddoan-speaking bloc extending from Texas into South Dakota. Much about the culture of these tribes relates them closely to the southeast. Thus, it seems probable that the Caddo Tribe of Texas remained near the Proto-Caddoan homeland, while the Wichita, Pawnee and Arikara moved north.

When these various lines of evidence are considered together, they suggest that the spread of maize in the Plains probably paralleled the spread of maize in central and northern Utah. The introduction of Maíz de Ocho into the part of the Southeast contiguous to the Southern Plains may have triggered a population expansion that resulted in a movement of people into the Central Plains, which had not been suited to the growing of the kinds of maize previously available. Furthermore, it seems very likely that Maíz de Ocho and the Central Plains tradition which it made possible were both carried by speakers of Caddoan languages. Because the western part of the Plains, especially, was environmentally precarious for the growing of maize, decreased rainfall in the 1400's probably caused a withdrawal of these prehistoric farmers to the northeast.

In spite of the great amount of archaeological salvage work done in the Missouri River Basin since about 1946, the dating of the beginnings of sedentary farming cultures in the Dakotas is not exactly known, but Wedel (1961) considers it later than the beginning of Upper Republican farther south. In central South Dakota, Lehmer (1954) and others recognize a blending of two traditions: one from the East and one from the Central Plains, of which Upper Republican is a classic example. The fact that this blending took place apparently well after the beginning of the Central Plains tradition helps support a southern or southwestern origin of maize in the Plains.

Later sites in the Plains, most of them dating from after ca. A.D. 1600, have yielded specimens of maize with a very significant percentage of eight-rowed cobs that are predominantly Maíz de Ocho. At some sites, the maize is entirely eight-rowed. Farther east, across the northern United States, Brown and Anderson (1947) showed the same pattern, with a general tendency for the percentage of eight-rowed specimens to be higher in the extreme north. Furthermore, all the sites across the northern United States from which specimens of maize have been collected are apparently of a date later than ca. A.D. 1000 (Brown and Anderson, 1947). As the area of maize cultivation expanded north, natural selection would have played a very important part in filtering out Maiz de Ocho germplasm in the form of the Northern Flint, which was the sole historic Indian maize from the Dakotas across the northern United States to the Atlantic Ocean.

In any case, the introduction of Maíz de Ocho into what is now the United States probably did more to change the way of life of more of its people in a short time than did any other single prehistoric innovation.

Furthermore, if additional archaeological and botanical work bears out the reconstruction of the history of Maíz de Ocho here outlined, and we think that it may, the solution of many local archaeological problems will be greatly facilitated, and an understanding of the original source of Northern Flint germplasm should advance the field of hybrid maize breeding.

ACKNOWLEDGMENTS

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Table I. Distribution of eight-rowed archaeological maize. Only specimens which show clear evidence of Maíz de Ocho are included in the percentages from collections which we examined. Collections containing fewer than five specimens are marked (*). Few of the sites have been precisely dated so most of the dates must be considered close approximations.

State and (County)	*Site and (Cultural Affiliation)*	*Date A.D.*	*% 8 Row*	*Reference*
CHIHUAHUA	Waterfall Cave	1100–1600	36	Cutler (1960)
	Swallow Cave, Level I	ca.900	33	Mangelsdorf & Lister (1956)
	Swallow Cave, Level II	ca.1000	17	Mangelsdorf & Lister (1956)
ARIZONA				
Pima	Reeve Ruin (Western Pueblo)	1250–1550	66	Cutler *in:* DiPeso (1958)
Gila	Richards Cave (Sinagua)	1100–1200	29	Galinat *et al.* (1956)
Navajo	Painted Cave (Kayenta Anasazi)	1247	20	Haury (1945)
Apache	Cave 8 (Kayenta Anasazi)	800–1200		Guernsey & Kidder (1921)
?	Antelope Cave	1000–1150	12	Cutler & Bower *in:* Adams *et al.* (1961)
NEW MEXICO				
Grant	Cave, Mouth of Shelley Canyon (Mogollon)	700–1200	33*	Peabody Mus. Cat. 97439 & Cosgrove (1947)
Catron	Kelly Cave (Mogollon)	700–1200	59	Peabody Mus. Cat. A7251 & Cosgrove (1947)
Catron	Tularosa Cave, Level 4	700–	62	Cutler (1952)
	(Mogollon) Level 3		73	
	Level 2		63	
	Level 1	1200	67	
UTAH				
San Juan	NA6456 (Anasazi)	1100–1300	24	Cutler & Bower *in:* Adams *et al.* (1961)
San Juan	NA3732 (Anasazi)	1150–1200	33	Cutler & Bower *in:* Adams *et al.* (1961)
San Juan	NA6813 (Anasazi)	?	29	Cutler & Bower *in:* Adams *et al.* (1961)
Wayne	Morss 21 (Fremont)	950–1200	50*	Peabody Mus. Cat. A6466 & Morss (1931)
Wayne	Morss 37 (Fremont)	950–1200	100*	Peabody Mus. Cat. A6819 & Morss (1931)
Wayne	FL 12–4 (Fremont)	950–1200	25*	Peabody Mus. Cat. 33–2–10–196, Gunnerson, (n.d. b)
Sevier	Old Woman (Fremont)	950–1200	?	Taylor (1957)

TABLE I (*cont.*)

Sevier	Snake Rock (Fremont)	950–1200	10	Gunnerson (n.d. a)
Grand	Turner-Look (Fremont)	950–1200	?	Nickerson *in:* Wormington (1955)
Uintah	ET 6-3 (Fremont)	950–1200	3	Peabody Mus. Cat. A7612 & Gunnerson (n.d. b)
Carbon	PR 4–27 (Fremont)	950–1200	33	Peabody Mus. Cat. A7984 & Gunnerson (n.d. b)
Uintah	A 6-1 (Fremont)	950–1200	7	Peabody Mus. Cat. A7944, A7945 & Gunnerson (n.d. b)
Grand	Luster Cave	900–1000	33	Nickerson & Hou *in:* Wormington & Lister (1956)
TEXAS				
Cherokee	Davis Site	ca.800–1000	?	Jones (1949)
KANSAS				
Rice	Tobias Site	ca.1550	20	Brown & Anderson (1947)
Doniphan	Doniphan Site	ca.1750	29	Brown & Anderson (1947)
Doniphan	Fanning Site (Oneota)	ca.1700–	50*	Brown & Anderson (1947)
MISSOURI				
Platte	Steed Kisker	1600–1800	40	Brown & Anderson (1947)
McDonald	Jane	?	?	Brown & Anderson (1947)
NEBRASKA				
Knox	Ponca Fort	1800	100	Brown & Anderson (1947)
Boyd	Lynch	ca.1500	40	Brown & Anderson (1947)
Douglas	A-3 (Nebraska Culture)	1100–1550	27	Peabody Mus. Cat. 82528
Douglas	Debelka C (Nebraska Culture)	1100–1550	39	Peabody Mus. Cat. 90409
Douglas	Wright Place (Nebraska Culture)	1100–1550	65	Peabody Mus. Cat. 90579
Frontier	Medicine Creek, Misc. (Upper Republican)	1000–1550	?	Kivett (1949; 280)
SOUTH DAKOTA				
Stanley	Phillips Ranch (Snake Butte Focus)	1750–1800	100	Lehmer (1954)
Stanley	Dodd Site (Stanley Focus)	1700–1750	100	Lehmer (1954)
?	Elk Creek (Historic Arikara)	ca.1800	100	Brown & Anderson (1947)
Corson	Leavenworth (Historic Arikara)	ca.1800	100	Brown & Anderson (1947)

Table I (*cont.*)

Corson	Rygh	1750–1800	25*	Brown & Anderson (1947)
ILLINOIS				
Madison	Cahokia Mound			Bareis, personal communication
MICHIGAN				
Wayne	Gibralter		100*	Brown & Anderson (1947)
OHIO				
Lancaster	Kettle Hill		78	Brown & Anderson (1947)
Lancaster	Baldwin		100*	Brown & Anderson (1947)
?	Gartner Village (Fort Ancient)	ca.1500	100*	Brown & Anderson (1947)
?	Fuert (Fort Ancient)	ca.1500	33	Brown & Anderson (1947)
?	Baum	ca.1350	100*	Brown & Anderson (1947)
?	Madisonville Mound	1600–1700	71	Brown & Anderson (1947)
NEW YORK				
Sackett	Sackett Co. (Owasco)	ca.1000	91	Brown & Anderson (1947)
?	Silver Wheels (Iroquois)	ca.1500	50*	Brown & Anderson (1947)
SOUTH CAROLINA				
Kershaw	McDowell Mound		40	Brown & Anderson (1947)
GEORGIA				
Columbia	Stallings Mound	probably after 1600	50	Brown & Anderson (1947) and Claflin (1939)
ALABAMA				
?	Guntersville Basin TVA		25	Brown & Anderson (1947)
Houston	Seaborn Mound (Fort Walton)	ca.1400	67	Neumann (1961)
KENTUCKY				
?	Kings Mound		20	Brown & Anderson (1947)

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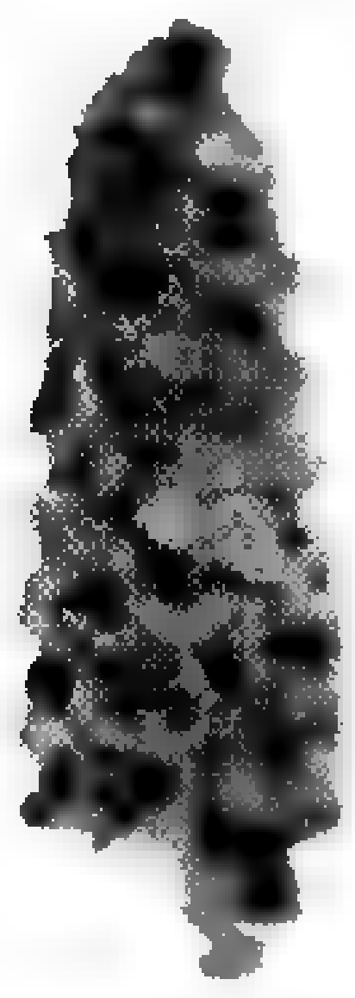
ILLUSTRATIONS

EXPLANATION OF THE ILLUSTRATION

PLATE XX. Eight-rowed cobs from various sites in the Southwest. Figs. 1–4 are probably just tripsacoid Chapalote types, as is reflected in their slender rachis, tapered butt, narrow cupules and indurated upcurved glumes. Figs. 5–12 represent the new eight-rowed race, Maiz de Ocho, as is reflected in their thick straight rachis, swollen butt and wide cupules.

Fig. No.	*Cultural Affiliation and Date A.D.*	*Provenience and Reference*	*Peabody Museum Catalogue No.*
1	Fremont (950–1200)	Site PR 3–31. 30 mi. NW of Price, Utah. Gunnerson (n.d. b)	A7800
2	Fremont (950–1200)	Site PR 3–31. 30 mi. NW of Price, Utah. Gunnerson (n.d. b)	PR 4–31
3	Fremont (950–1200)	Site PR 3–31. 30 mi. NW of Price, Utah. Gunnerson (n.d. b)	A7761
4	Fremont (950–1200)	Site PR 3–31. 30 mi. NW of Price, Utah. Gunnerson (n.d. b)	A7800
5	Fremont (950–1200)	Site ET 6–3. 60 mi. S of Vernal, Utah. Gunnerson (n.d. b)	A7612
6	Fremont (950–1200)	Site A 6–1. 6 mi. NW of Vernal, Utah. Gunnerson (n.d. b)	A7945
7	Fremont (950–1200)	Site PR 4–27. 30 mi. NW of Price, Utah. Gunnerson (n.d. b)	A7984
8	Fremont (950–1200)	Site PR 4–27. 30 mi. NW of Price, Utah. Gunnerson (n.d. b)	A7984
9	Kayenta Anasazi (700–1250)	Cave 8. NW of Kayenta, Arizona. Guernsey and Kidder (1921 : 34)	A3520
10	Fremont (950–1200)	Site FL 12–4, 8 mi. E of Fruita, Utah. Gunnerson (n.d. b)	10/196
11	Fremont (950–1200)	Site 21. 15 mi. S of Fruita, Utah. Morss (1931 : 11–12)	A6466
12	Fremont (950–1200)	Site 37. 11 mi. N of Fruita, Utah. Morss (1931 : 27)	A6819

PLATE XX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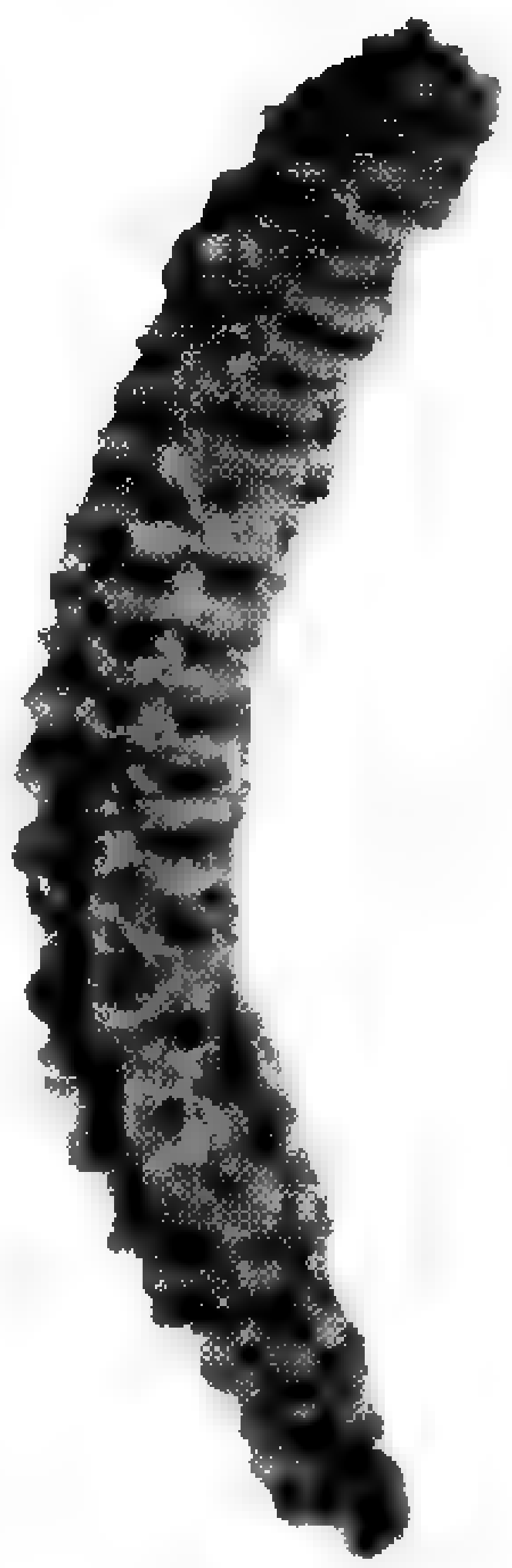
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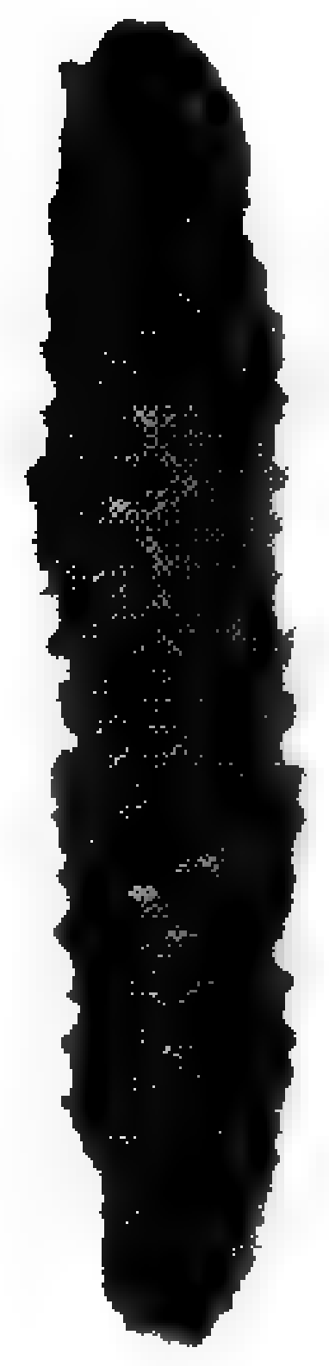
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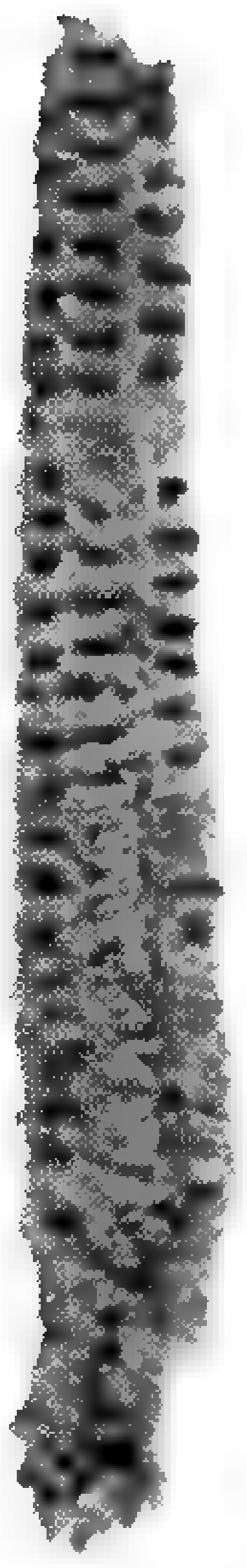
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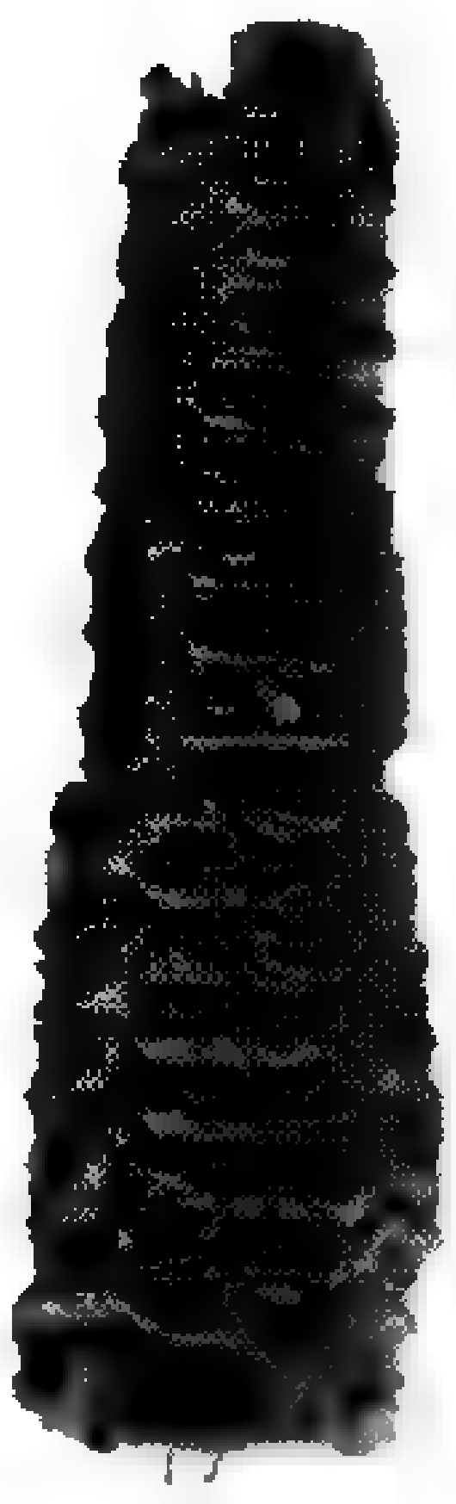
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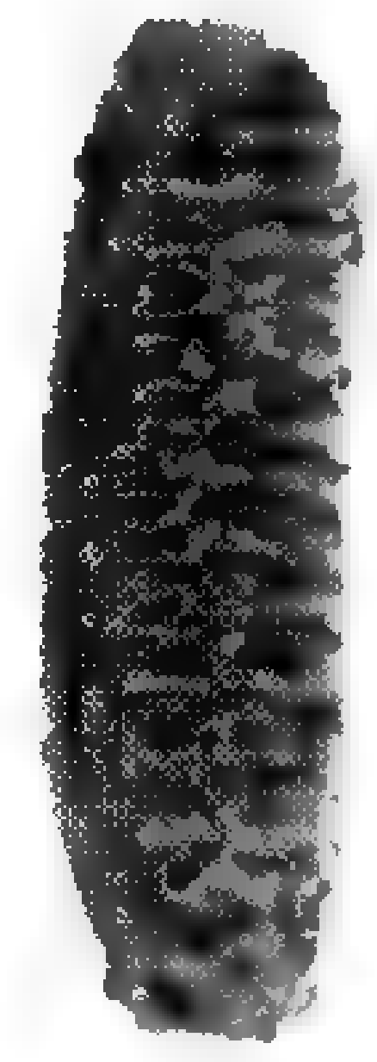
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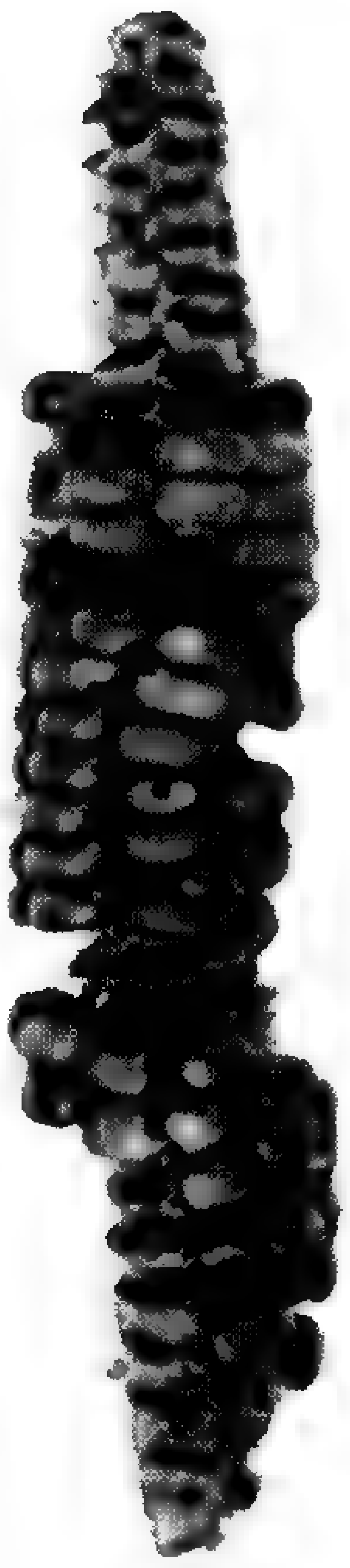
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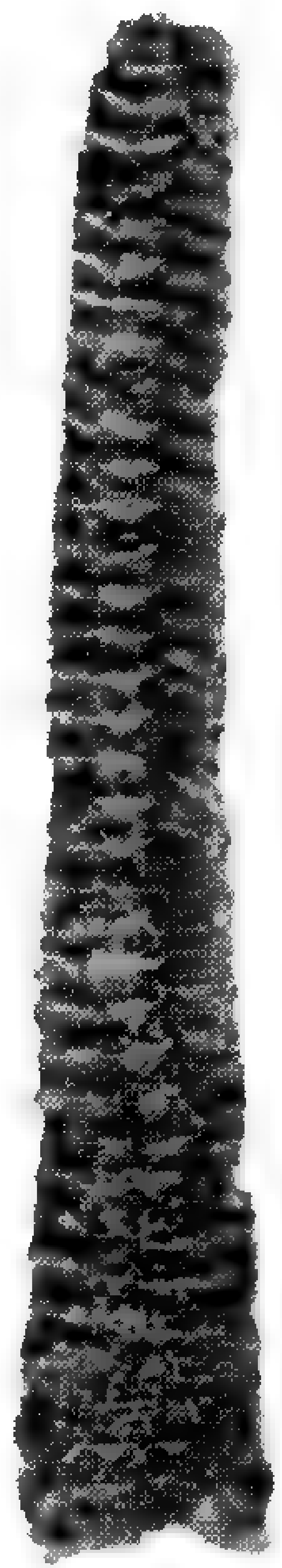
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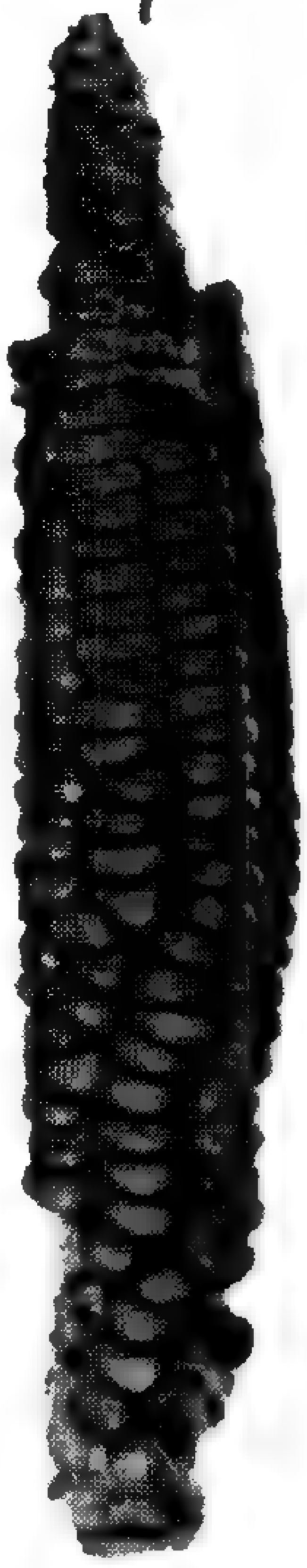
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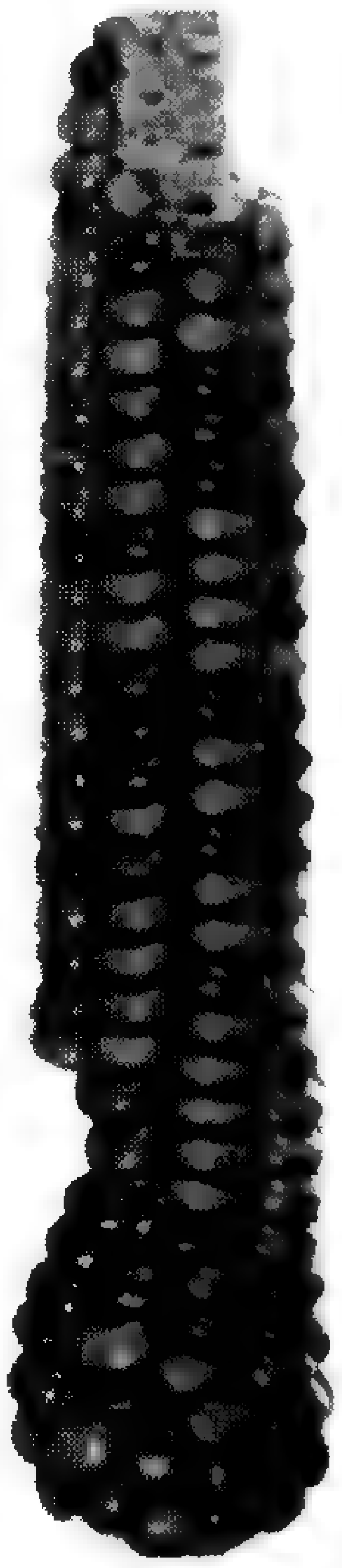
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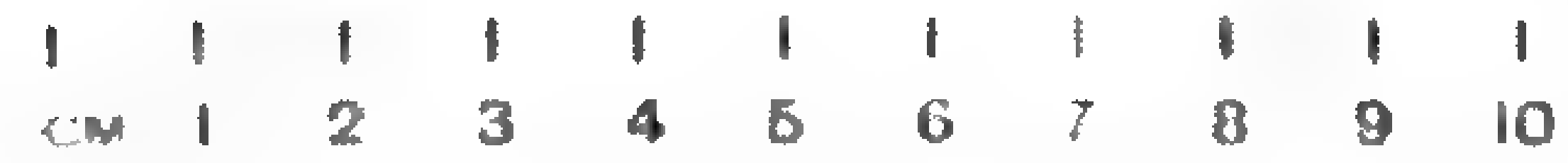
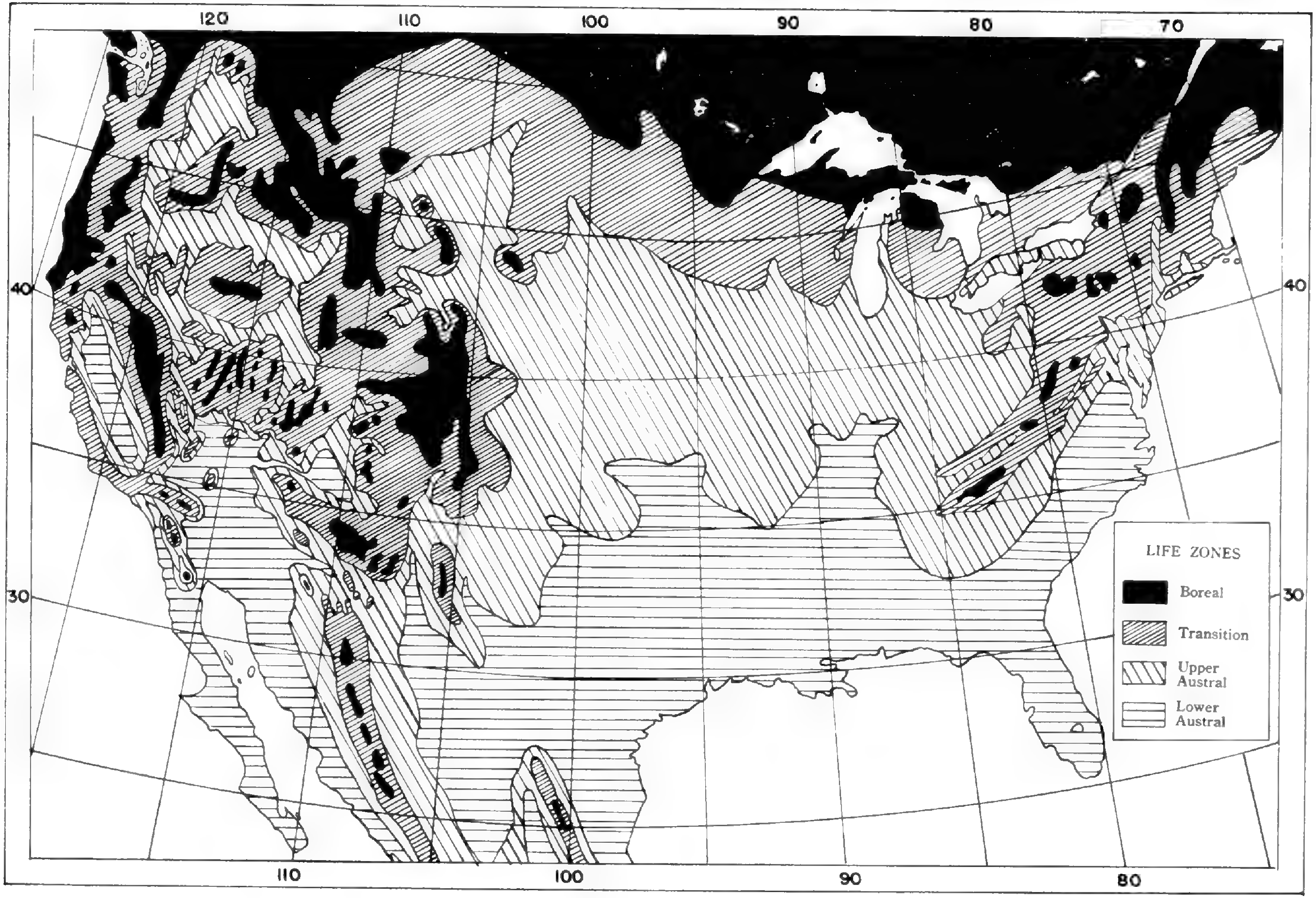
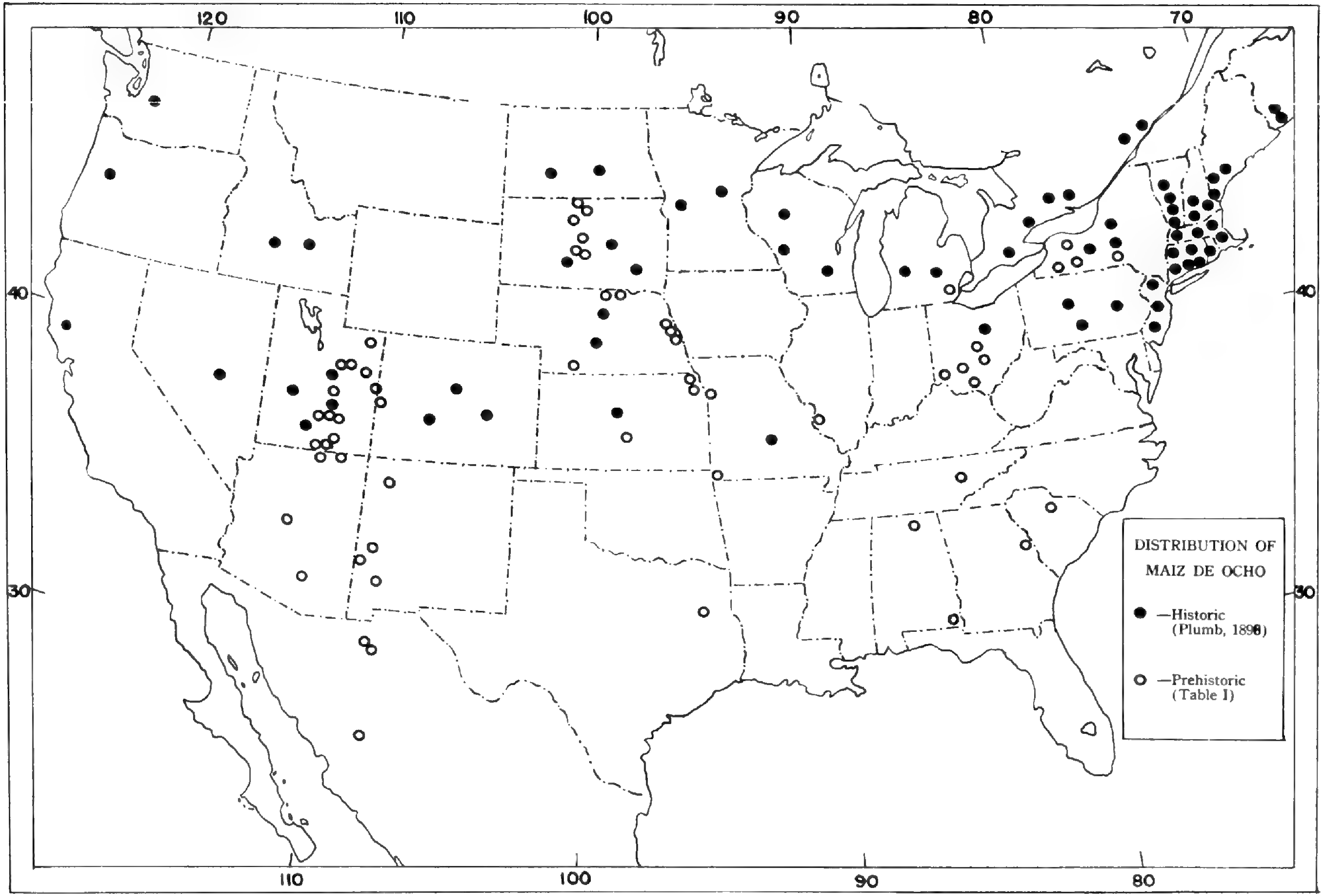


PLATE XXI



Adapted with modifications from Plumb (1898)

PLATE XXII


120
110
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70
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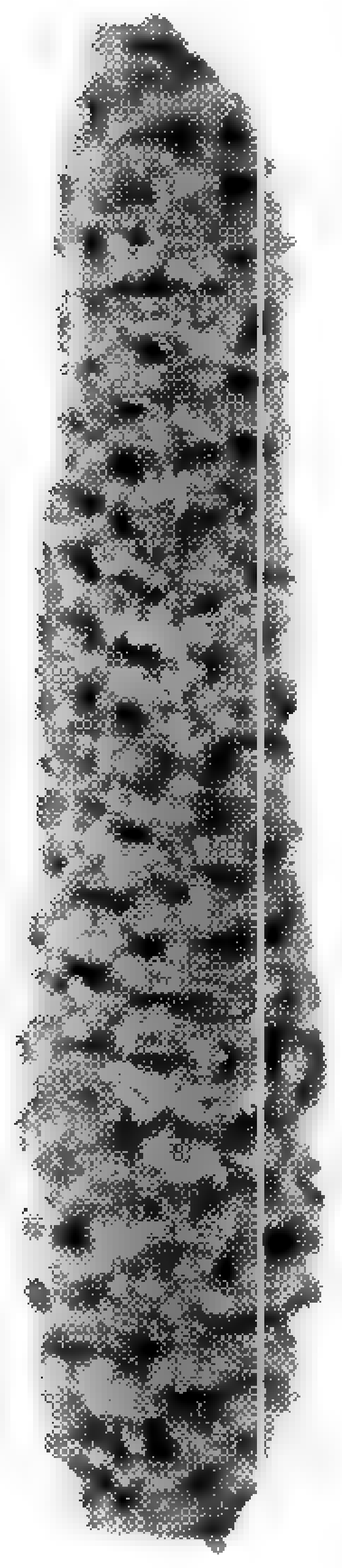
80
DISTRIBUTION OF MAIZ DE OCHO
● —Historic (Plumb, 1898)
○ —Prehistoric (Table I)

EXPLANATION OF THE ILLUSTRATION

Plate XXIII. Variation in cobs from sites in southwestern New Mexico after the introduction of Maíz de Ocho. Some of the representative Chapalote types (figs. 1–3) remain together with highly tripsacoid forms of Chapalote (figs. 4–6) as well as nearly pure types of the Maíz de Ocho (figs. 7–9) and their most productive hybrid products which approach the best ears of modern Pueblo (figs. 10–12).

Fig. No.	*Cultural Affiliation and Date A.D.*	*Provenience and Reference*	*Peabody Museum Catalogue No.*
1	Mogollon (?–1200)	Cave 7, 26 mi. NE of El Paso, N.M. Cosgrove (1947 : 38)	96848
2	Mogollon (?–1200)	Cave 7, 26. mi. NE of El Paso, N.M. Cosgrove (1947 : 38)	96848
3	Mogollon (?–1200)	Cave 7, 26 mi. NE of El Paso, N.M. Cosgrove (1947 : 38)	96848
4	Mogollon (?–1200)	Kelly Cave, 10 mi. N of Alma, N.M. Cosgrove (1947 : 25–26)	A7251
5	Mogollon (?–1200)	Cave 2, W. Fork of Gila R. 20 mi. E of Alma, N.M. Cosgrove (1947 : 22)	96959
6	Mogollon (?–1200)	Cave 1, Middle Fork, Gila R. 25 mi. E of Alma, N.M. Cosgrove (1947 : 20)	79010
7	Mogollon (?–1200)	Near mouth of Shelley Canyon, 25 mi. SE of Alma, N.M. Cosgrove (1947)	97439
8	Mogollon (?–1200)	Kelly Cave, 10 mi. N of Alma, N.M. Cosgrove (1947 : 25–26)	A7251
9	Mogollon (?–1200)	Kelly Cave, 10 mi. N of Alma, N.M. Cosgrove (1947 : 25–26)	A7351
10	Mogollon (?–1200)	Steamboat Cave, 30 mi. SE of Alma, N.M. Cosgrove (1947 : 10–13)	97143
11	Mogollon (?–1200)	Steamboat Cave, 30 mi. SE of Alma, N.M. Cosgrove (1947 : 10–13)	97143
12	Mogollon (?–1200)	Steamboat Cave, 30 mi. SE of Alma, N.M. Cosgrove (1947 : 10–13)	97143

PLATE XXIII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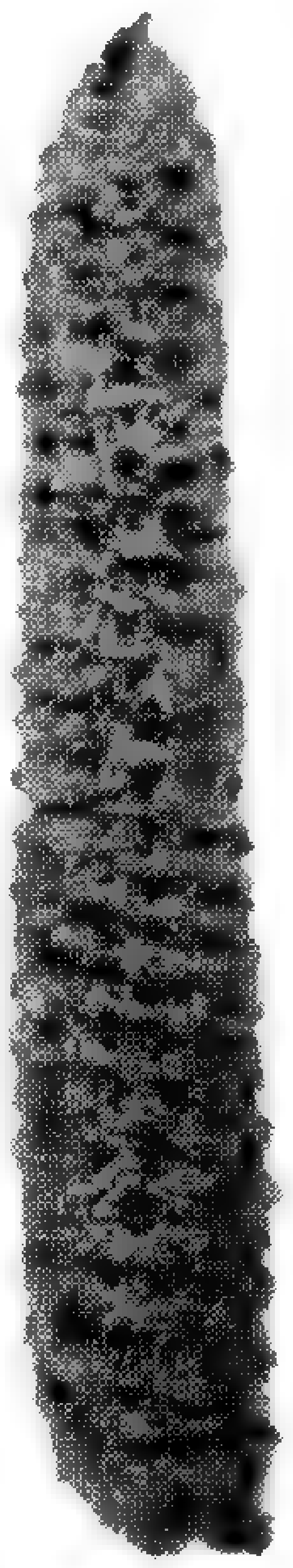
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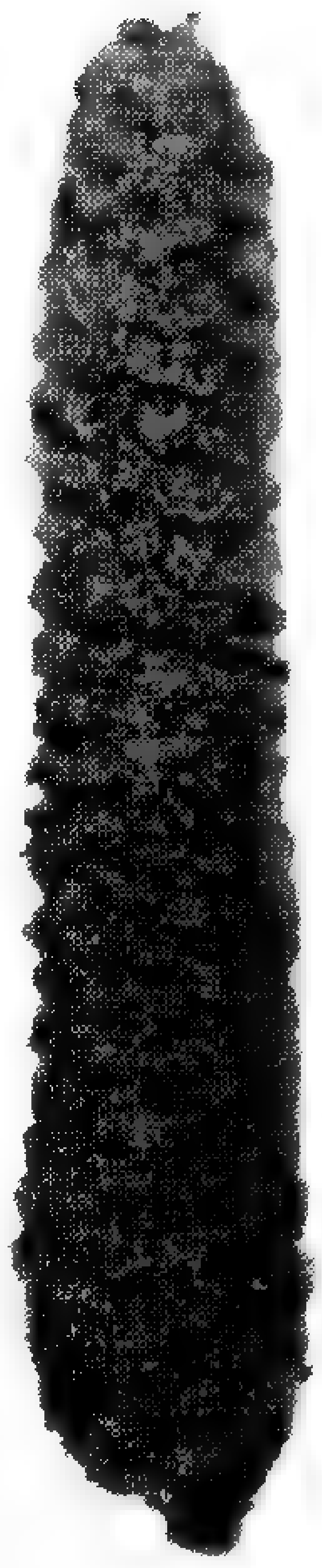
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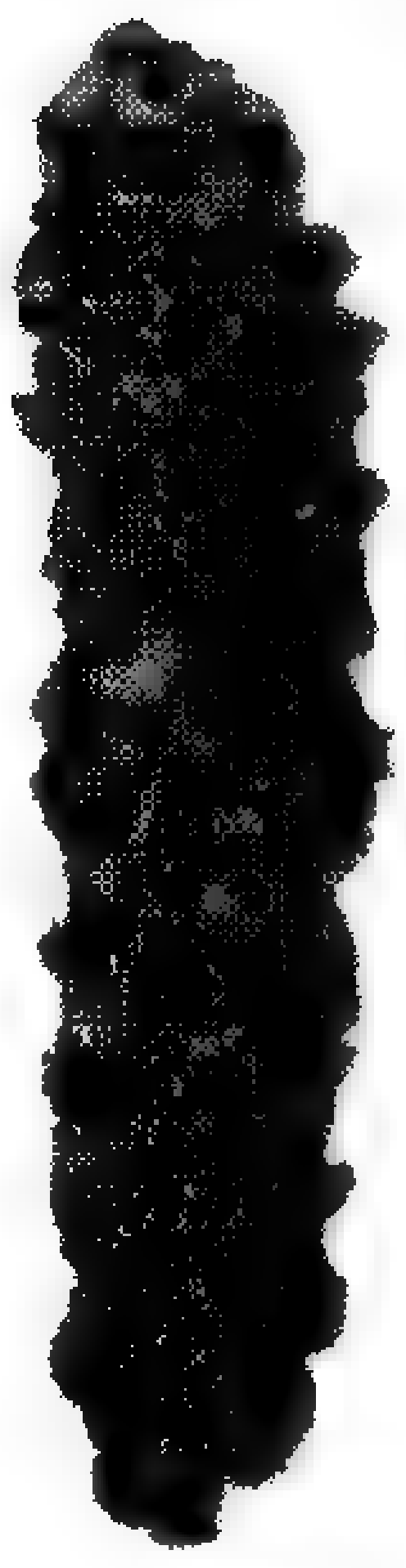
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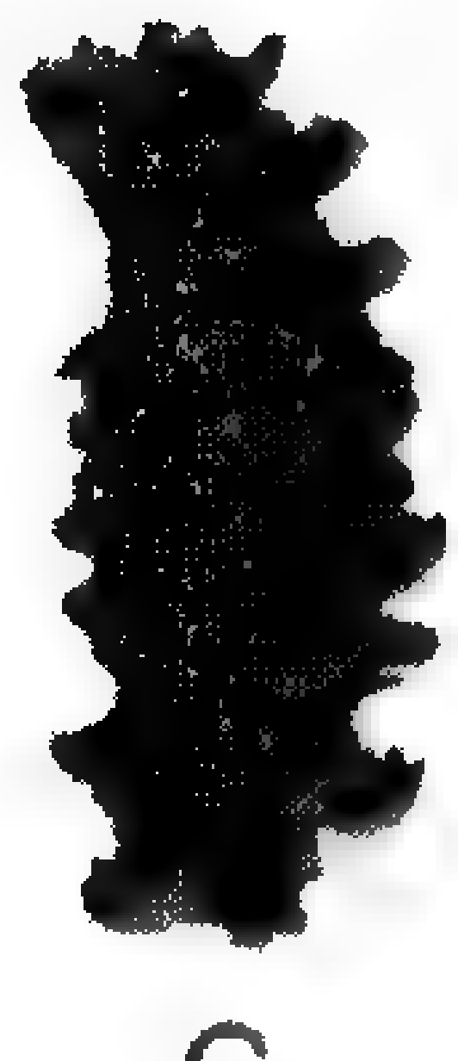
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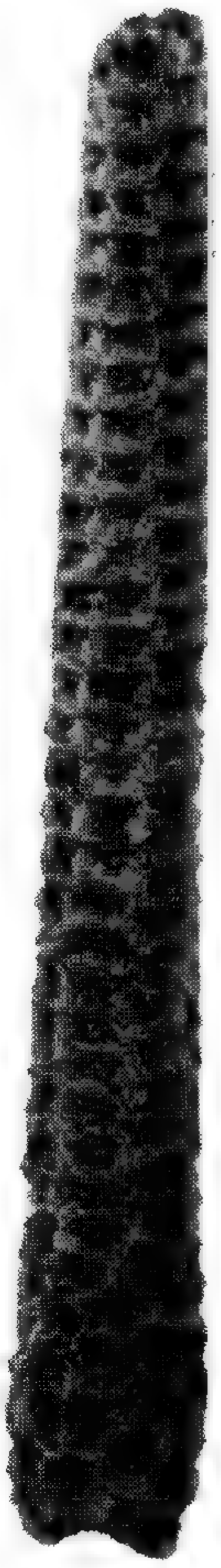
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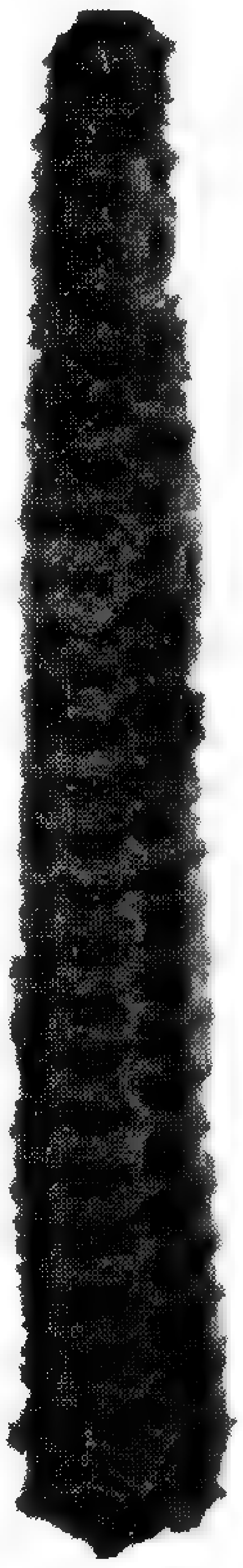
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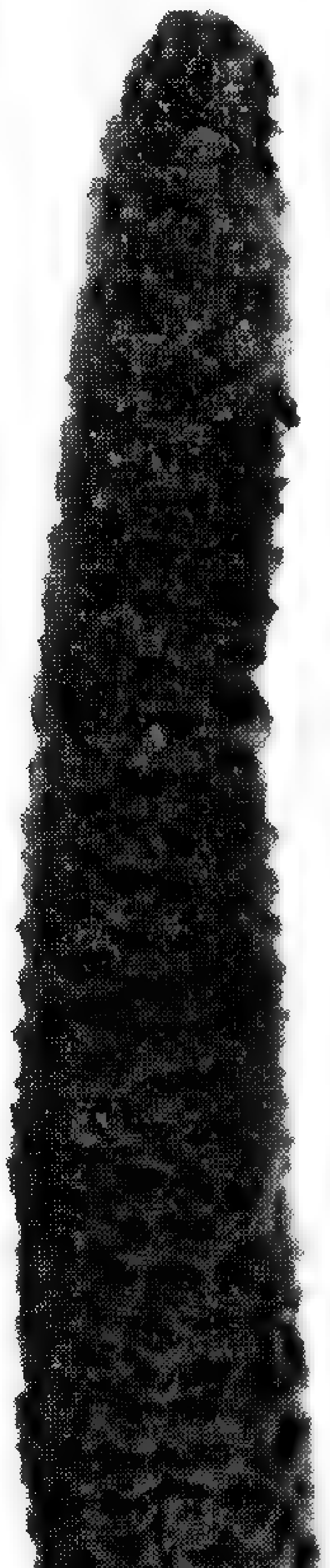
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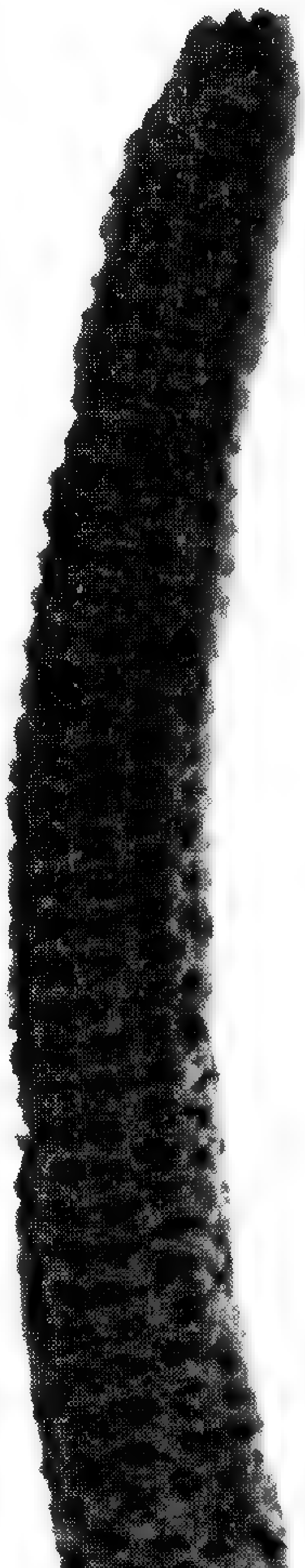
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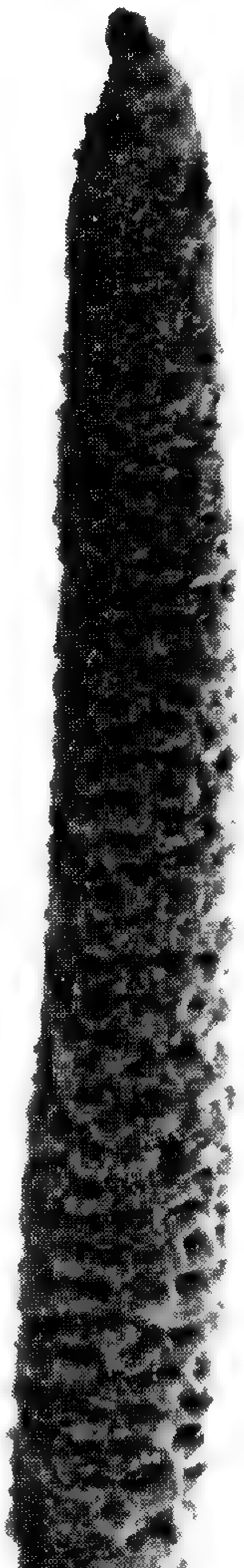
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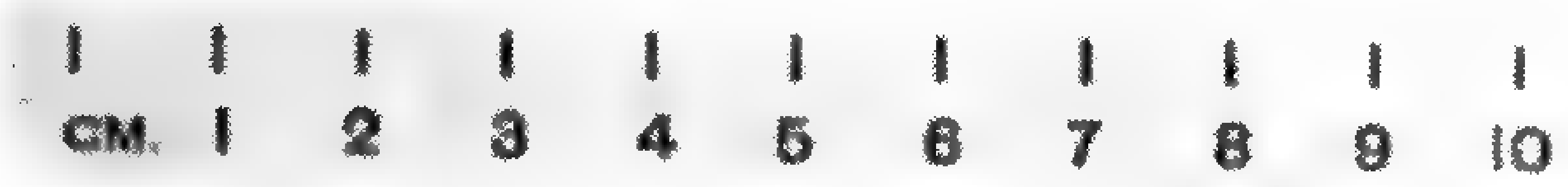
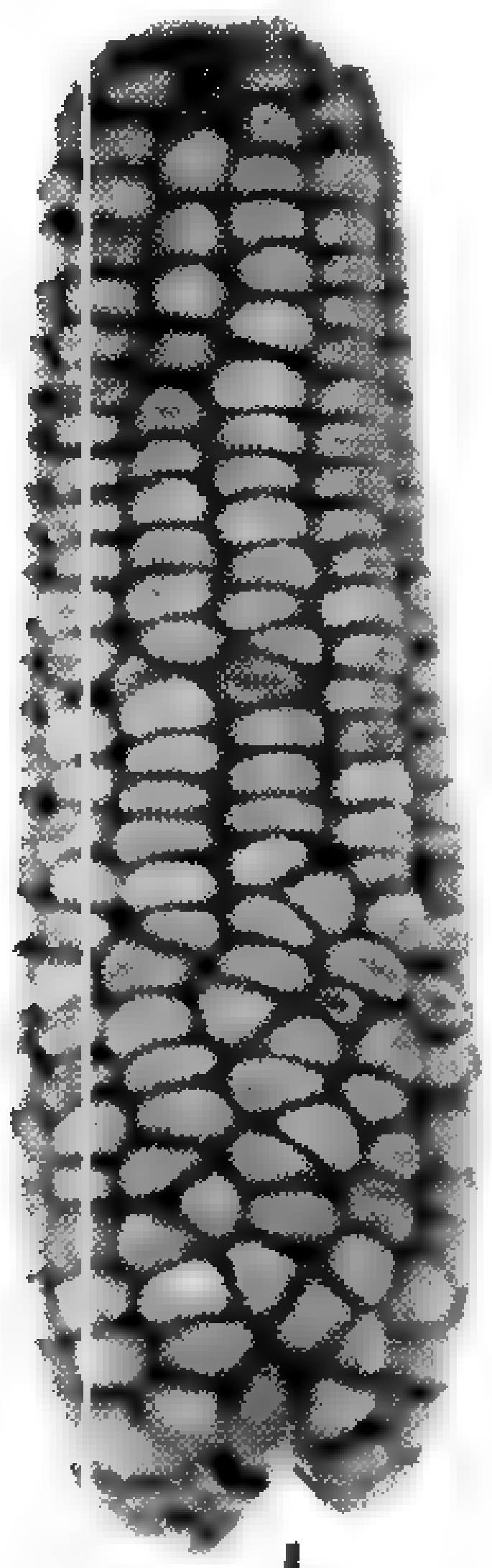


EXPLANATION OF THE ILLUSTRATION

Plate XXIV. Prehistoric dent maize from various sites in the Fremont area of Utah. Fig. 4, which is from the southeast corner of this area, is slightly older than the other specimens and is essentially a dented form of Chapalote. The rest of the specimens involve Maíz de Ocho as well as Chapalote and teosinte in their origin.

Fig. No.	*Cultural Affiliation and Date A.D.*	*Provenience and Reference*	*Peabody Museum Catalogue No.*
1	Fremont (950–1200)	Site 21. 15 mi. S of Fruita, Utah. Morss (1931: 11–12)	A6466
2	Fremont (950–1200)	Site PR 4–31. 30 mi. NW of Price, Utah. Gunnerson (n.d. b)	A7769
3	Fremont (950–1200)	Site A 6–1. 6 mi. NW of Vernal, Utah. Gunnerson (n.d. b)	A7944
4	Basketmaker (200–700)	Site SR 16–6. 35 mi. SE of Hanksville, Utah. Gunnerson (n.d. b)	10/264
5	Fremont (950–1200)	Site 19. 15 mi. S of Fruita, Utah. Morss (1931: 10–11)	A6478
6	Fremont (950–1200)	Site 19. 15 mi. S of Fruita, Utah. Morss (1931: 10–11)	A6478
7	Fremont (950–1200)	Site 19. 15 mi. S of Fruita, Utah. Morss (1931: 10–11)	A6520
8	Fremont (950–1200)	Site PR 4–28. 30 mi. NW of Price, Utah. Gunnerson (n.d. b)	A7736
9	Fremont (950–1200)	Site A 6–1. 6 mi. NW of Vernal, Utah. Gunnerson (n.d. b)	A7936
10	Fremont (950–1200)	Site A 6–1. 6 mi. NW of Vernal, Utah. Gunnerson (n.d. b)	A7944
11	Fremont (950–1200)	Site A 6–1. 6 mi. NW of Vernal, Utah. Gunnerson (n.d. b)	A7944
12	Fremont (950–1200)	Site A 6–1. 6 mi. NW of Vernal, Utah. Gunnerson (n.d. b)	A7944

Plate XXIV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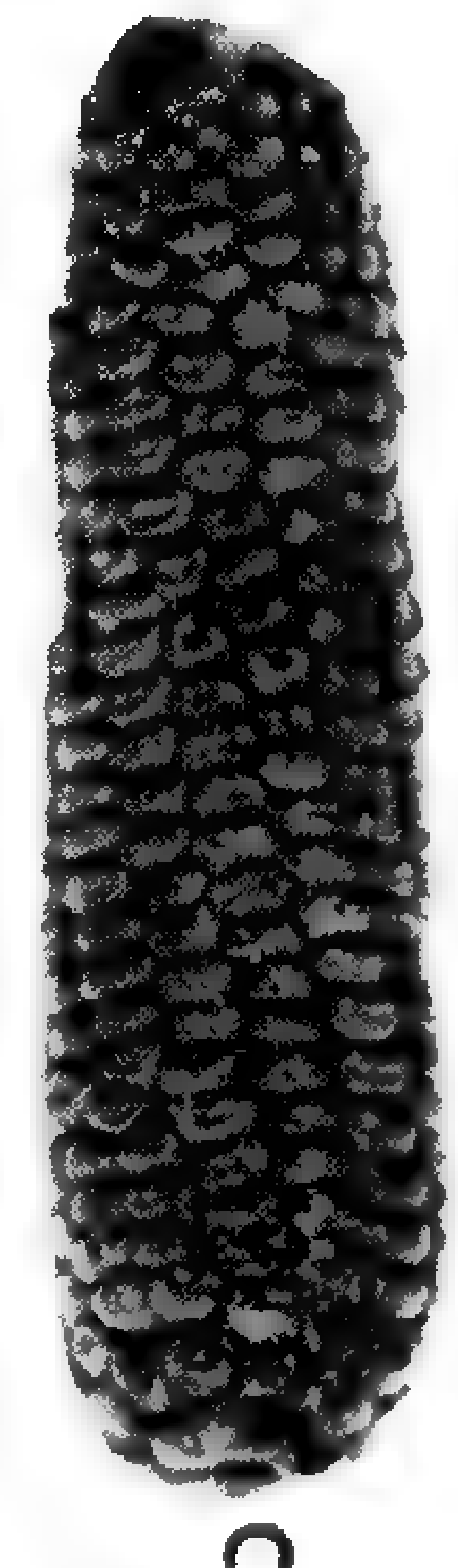
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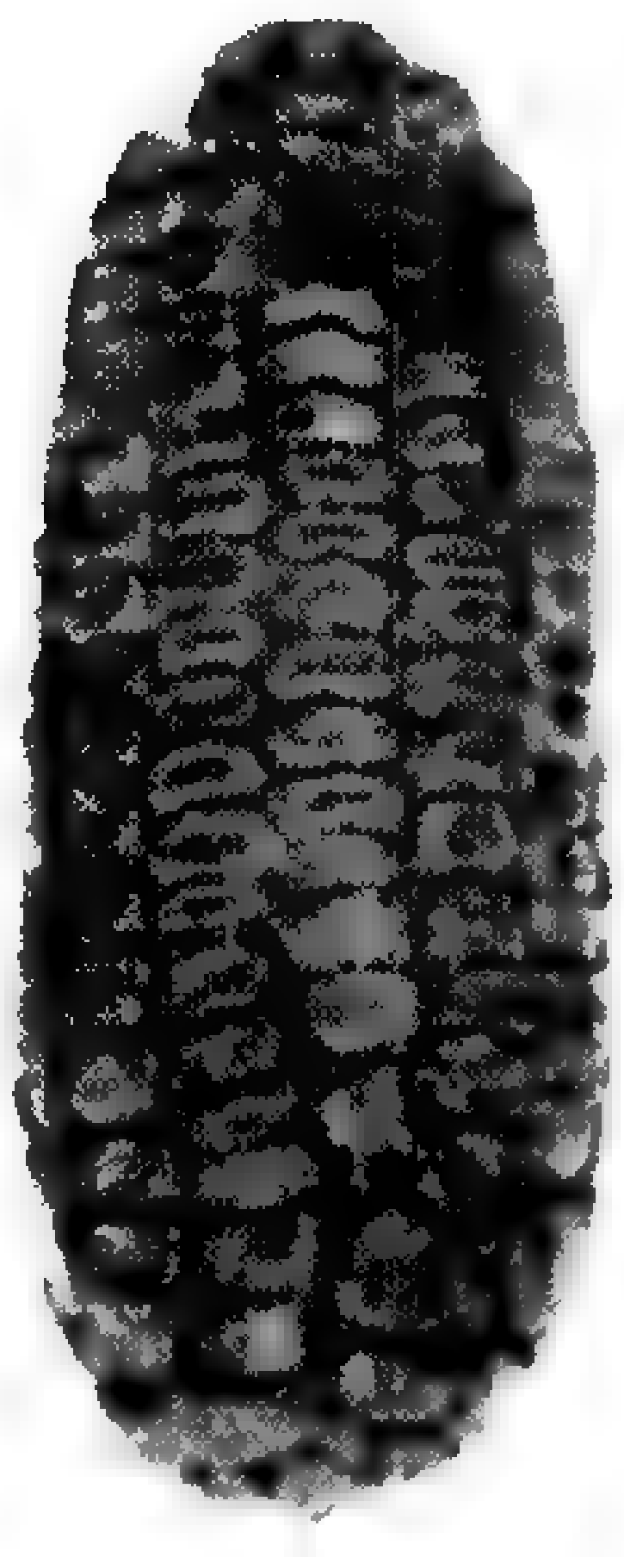
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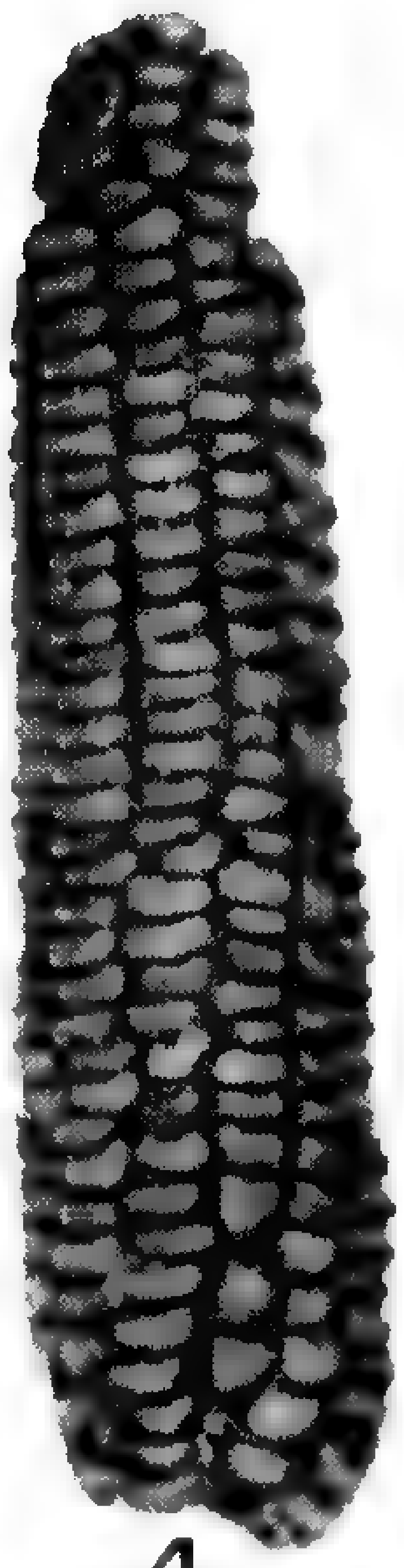
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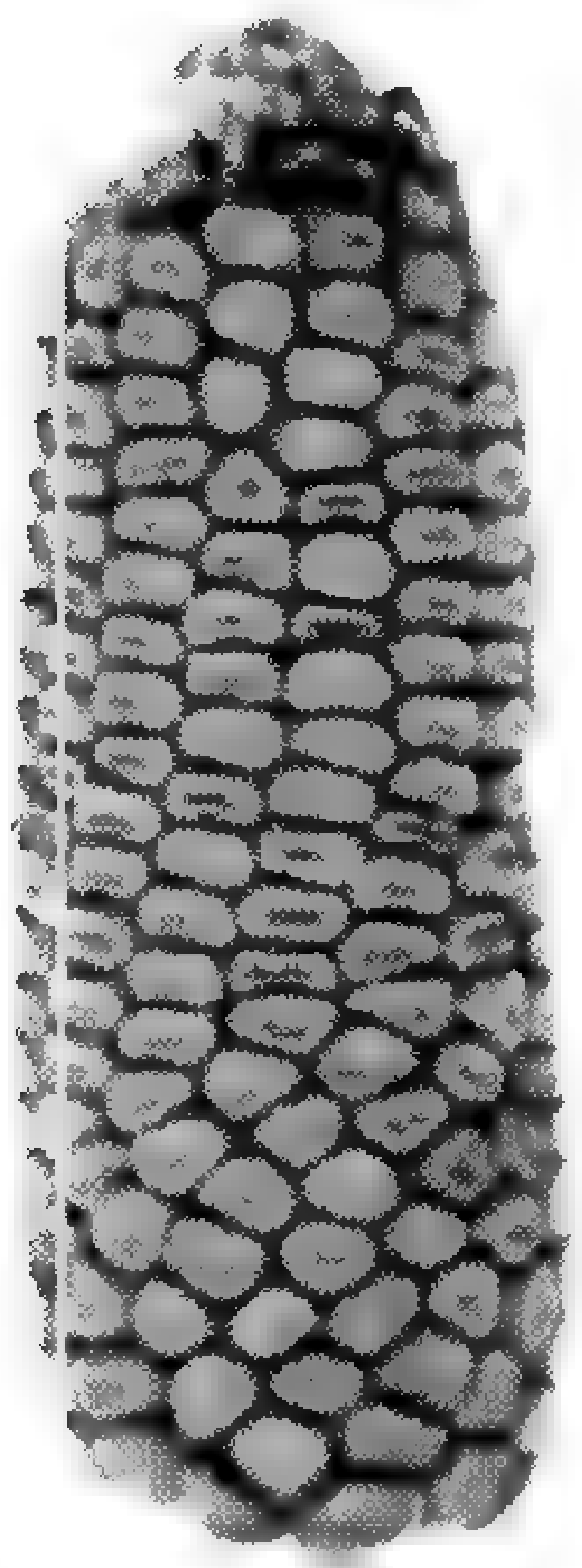
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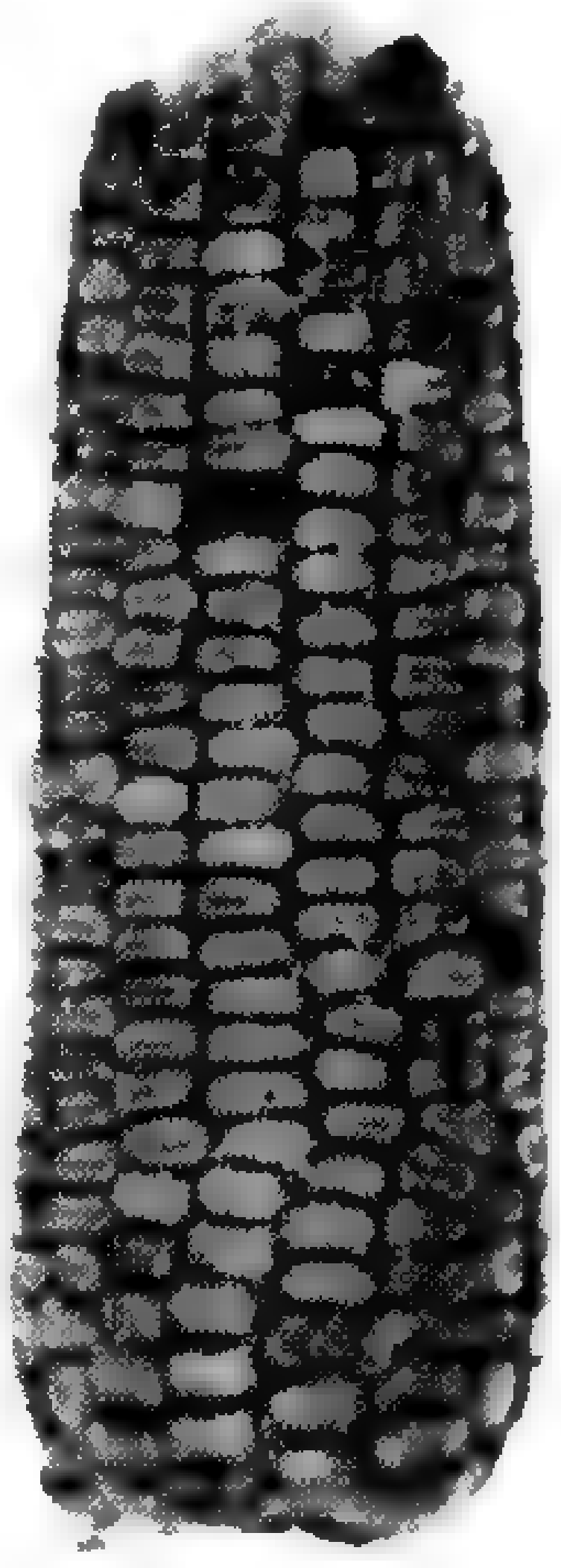
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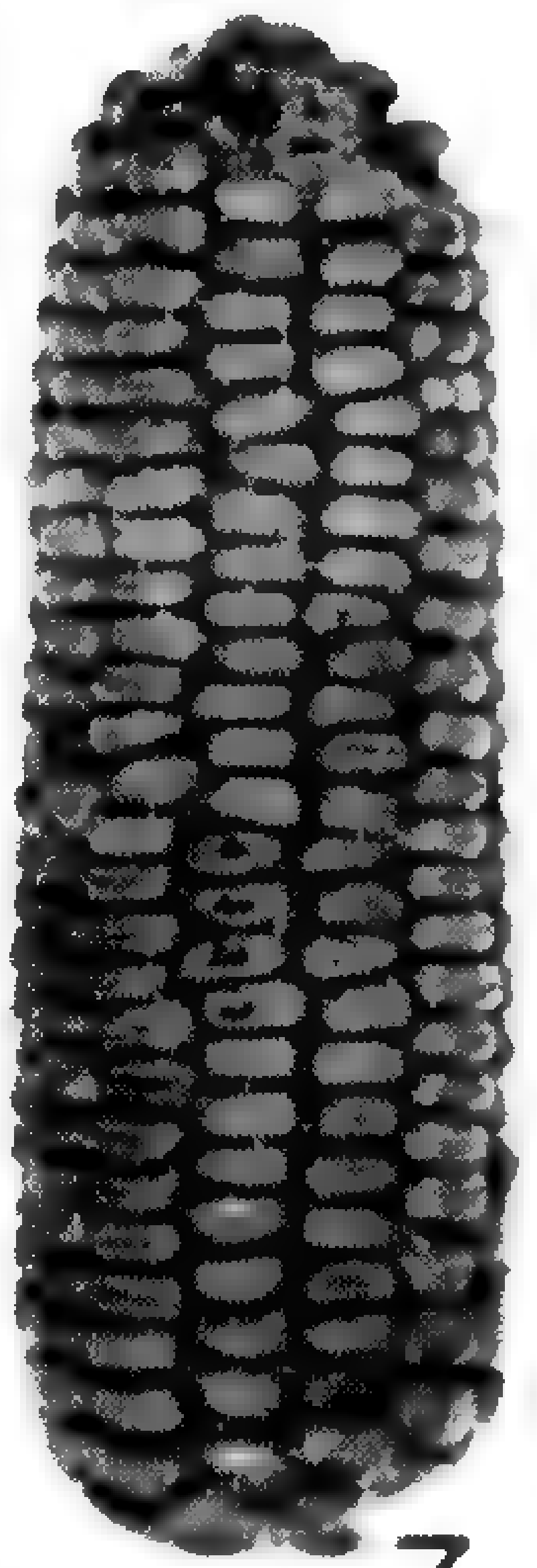
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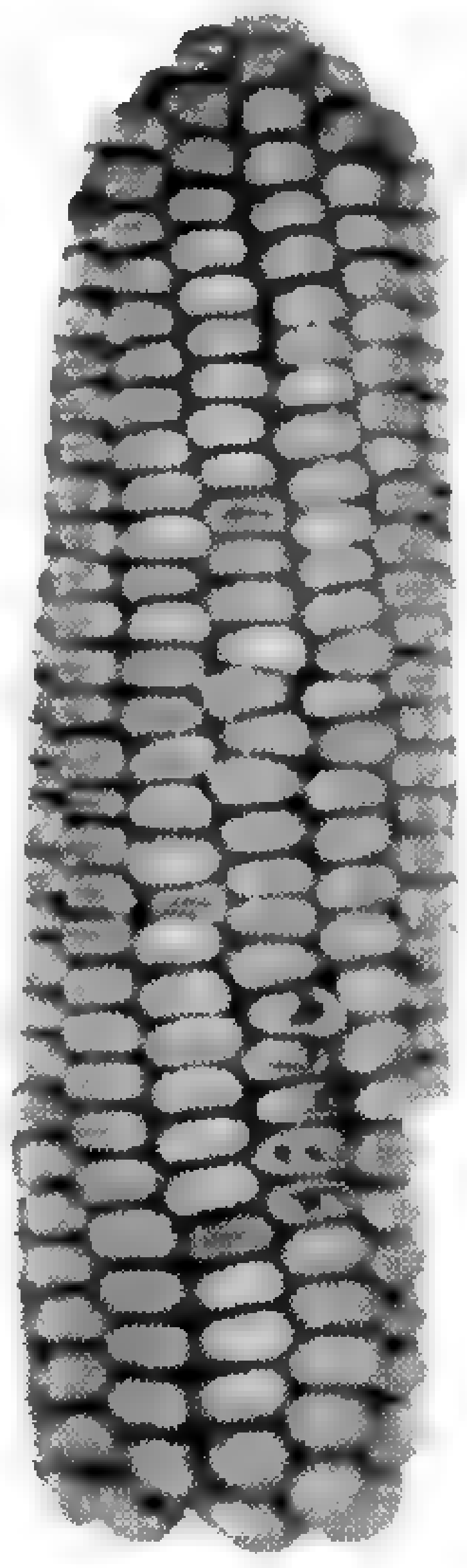
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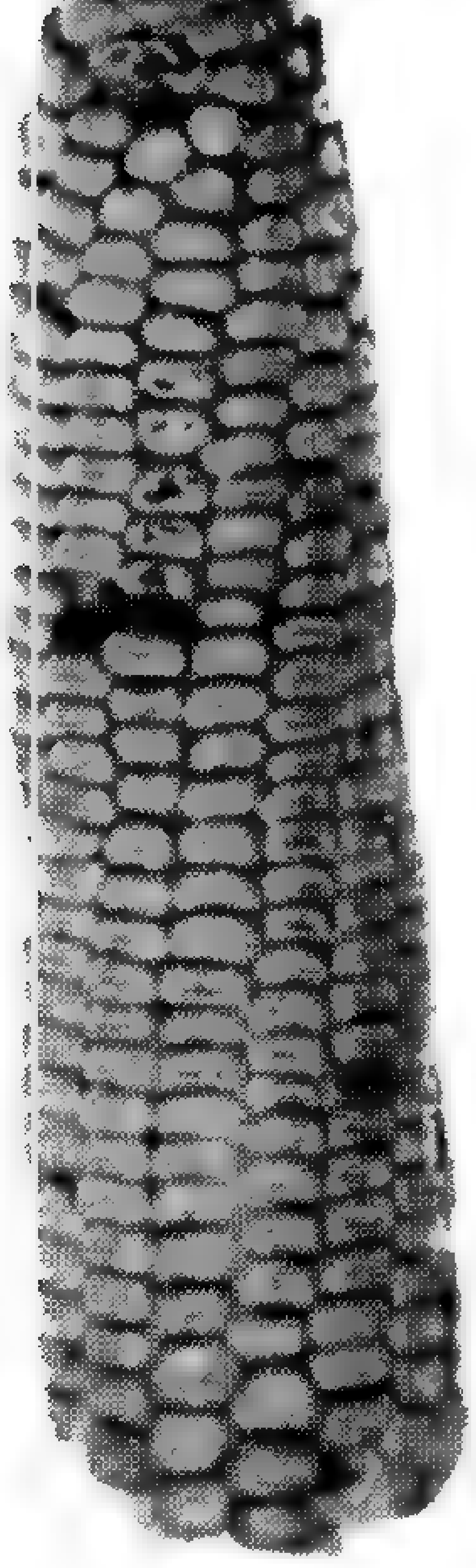
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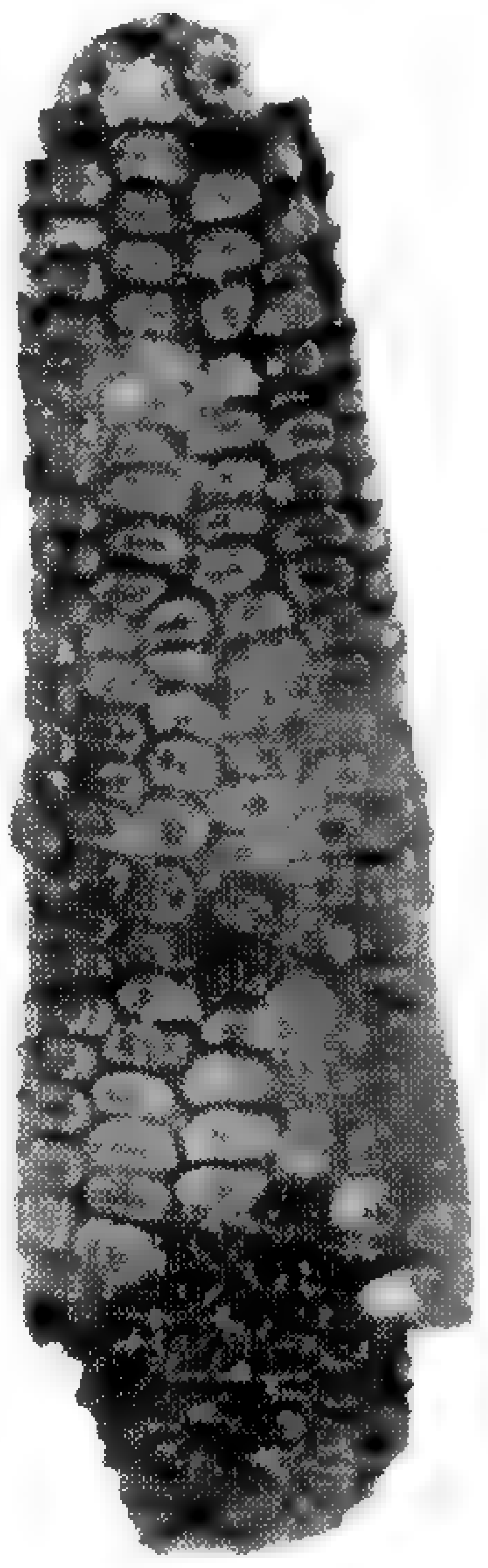
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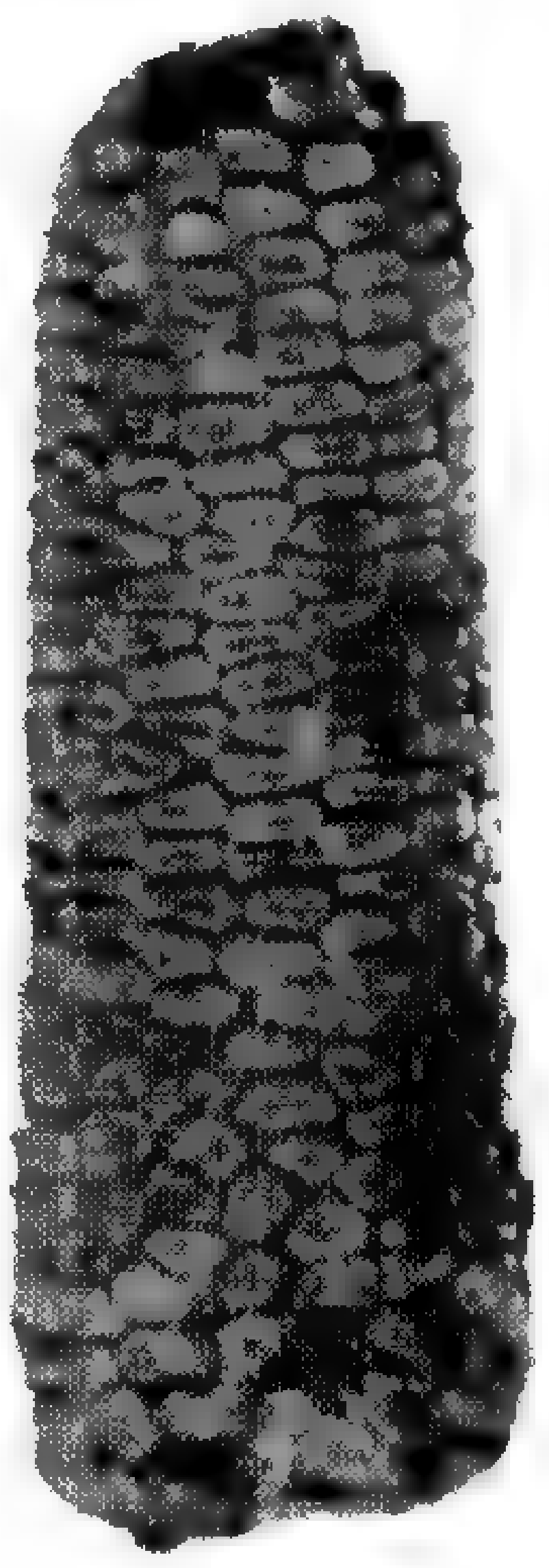
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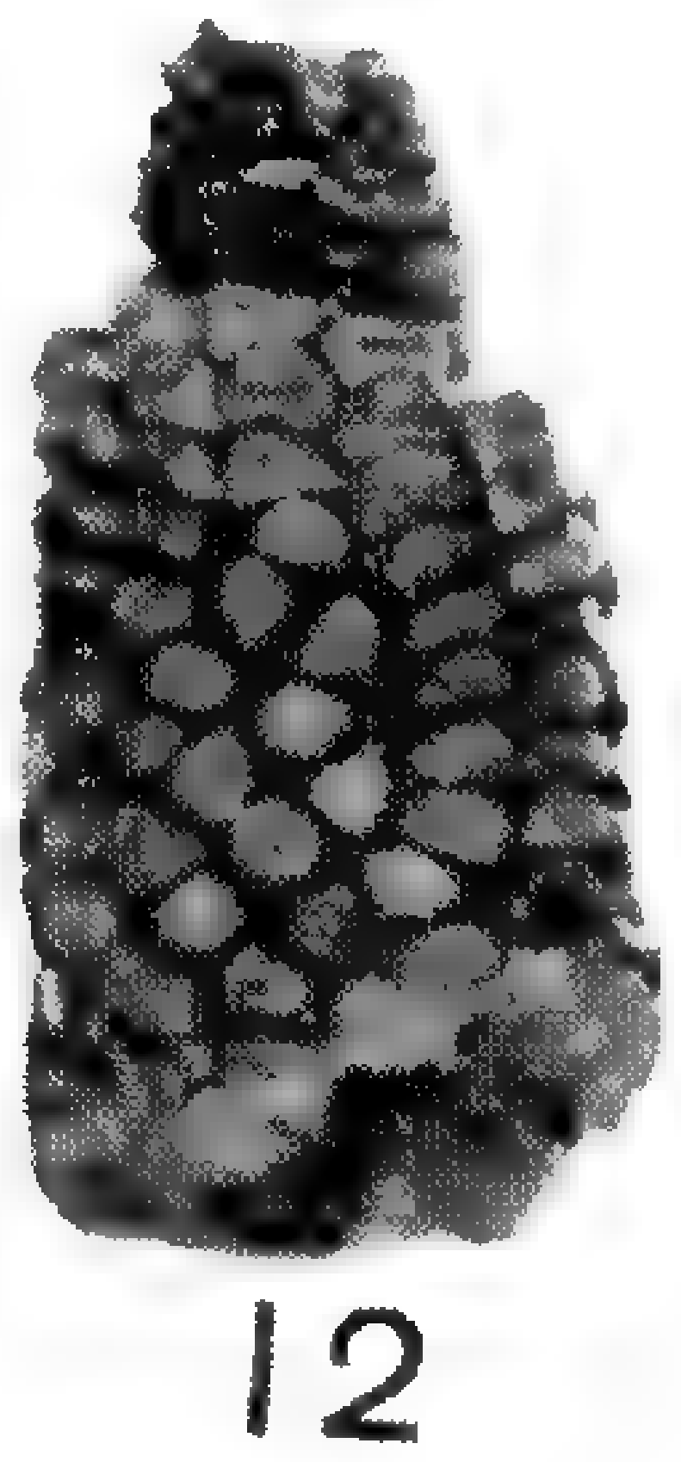
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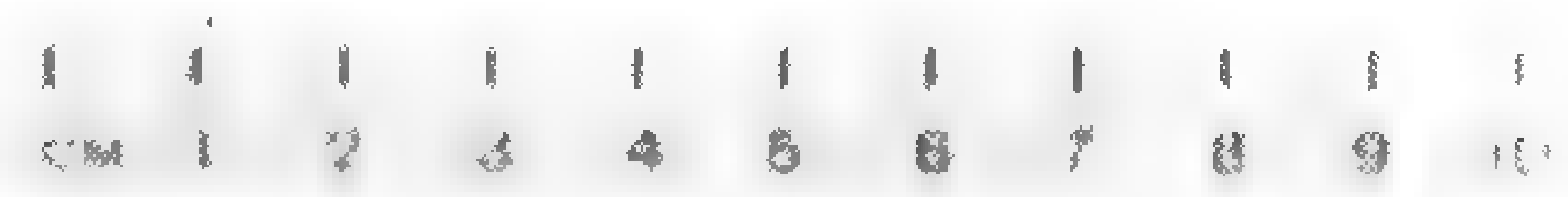
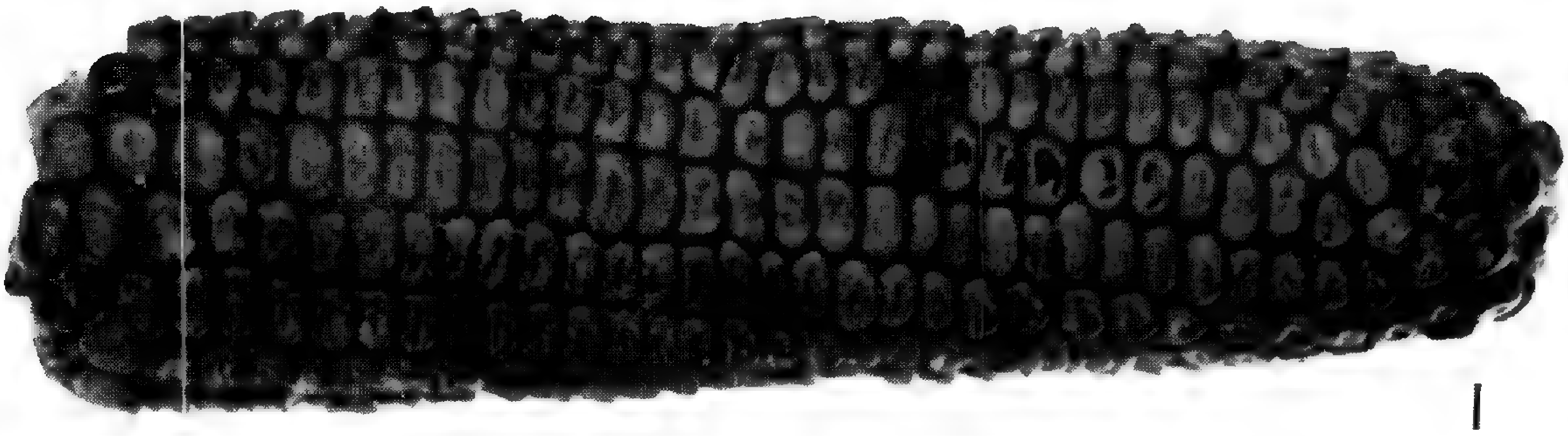


EXPLANATION OF THE ILLUSTRATION

Plate XXV. Illustration of the close similarities among the races Maize Blando de Sonora, Pima-Papago and Fremont Dent.

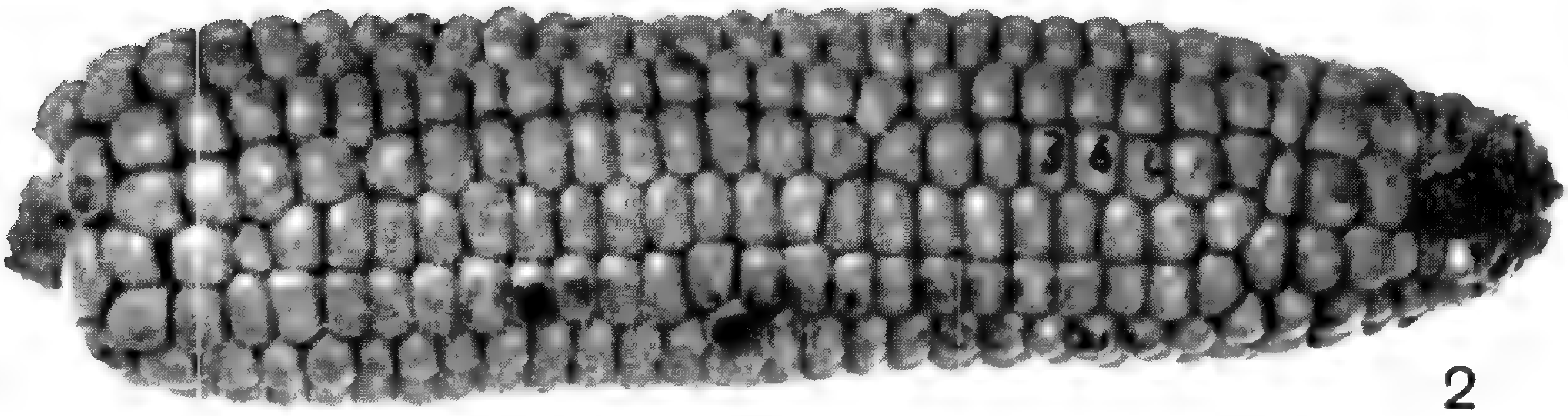
Fig. No.	*Cultural Affiliation and Date A.D.*	*Provenience and Reference*	*Peabody Museum Catalogue No.*
1	Fremont (950–1200)	Site 19. 12 mi. S of Fruita, Utah. Morss (1931 : 10)	A6520
2	Hopi Pueblo 1880	Hopi Pueblo, 80 mi. NE of Flagstaff, Arizona	3641
3	Maize Blando de Sonora, modern	E. J. Wellhausen, Rockefeller Foundation, Mexico	

PLATE XXV



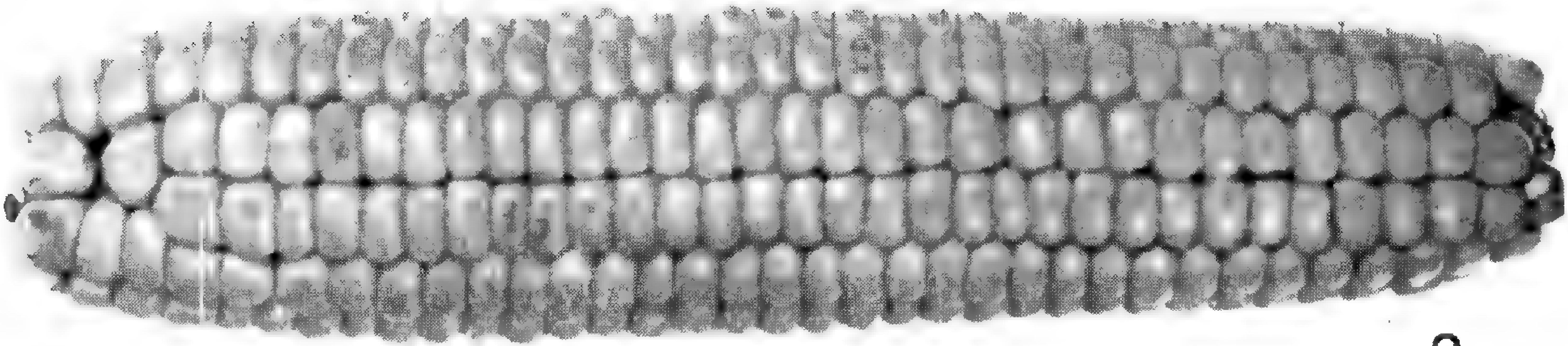
1

FREMONT DENT



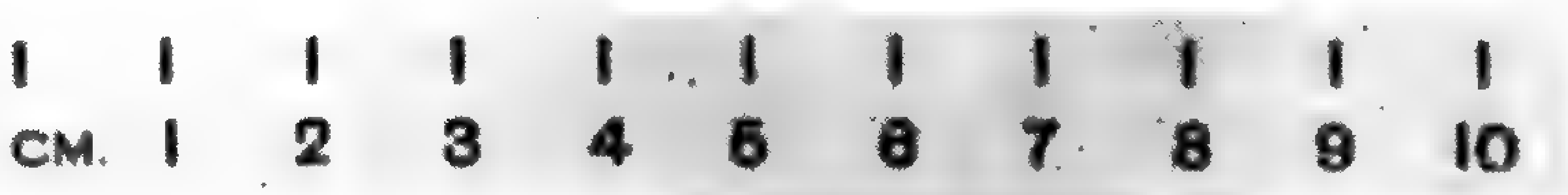
2

PIMA-PAPAGO



3

MAIZE BLANDO DE SONORA

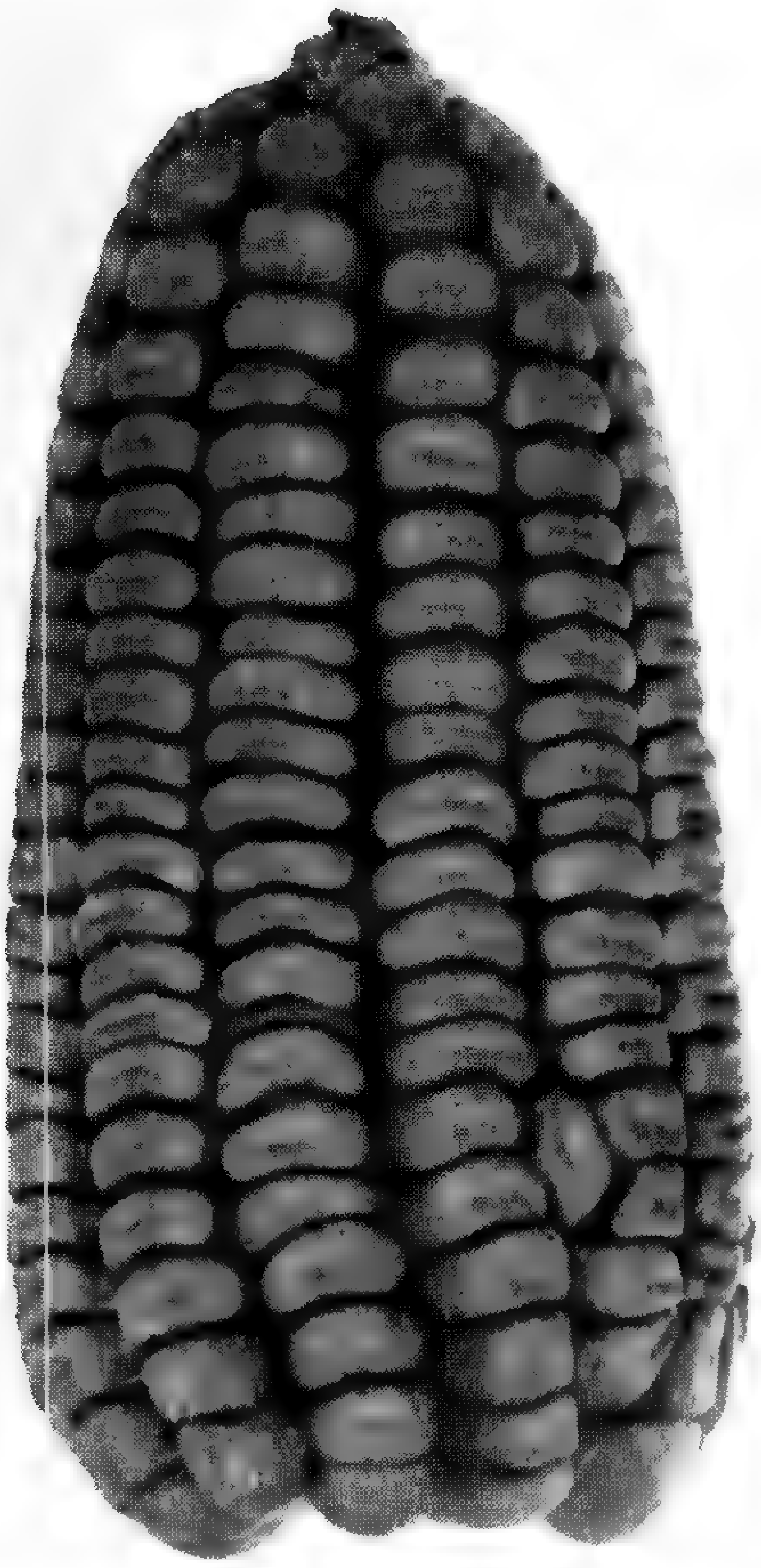


EXPLANATION OF THE ILLUSTRATION

PLATE XXVI. A comparison of the most Zapalote Chico-like archaeological specimen available to us from Fremont sites to actual Zapalote Chico.

Fig. No.	*Cultural Affiliation and Date A.D.*	*Provenience and Reference*	*Peabody Museum Catalogue No.*
1	Zapalote Chico modern	E. J. Wellhausen, Rockefeller Foundation, Mexico	
2	Fremont (950–1200)	Site A 6–1. 6 mi. NW of Vernal, Utah. Gunnerson (n.d. b)	A7944

PLATE XXVI



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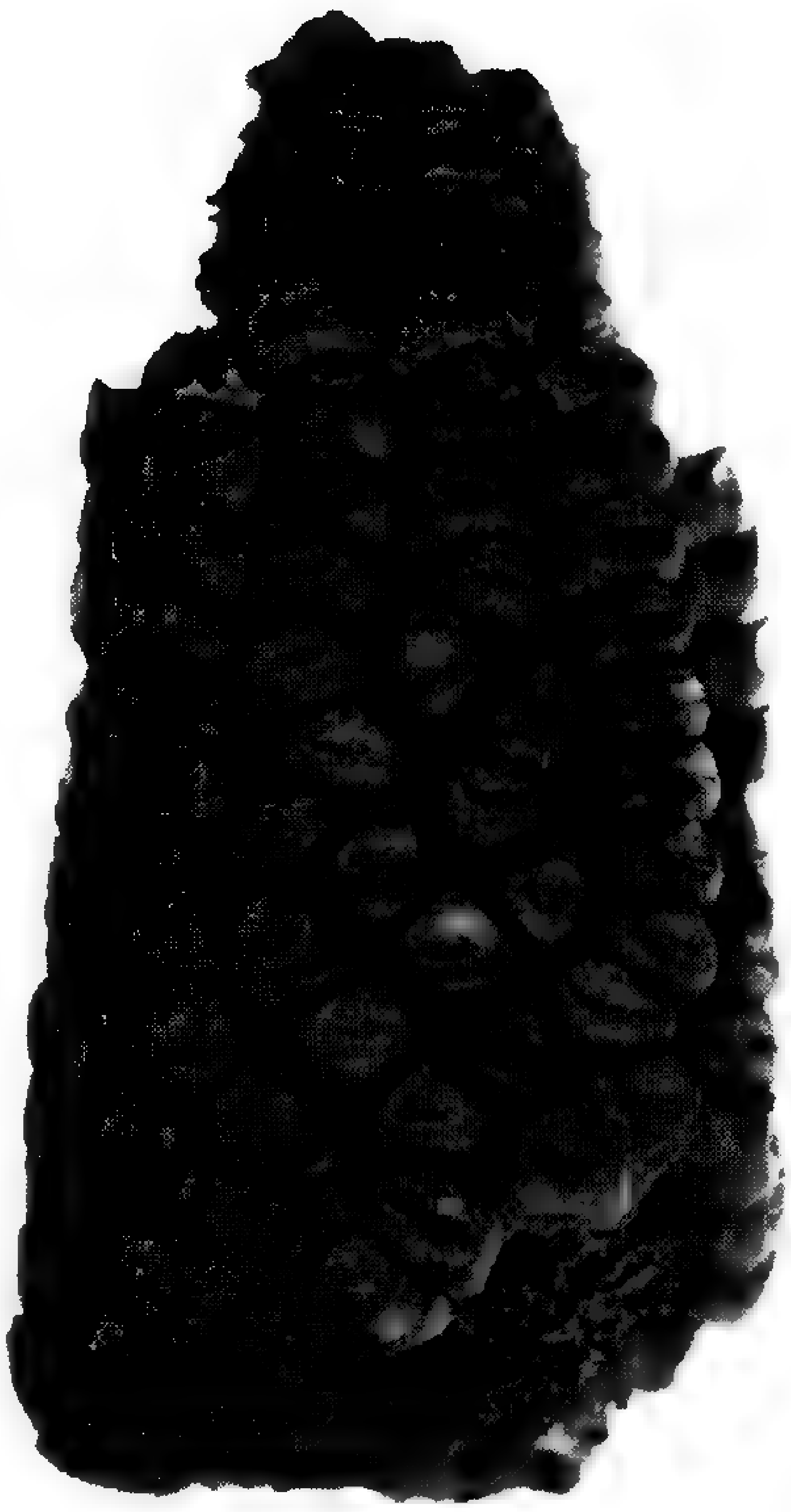

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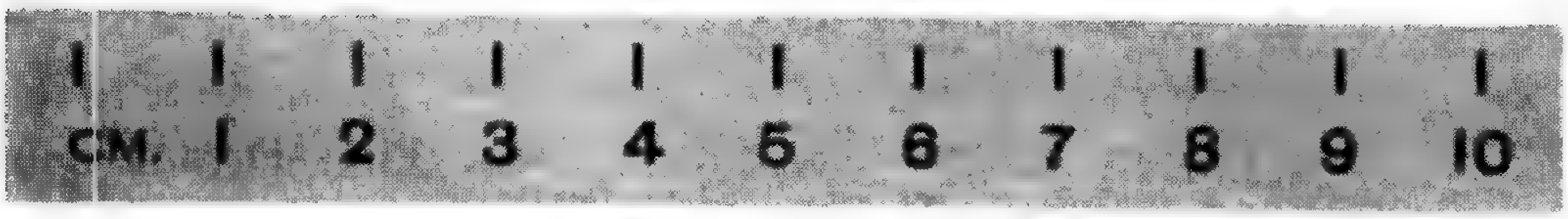

EXPLANATION OF THE ILLUSTRATION

PLATE XXVII. The evolutionary sequence in maize in the Southwest, as herein presented, is summarized in a pictorial manner in this plate. In the lower-right-hand corner is an example of pre-Chapalote, the first race to appear in the Southwest (about 5000 years ago). When teosinte introgression was introduced into this race at about 500 B.C., it produced the Early and Evolved Chapalote types shown just above. About A.D. 700 a new eight-rowed race, possibly derived from Cabuya of South America, arrived in the Southwest, where it also hybridized with the indigenous types of Chapalote. Sometimes this eight-rowed race reasserted itself in the resulting segregations, except for acquiring flinty kernels, as shown by the vertical ear labeled Maíz de Ocho-S.W. Flint on the lower left, or nearly reasserted itself as illustrated by the adjacent ear, Near Maíz de Ocho. More frequently the truly intermediate conditions such as the Fremont Dent type in the northern part of the Southwest, the Pima-Papago type above it from the southern part of the Southwest or, still farther south, Maíz Blando from the Mexican state of Sonora came to predominate. Even more productive hybrids eventually evolved from the blending of Harinoso de Ocho, Chapalote and teosinte to yield such large ears as those of the Pueblo race (top center right) and its Mexican counterpart, Cristalino de Chihuahua (top center left).

Modern counterparts of prehistoric Chapalote and Maíz de Ocho can still be found growing in areas where they became well adapted. In the upper left corner are modern survivors, apparently only slightly changed, of the Maíz de Ocho which entered the Southwest about A.D. 700. The three modern (1961) ears of Chapalote in the upper right corner match off precisely with the nearly 2000-year-old ears of Early and Evolved Chapalote. The ear of Maíz Blando de Sonora is a modern counterpart of the Fremont Dent and Pima-Papago maize which have persisted for the last 1000 years. (The provenience is given in Table II.)

PLATE XXVII

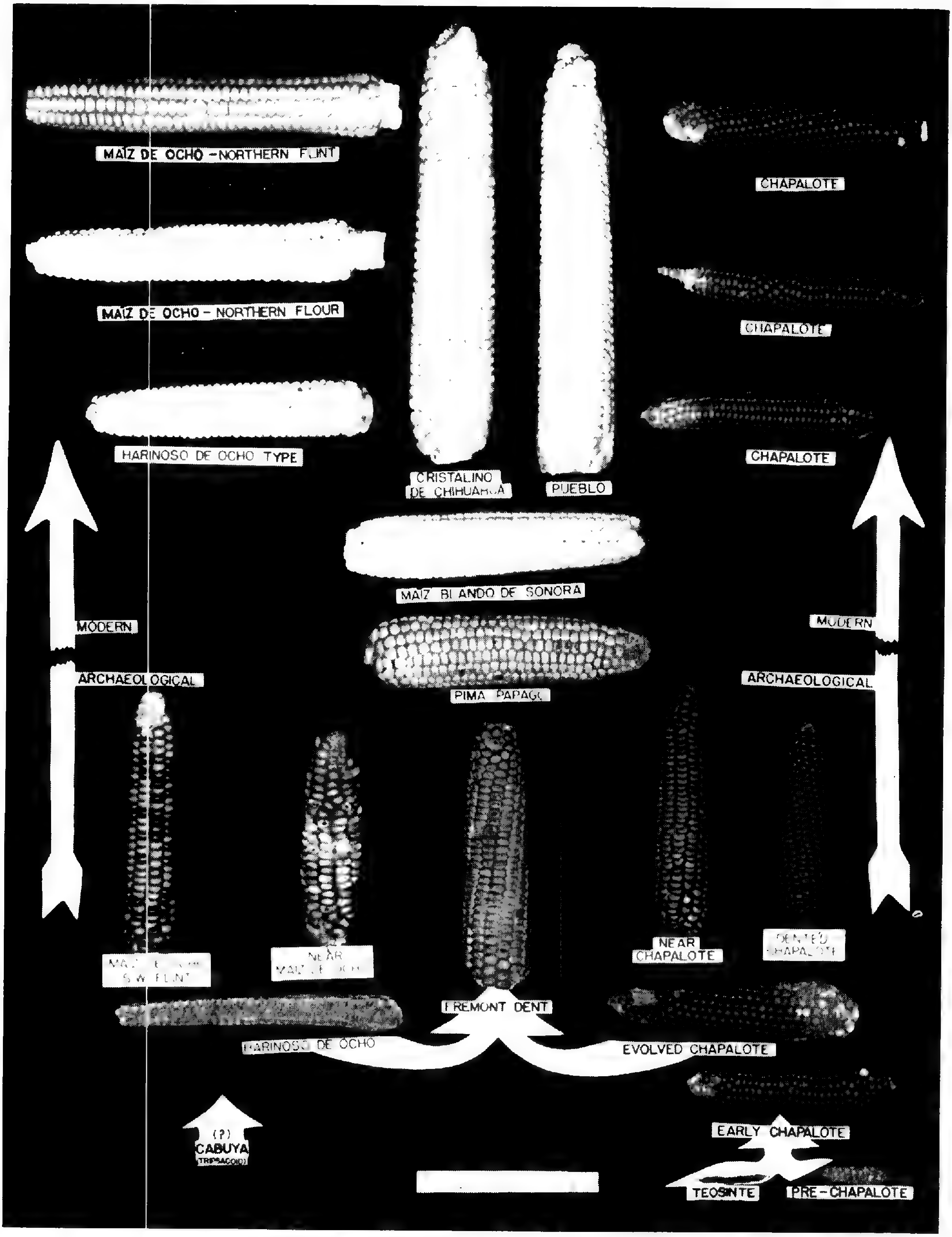
MAIZ DE OCHO - NORTHERN FLINT
CRISTALINO DE CHIHUAHUA
PUEBLO
CHAPALOTE
MAIZ DE OCHO - NORTHERN FLOUR
CHAPALOTE
HARINOSO DE OCHO TYPE
CHAPALOTE
MAIZ BLANDO DE SONORA
MODERN
ARCHAEOLOGICAL
PIMA PAPAGO
MODERN
ARCHAEOLOGICAL
MAIZ DE OCHO S.W. FLINT
NEAR MAIZ DE OCHO
FREMONT DENT
NEAR CHAPALOTE
DENTED CHAPALOTE
HARINOSO DE OCHO
EVOLVED CHAPALOTE
(?) CABUYA (TRIPSACOID)
EARLY CHAPALOTE
TEOSINTE
PRE-CHAPALOTE

TABLE II. Provenience of specimens illustrated in Plate XXVII.

Archaeological Specimen	*Cultural Affiliation and Age*	*Provenience and Reference*	*Peabody Museum Catalogue No.*
Maíz de Ocho S.W. Flint	Fremont (A.D. 950–1200)	Site 37. 11 mi. N of Fruita, Utah. Morss (1931, p. 27)	A6819
Near Maíz de Ocho	Kayenta Anasazi (A.D. 700–1250)	Cave 8. NW of Kayenta, Arizona. Guernsey & Kidder (1921, p. 34)	A3520
Fremont Dent	Fremont (950–1200)	Site A 6–1, 6 mi. NW of Vernal, Utah. Gunnerson (n.d. b)	A7936
Near Chapalote	Basketmaker (A.D. 200–700)	Site SR 16–6, 40 mi. SE of Hanksville, Utah. Gunnerson (n.d. b)	10/264
Dented Chapalote	Fremont (A.D. 950–1200)	Site PR 4–31, 30 mi. NW of Price, Utah. Gunnerson (n.d. b)	A7769
Harinoso de Ocho	Mogollon (A.D. 700–1200)	Kelly Cave. 10 mi. N of Alma, N.M. Cosgrove (1947: 25–26)	97439
Evolved Chapalote	Basketmaker (A.D. 100–500)	Cave II, Marsh Pass, SW of Kayenta, Arizona. Kidder & Guernsey (1919, pp. 82–90)	A2481
Early Chapalote	Basketmaker (A.D. 100–500)	Cave II, Marsh Pass, SW of Kayenta, Arizona. Kidder & Guernsey (1919, pp. 82–90)	A2481
Pre-Chapalote	1600–300 B.C.	Coxcatlan Cave, Zone H. Tehuacan, Mexico. MacNeish (1962)	

Modern Specimens	*Provenience*
Harinoso de Ocho Type	modern grown by Hidatsa Indians and identical to Harinoso de Ocho of Wellhausen *et al.*, 1952.
Northern Flour	modern grown by Mandan Indians, N. Dakota.
Northern Flint	modern from New England.
Chapalote (three ears)	from E. J. Wellhausen, grown in Mexico, 1961.
Maíz Blando de Sonora	from E. J. Wellhausen, grown in Mexico, 1961.
Pima-Papago	collected in 1880 at Hopi Pueblos, N. Arizona. Peabody Museum Catalog No. 3641.
Cristalino de Chihuahua	from E. J. Wellhausen, grown in Mexico, 1961.
Pueblo	modern grown by Pueblo Indians.

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HARVARD UNIVERSITY

CAMBRIDGE, MASSACHUSETTS, NOVEMBER 22, 1963 VOL. 20, NO. 6

NOTES ON THE PRESENT STATUS OF *OLOLIUHQUI* AND THE OTHER HALLUCINOGENS OF MEXICO

BY

R. GORDON WASSON*

Piçietl, *peyotl*, *teonanacatl*, and *ololiuhqui*—these were the four great divinatory plants of Mexico at the time of the Conquest. We give the names in Nahuatl, the *lingua franca* of that time, spoken as a mother tongue by the Aztecs and many other peoples. By 'divinatory' we mean plants that served in Middle American cultures as keys to knowledge withheld from men in their normal minds, the keys to Extra-sensory Perception, the Mediators (as the Indians believed) between men and their gods. These plants were hallucinogens, psychotropic agents, psychotomimetics, if we must use the nonce-words of contemporary science.

Among the remote monolingual peoples of Mexico these plants continue to this day playing their divine role. Whenever the Indian family is troubled by a grave problem, it is likely to turn to one or the other of these plants and consult it according to the usage prevailing in the region. There were other drugs, certainly, that be-

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* Research Fellow, Botanical Museum of Harvard University. This paper was written in honor of Robert J. Weitlaner on the occasion of his 80th birthday and will be published in Spanish in the *Homenaje* edited under the auspices of a committee headed by Dr. Alfonso Caso in Mexico City.

long to the same class, and of these more will be said later. But if we may rely on the number and quality of the witnesses, the importance that they attribute to these plants, and the strangely moving episodes that they tell us of the Indians' utter faith in and defense of them—then these four were preëminent.

The civilization of Europe had known nothing like these novel drugs of Mexico, at least not in recorded history. Similar miraculous powers were attributed, in a way, to the Elements in the Mass; and the Catholic Church in Mexico was quick to perceive this, to it, alarming parallel. But belief in the divinity of the Sacrament called for an act of faith, whereas the Mexican plants spoke for themselves. In a number of situations the record is clear: the friars conceded the miracles wrought by these agents[1] but attributed them to the machinations of the Evil One. Root and branch, the Church strove to extirpate what it called this superstition, this idolatry of the miracle-working plants. The Church was unsuccessful; just how unsuccessful can be seen from the fact that these plants are taken today, throughout the Indian country, in ceremonials invoking the very name of the Virgin Mary, of the Saints (especially St. Peter and St. Paul), of Our Lord. The accessories to the rite are sold in every market place, at a special stall, often in the shadow of the parish church. The miracle-working plants pass from hand to hand by private arrangement; they are never exposed like ordinary garden produce. The rite takes place in midnight vigils, sometimes accompanied by stirring age-old chants in the vernacular. The Indians attending these rites may include prominent lay officials of the church; rumor hath it that in certain places the priest is the leading *curandero*. Let it not be forgotten that the primary use of the sacred plants was and continues to be religious—and by the same token medicinal.

Religion and medicine have not yet been separated out in many of the Indian communities.

Piçietl — *Nicotiana rustica* L.

The bright green powder of *piçietl* leaves is familiar all over the Indian country in Mexico. The *curandero* rubs it on the skin, over the forearms, temples, stomach, legs. It is this that constitutes a *limpia* or ritual cleansing. Formerly, when mixed with one part of lime to ten of *piçietl*, it was made into a wad that the Indian inserted between teeth and gums and sucked, much as the Kechua sucks coca, to give him strength. The friars inveighed against *piçietl* with a vehemence that is proof of its importance in the native culture. It is still indispensable in the religious life of the Indians. Is it possible that *piçietl* has pharmacological properties not yet discovered by science? May there be surprises for us in this plant?

Piçietl is *Nicotiana rustica* L., a sister species to our ordinary tobacco, *Nicotiana Tabacum* L. They both grow in Mexico. In Nahuatl together they are *yetl*, the former alone was *piçietl* (now in the vernacular *pisiete*), the latter alone was *quauhyetl*. Tobacco was already widely diffused throughout the Americas at the time of the Conquest. The Spaniards found it in the Antilles, the Portuguese in Brazil, the English in Virginia. Along with the plant the Spaniards took the name 'tobacco' from the Taíno people of Hispaniola and Cuba. Long since dead and gone, this Arawakan tribe bequeathed to the world a legacy of important words that gives us an engaging image of a blameless people: 'canoe', 'hammock', 'tobacco', maize', and 'potato', not to speak of a sixth, 'barbecue', that is in vogue today. And so the Taínos, cultivating their maize and sweet potatoes, smoking tobacco in their hammocks, paddling their canoes to the neighboring barbecue, were destined to be exterminated by the ferocious Caribs and the Europeans![2]

The use of tobacco spread throughout the world with epidemic speed. European explorers penetrating to lands far distant in Africa and Asia sometimes found that tobacco had reached there before them. Even the Church did nothing to combat it,—outside of Mexico, that is. The French *abbé* with his snuff box is a familiar figure in Europe's cultural history.

Peyotl — *Lophophora Williamsii* (Lem.) Coult.

The history of *peyotl*, known to science as *Lophophora Williamsii* (Lem.) Coulter, has been utterly different but equally spectacular. A cactus,[3] it is by that fact exclusively a New World plant, native to the arid regions of northern Mexico — to Coahuila, Zacatecas, San Luis Potosí, and Querétaro. Presumably the plant in colonial times grew only in the north, but its use extended south as far as the state of Oaxaca.[4] Today the Indians of central and southern Mexico seem to know it no longer. But the Indians of the north still consume it in their religious ceremonies, and it is extending its range, inching its way northward from tribe to tribe in the Plains area until it has now finally reached Canada. In the same spirit of blind misunderstanding that actuated the Church in colonial Mexico, there are elements in the North American community that would invoke the police and courts to stop a practice that gives spiritual solace to our surviving Indian population.

On a different cultural plane, *peyotl* made its bow in the great world in 1888, when the toxicologist Louis Lewin of Berlin published the first paper attempting to classify it botanically and describing its sensational qualities. He was followed by Dr. S. Weir Mitchell (1896) and Havelock Ellis (1897), men who commanded wide attention in the English-speaking world.[5] These papers served to alert the scientific and learned world to a new order of vegetable product, and opened the sluice-gates to an astonishing flow of discussion and experimentation. Though a booster dose was hardly needed, Aldous Huxley gave the theme a new dimension when he published his *The Doors of Perception* in 1954 and *Heaven and Hell* in 1955.

The bibliography on *peyotl* is enormous: one North American anthropologist, Weston La Barre, has devoted an important part of his professional life to keeping up with it and chronicling current developments.[6] The question presents itself seriously whether the output of articles can be laid solely to the scientific interest of a strange drug, or whether supplementing this there is a subjective effect that compels those who have eaten the plant to embark upon a mission to make known what they have experienced.

Peyotl (which has commonly been eroded to 'peyote') is a Nahuatl word. Alonso de Molina in his *Vocabulario* (1571) gives its meaning as *capullo de seda, or de gusano,* 'silk cocoon or caterpillar's cocoon,' which fits well the small woolly cactus that is its source. This is probably the explanation. Others[7] cite a number of similar words in Nahuatl that invoke splendor or illumination. May these words not be secondary, having been born of the splendor of the visions that *peyotl* gives? For reasons that seem to have sprung from popular confusion, the English-speaking population of the Southwest came to call the dried *peyotl* 'mescal buttons.' Lewin, Mitchell, and Ellis, by their use of the terms, fixed this grievous misnomer in the English language. Later, when the active agent came to be isolated, the chemists called the alkaloid 'mescaline', thus compounding the mistake. 'Mescal' comes from the Spanish of Mexico *mezcal,* derived in its turn from Nahuatl *mexcalli,* the name for the agave, *maguey*, or century plant from which pulque is made, which, when distilled, yields *mezcal*. *Mezcal* has nothing to do with 'mescal buttons' or 'mescaline'. This confusion is the lexicographers' nightmare, as can be seen in many English-language dictionaries where erroneous citations are given under the respective meanings of the word.

On the other hand there is an important *mejicanismo* that has largely escaped the lexicographers: *piule*, a generic name in Mexico for the hallucinogens. J. J. Santamaría traces it to Zapotec, in my opinion on insufficient grounds. I have heard it applied to hallucinogenic mushrooms among the Zapotec-speakers of the Sierra Costera, at San Augustín Loxicha: *piule de barda*, *piule de cherìs*, these being distinct species of such mushrooms, or simply *piule*.[8] Does it not stem from *peyotl*, thus: *péyotl/péyutl*➳*peyúle*➳*piule?* As Dr. Aguirre Beltrán has shown us, in early colonial times *peyotl* was in use in Oaxaca. The present-day currency of the word among some monolingual Zapotecs might come down from that period.

Teonanacatl — 'God's flesh'

At least twenty-five of our early sources, many of them among our most important, speak of *teonanacatl*, 'God's flesh'[9], the sacred mushrooms of Middle America. Bernardino de Sahagún refers to them repeatedly and at some length. He gives in Nahuatl the text of his native informants. Of the Nahuatl poems preserved for us, one mentions them, and probably others refer to them metaphorically. There are miniatures of them in two of the early codices. We in the 20th Century would have expected the European in colonial Mexico to try them out, to satisfy his curiosity as to their properties. There is no record of any such experiment. The Spaniards (if we may judge by their words) at first rejected them with horror and loathing as an abomination, and in the ensuing centuries simply ignored them.

Such was this neglect that in 1915 William E. Safford, a North American economic botanist of established reputation, found it possible to read a major paper before a learned society, afterwards published in a respectable learned journal, denying that there had ever been sacred mushrooms in Mexico.[10] Virtually no one challenged him. In a world indifferent to such matters, torn by warfare, his arguments won by default. Only a single thin voice was raised in persistent protest, the voice of Dr. Blas Pablo Reko, a Mexican citizen born in Austria of Slavic family background, a tireless and enthusiastic field worker but one given to fanciful theories and so not taken seriously.[11] He kept insisting not only that the mushrooms had existed but that the cult survived in places off the beaten track in Oaxaca.

Twenty years went by until, one day in 1936, Ing. Roberto J. Weitlaner got his hands on some of the sacred mushrooms in Huautla de Jiménez. He sent them to Reko, who forwarded them to Harvard, where they arrived in such a state that they could not be identified. On the record Ing. Weitlaner was the first white man in modern times to have seen the *teonanacatl*. Two years later, on July 16, 1938, his daughter Irmgard, with the young anthropologist who was destined to become her husband, Jean Bassett Johnson, together with two others, Bernard Bevan and Louise Lacaud, attended a mushroom rite in Huautla, in the home of José Dorantes. Johnson later gave a full account of the event.[12] So far as the sources go, they were the first white persons to attend such a ceremony.

One month later, in mid-August, the Harvard botanist Richard Evans Schultes, also in Huautla, received from native informants specimens of three species that they said were of the sacred class. He took them back to Cambridge. His field notes describe with unmistakable precision the species that was to be defined in 1956 by Roger Heim as *Psilocybe caerulescens* Murr. var. *mazatecorum* Heim.[13] Dr. David Linder, Harvard mycologist, confirmed another as *Panaeolus campanulatus* L. var. *sphinctrinus* (Fr.) Bresad. Some time later the third species was identified at Harvard by Dr. Rolf Singer as *Stropharia cubensis* Earle,[14] but he did not disclose his discovery, not even to Schultes, until many years later when it was too late to serve a purpose.

Then the Second World War supervened. Johnson was killed in North Africa in 1942. Reko died in 1953. Schultes' activities were diverted to other geographical regions. The outside world had been on the brink of discovering the Mexican mushrooms, but the war blanketed everything and the mushrooms slipped back into the well of the forgotten.

Meanwhile the matter was being approached from an altogether different angle in New York, by the Wassons, husband and wife, who had spent more than two decades gathering data on the role of mushrooms in primitive societies in Eurasia. This theme in anthropology, which we called *ethnomycology*, had never before been explored in the West. Eurasia embraced so many cultures and so much history and literature that we had resolved early in our inquiries to stop with Eurasia and leave Africa and the Americas to others. Our Eurasian studies had led us to formulate a bold surmise: viz., that mushrooms had played a religious role in the lives of our remote ancestors, a role far more important than the world had supposed. We were still preoccupied with this idea when in September 1952, suddenly, we learned that a mushroom cult had been reported in 16th Century Mexico.

On receipt of this, to us, sensational news, we resolved to embark upon a quest for surviving traces of that cult. At the time we knew nothing, absolutely nothing, about the cultures of Middle America. What awaited us in Mexico turned out to exceed our most sanguine anticipations, in the intellectual adventure of discovering for ourselves the rich Indian cultures of Middle America and in our rediscovery of the rite of the sacred mushroom.

In the beginning we discovered Ing. Roberto J. Weitlaner. Without minimizing what we owe to others, I rejoice that this occasion presents itself when I may properly define my debt to him. He led us by the hand on our first excursion on muleback into the Indian country, to Huautla de Jiménez; on my second trip to Mazatlán de los Mixes; then on my visits to San Augustín Loxicha in the Sierra Costera, and to the Mazahua country. For ten years I have had repeated recourse to him, to tap his immense knowledge of the Indians, their ways, their languages, their history. He has guided my steps in the libraries, unearthed apt quotations in the sources bearing on our theme, introduced me to others working in the field who could also pin down facts. His patience, good humor, and *joie de vivre*, in the Sierra and in Mexico City, are unfailing. But above all else I have tried to learn from him his secret of dealing with the Indians. The Indians are simply living by the conventions of an orally transmitted culture such as our own forebears lived by only a little while ago. When you visit their villages you make allowances for this time lag. You do not treat them kindly as inferiors or children. You do not treat them *as though* they were equals. The Indians are quick to see through such fronts. Ing. Weitlaner taught us to treat the Indians *as* equals—a secret simple yet elusive. As the poet said, truly 'this is the famous stone that turneth all to gold'.

The news of the Mexican sacred mushrooms burst upon the world in the spring of 1957 with the publication of our book, *Mushrooms Russia & History*, and our articles in the popular magazines.[15] Roger Heim, Membre de l'Institut, Director of the Muséum National d'Histoire Naturelle, visited the Indian country of Mexico three time in response to our invitation, seeking out the sacred mushrooms. He identified fourteen species belonging to three genera—*Psilocybe*, *Stropharia*, and *Conocybe*—besides a number of subspecies. Most of them were new to science, although they had been known to the Indians for centuries, probably millennia. Dr. Albert Hofmann in the Sandoz laboratories of Bâsle undertook the delicate task of isolating the active agents, defining their molecular structure, and finally synthesizing them. By 1958, a surprisingly short time, he had accomplished his work. Many investigators began to study the properties of *psilocybine* and *psilocine*, as Dr. Hofmann called the active agents, and their possible use. In a recent bibliography I have listed some 200 papers on work with these mushrooms that have already appeared, in the past five years, in learned and scientific journals;[16] not to speak of the hundreds of articles that have come out in a score of countries in the lay press. Here again there seem to be signs that those who have experienced the mushrooms feel a compulsion to impart to others the staggering effects of *teonanacatl*.

Pipiltzintzintli — *Salvia divinorum* Epling & Jávito

Though *teonanacatl* has been rediscovered and identified, there still remain other plants classed with it in the colonial sources as possessed of divine (or Satanic) attributes that defeat our efforts at interpretation. Both Sahagún and Juan de Cárdenas refer to a plant that they call respectively *poyomatli* or *poyomate*,[17] grouping it with other hallucinogens. Its identity is unknown. In his *Medicina y Magia* Dr. Aguirre Beltrán cites other references to this plant in the unpublished records of the inquisition. He likewise supplies numerous references to a second plant that belongs in the divinatory group, a plant the name of which is variously spelled in his sources but that he thinks in the original Nahuatl should be *piPiltzintzintli.*[18] Its identity, too, is unknown. The plant grew in the area where *ololiuhqui* flourished; but whereas *ololiuhqui* is the seed of a morning glory, the seed of *pipiltzintzintli* is never mentioned. It is called an *hierba*, never an *hiedra* or *bejuco* like the morning glory. There was a *macho* and an *hembra*, or male and female varieties. It was cultivated.

All of these attributes fit the *hojas de la Pastora* that the Mazatecs generally use as a divinatory plant. In September 1962 we gathered specimens of the *hojas de la Pastora*, and they were found to be a species new to science: Epling and Játiva named it *Salvia divinorum.*[19] Among the Mazatecs I have seen only the leaves ground on the *metate*, strained, and made into an infusion. The colonial records speak of an infusion made from the roots, stems, and flowers. But this is not incompatible with our information about *Salvia divinorum:* the Mazatecs may confine themselves to the leaves of a plant that has the divine virtue in all its parts. I suggest that tentatively we consider *pipiltzintzintli*, the divine plant of pre-Conquest Mexico, identical with the *Salvia divinorum* now invoked in their religious supplications by the Mazatecs.

Of divinatory plants in use today that could have been used in Middle America before the Conquest, we have had experience with two: *toloache*, presumably the seeds of *Datura meteloides* Dun., and *colorines*, the seeds of *Rhynchosia pyramidalis* (Lam.) Urb. Though I know of

PLATE XXVIII

Flowering *Salvia divinorum* E. & J., 'hojas de la Pastora', held by Irmgard Weitlaner Johnson. 1962. *Photo by* WASSON no references to *colorines* in colonial sources, I think that they are present in the famous Tepantitla fresco where strings of seeds and mushrooms are falling from the hand of Tlaloc, and where some of the seeds are red and black, with the hilum distinctly placed in the red field.[20] On the slopes of Popacatepetl the sacred mushrooms are still taken with *colorines*. It is vital that the hilum be in the red field; if it is in the black patch, it is the toxic seed of *Abrus precatorius* L., also called *colorines* and much used for beads by the Veracruzanos.

Ololiuhqui — *Rivea corymbosa* (L.) Hall. fil.*

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* There have recently been suggestions that the correct name of ololiuhqui is ***Turbina corymbosa*** (L.) Raf.

These suggestions arise from two articles which have appeared in the past several years: Roberty, G.—"Genera Convolvulacearum" in Candollea 14 (1952) 11–60; Wilson, K.A.—"The genera of Convolvulaceae in the southeastern United States" in Journ. Arn. Arb. 41 (1960) 298–317.

Roberty separates ***Ipomoea***, ***Rivea*** and ***Turbina***, putting the three into different subfamilies. He keeps in Rivea only one species of India and Ceylon. In Turbina, he has three species; ***T. corymbosa*** (which he states occurs in tropical America, the Canary Islands and the Philippines) and two other species of Mexico.

Wilson, in a key to the genera of Convolvulaceae in the southeastern states, separates out Turbina as a genus distinct from Ipomoea. While Turbina is keyed out as a distinct genus, there is no technical consideration of it in the body of the paper which follows the key. One, consequently, must assume that Turbina (as conceived by Wilson) does not occur in southeastern United States. There is, furthermore, no reference to the binomial ***Turbina corymbosa*** as such. Wilson pointed out that: "Generic lines are difficult to draw in this family, and treatments vary with different authors depending upon the emphasis placed on the taxonomic characters used. . . . "

The question of whether to use the binomial ***Rivea corymbosa*** or to assign the concept to Ipomoea on the one hand or Turbina on the other is, in effect, one of personal evaluation by botanists of the importance of characters.

When I first discussed ololiuhqui in 1941 (Schultes, R.E.: "A contribution to our knowledge of Rivea corymbosa, the narcotic ololiuqui of the Aztecs" (1941)), I looked into the problem of the generic position of the concept. I decided that, if indeed one were justified in separating this concept from Ipomoea, it must be accommodated in Rivea. The outstanding Argentinian specialist on the Convolvulaceae, the late Dr. Carlos O'Donell, who was spending a year at Harvard University at that time, worked with me closely in this study and was in complete agreement. I have studied this problem again in connection with Wasson's recent work and see no reason to change my opinion. Furthermore, it is clear that such an authority as the late Professor E. D. Merrill referred this concept to Rivea, placing Turbina in synonymy under Rivea and *T. corymbosa* in synonymy under *R. corymbosa*.

In view of the fact that such authorities as O'Donell and Merrill elected to use *Rivea corymbosa;* that Wilson acknowledges that "the entire family is in need of intensive study and . . . all characters must be thoroughly re-evaluated"; that Roberty's article is hardly conservative and actually adds little to our basic knowledge of the family; and that the ethnobotanical and chemical literature has accepted *Rivea corymbosa*—in view of all these circumstances perhaps we might well continue to use the best known name until a really comprehensive study by a recognized specialist indicates that it is wrong.

Rivea corymbosa (*L.*) *Hallier fil.* in Engler Bot. Jahrb. 8 (1893) 157.

Convolvulus corymbosus Linnaeus Syst. Nat. Ed. 10, 2 (1759) 923.
Ipomoea corymbosa (L.) Roth Nov. 11. Sp. Ind. Orient (1821) 109.
Turbina corymbosa (L.) Rafinesque Fl. Tellur. 4 (1838) 81.

—R. E. SCHULTES

The least known in the outside world of our quartet of major Mexican divinatory agents is *ololiuhqui;*‡ yet it is perhaps the best known and most widely used among the Indians of that country. In the race for world attention *ololiuhqui* has been a slow starter. Beyond the confines of the Sierra Madre few except specialists have heard of it, and the bibliography on it is short. But its properties are as sensational as those of *teonanacatl* and *peyotl.* Its identity was settled in 1941. The enigma of its chemistry was resolved in 1960, when on August 18 of that year Dr. Albert Hofmann read his paper in Australia

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‡ Although the spelling *ololiuqui* has gained wide acceptance and is now the commonest orthography, linguistic evidence indicates that this Nahuatl word is correctly written *ololiuhqui.*

before an audience of scientists, many of whom were plainly incredulous, so astonishing were his findings.[21] In this number of the *Botanical Museum Leaflets* he himself rounds out and completes his discoveries, and I shall not anticipate them here.

Ololiuhqui in Nahuatl is the name of the seeds, not of the plant that yields the seeds. The word means 'round thing', and the seeds are small, brown, and oval. The plant itself is a climber, called appropriately *coaxihuitl*, 'snake-plant', in Nahuatl, and *hiedra* or *bejuco* by the Spanish writers. It is a morning glory, and it grows easily and abundantly in the mountains of southern Mexico. Unlike *teonanacatl*, it bears seed over months and the seed can be kept indefinitely, and carried far and wide, to regions where the plant itself does not grow. In Spanish it is commonly known as *semilla de la Virgen*, and in the various Indian languages there are names for it that should be carefully assembled by teams of linguists and then studied for their meanings and associations. In Oaxaca, only among the Triqui of Copala have I found no familiarity with it.

Past experience has shown that for a divinatory plant to enlist the attention of the outside world two steps are usually necessary. First, it should be correctly and securely identified. Second, its chemistry should be convincingly worked out. Richard Evans Schultes settled the identity of *ololiuhqui* in the definitive paper published in 1941.[22] It is the seed of a species of *Convolvulaceae: Rivea corymbosa* (L.) Hall. fil. Schultes was not the first to link *ololiuhqui* with this family, but for decades there had been disputes over its identity, and since Schultes published his paper there has been none. The starting point for any student of the subject is Schultes's paper.

It is not my intention here to tell over again the story told by Schultes. I will only supplement what he had to say with this observation. In the writers of the colonial period *ololiuhqui* receives frequent mention, especially in the *Tratado* of Hernando Ruíz de Alarcón. Throughout these references there runs a note of sombre poignancy as we see two cultures in a duel to death,—on the one hand, the fanaticism of sincere Churchmen, hotly pursuing with the support of the harsh secular arm what they considered a superstition and an idolatry; on the other, the tenacity and wiles of the Indians defending their cherished *ololiuhqui.* The Indians seem to have won out. Today in almost all the villages of Oaxaca one finds the seeds still serving the natives as an ever present help in time of trouble.

Tlitliltzen — *Ipomoea violacea* L.*

Since the appearance of the Schultes paper in 1941, and apart from the chemical findings of Dr. Hofmann, there has been only one important contribution to our knowledge of the morning glory seeds. In 1960 Don Tomás MacDougall published his discovery that in various parts of Oaxaca, especially in the Zapotec area, another seed is used exactly as *ololiuhqui* is.[23] This is the seed of a second morning glory, *Ipomoea violacea* L. In Zapotec *ololiuhqui* is known currently as *badoh;* the

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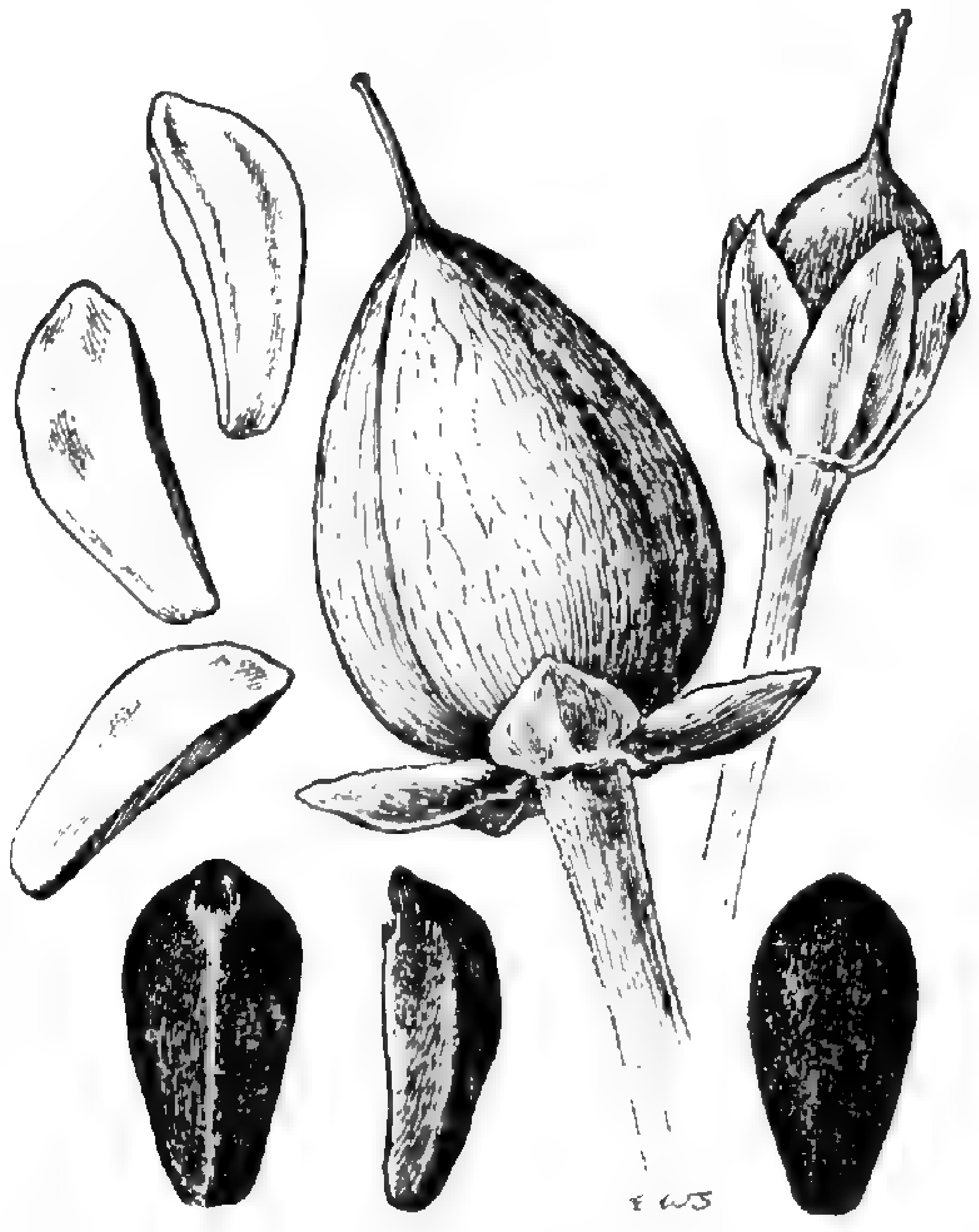
* Taxonomically, the genus Ipomoea is extremely difficult. The binomial *Ipomoea tricolor* has already crept into the limited literature that has grown up in connection with this second kind of ololiuqui. Inasmuch as some confusion may result in the use of two names—*Ipomoea tricolor* and *I. violacea*—we should point out that, after a study of plant material and the taxonomic history of these binomials, I am in agreement with the American specialist in the Convoluvulaceae, H. D. House (House, H. D.: "The North American species of the genus Ipomoea" in Ann. N.Y. Acad. Sci. 18 (1908) 259), that both names actually refer to one polymorphic species. In this case, then, the older name is *Ipomoea violacea* L. Sp. Pl. (1753) 161 which should be used in preference to its synonym *I. tricolor* Cav. Ic. Pl. Rar. 3 (1794) 5, t. 208.—R. E. Schultes

second seed is *badoh negro* or *badungás*, the full Zapotec equivalent of *badoh negro*. The black seeds are long and somewhat angular. In Nahuatl they could hardly be called *ololiuhqui*, since this term means the 'round things' or 'pellets'.

The Nahua must have known them: what then did they call them? We believe the answer is to be found in Pedro Ponce's *Breve Relación de los Dioses y Ritos de la Gentilidad*, Par. 46, where he speaks of *ololiuhqui*, *peyote*, and *tlitliltzin*, all with the same magnetic properties. The third, possibly a hapax in the corpus of surviving classic Nahuatl documentation, is clearly not *ololiuhqui*, since both are mentioned in the same sentence as distinct products. The word comes from the Nahuatl root meaning 'black', with a reverential suffix. May we not assume that this was the name current in classic Nahuatl for the black seeds that Don Tomás found in wide use among the Zapotecs in the 1950's? Apparently there is a further reference to *badoh negro* in the records of the Inquisition: a Negro slave who was also a *curandero* used



Capsule and seed of *Ipomoea violacea*, enlarged two and one half times.

the term *ololiuhqui del moreno*, which Dr. Aguirre Beltrán thinks was his way of saying 'black *ololiuhqui*'. But since this Negro was obviously a stranger both to Nahuatl and to Spanish, little can be deduced from his terminology.[24]

According to Don Tomás, in San Bartolo Yautepac, a village of the Sierra Costera, only the black seed is used, but in many villages both kinds are known. The black is widely regarded as the more potent. In some places the black seed is called *macho*, 'male', and the men take it; the *Rivea* seed, known as *hembra*, 'female', is for the women. The dose is often seven or a multiple thereof—seven, or 14, or 21; or the seeds are measured in the cup of the hand; or, as one informant in the Sierra Mazateca told me, one takes a beer-cap full of *Rivea* seed.

In recent years a number of experimenters have taken the *Rivea* seeds with no effects, and this has led one of them to suggest that the reputation of *ololiuhqui* is due wholly to auto-suggestion.[25] These negative results may be explained by inadequate preparation. The Indians grind the seeds on the *metate* (grinding stone) until they are reduced to flour. Then the flour is soaked in cold water, and after a short time the liquor is passed through a cloth strainer and drunk. If taken whole, the seeds give no result, or even if they are cracked. They must be ground to flour and then the flour soaked briefly in water. Perhaps those who took the seeds without results did not grind them, or did not grind them fine enough, and did not soak the resulting flour. The chemistry of the seeds seems not to vary from region to region, and seeds grown in the Antilles and in Europe are as potent as those grown in Oaxaca. I have taken the black seeds twice in my home in New York, and their potency is undeniable.

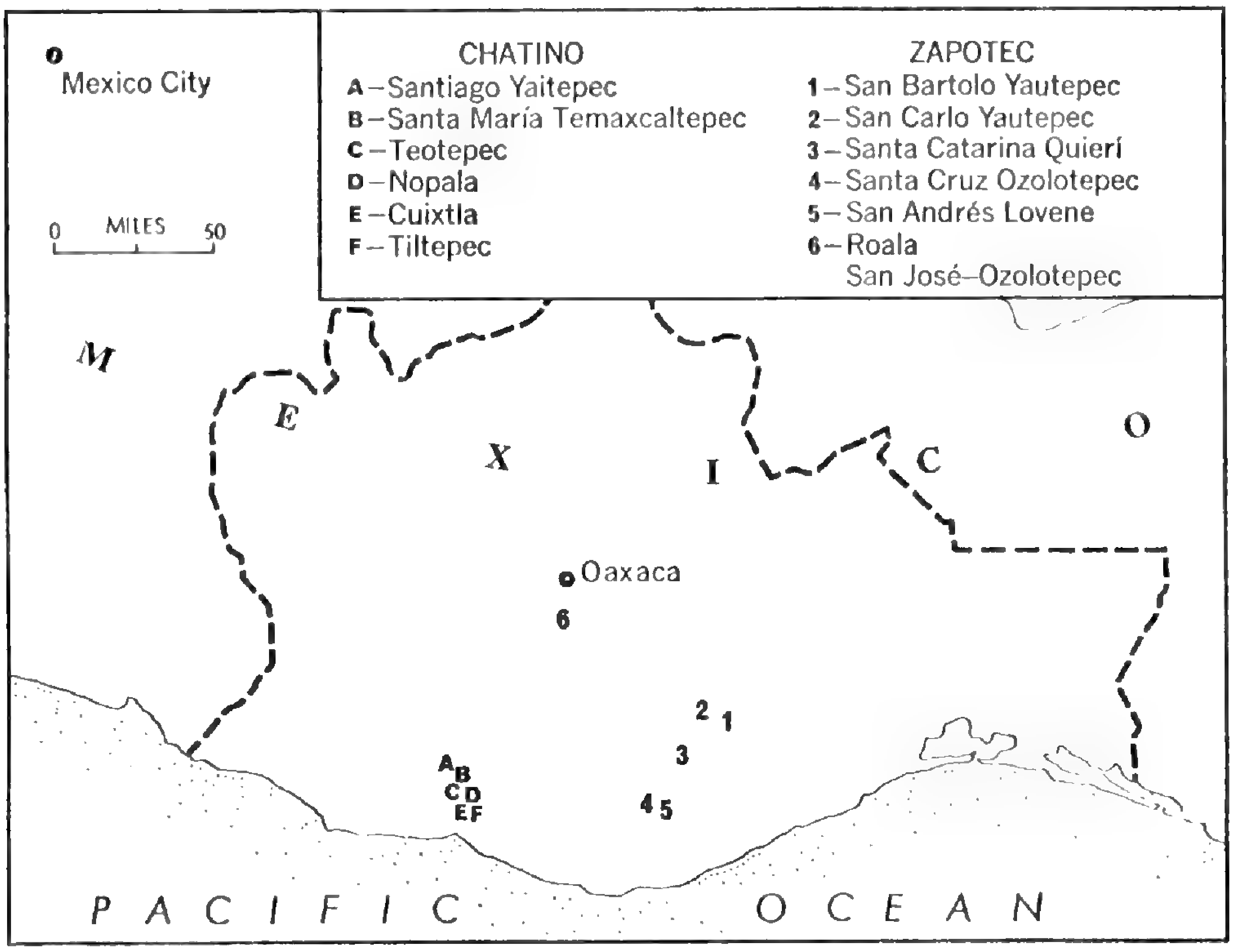
Don Tomás MacDougall and his colleague Francisco Ortega of Tehuantepec, both old and excellent friends

PLATE XXIX

Ipomoea violacea

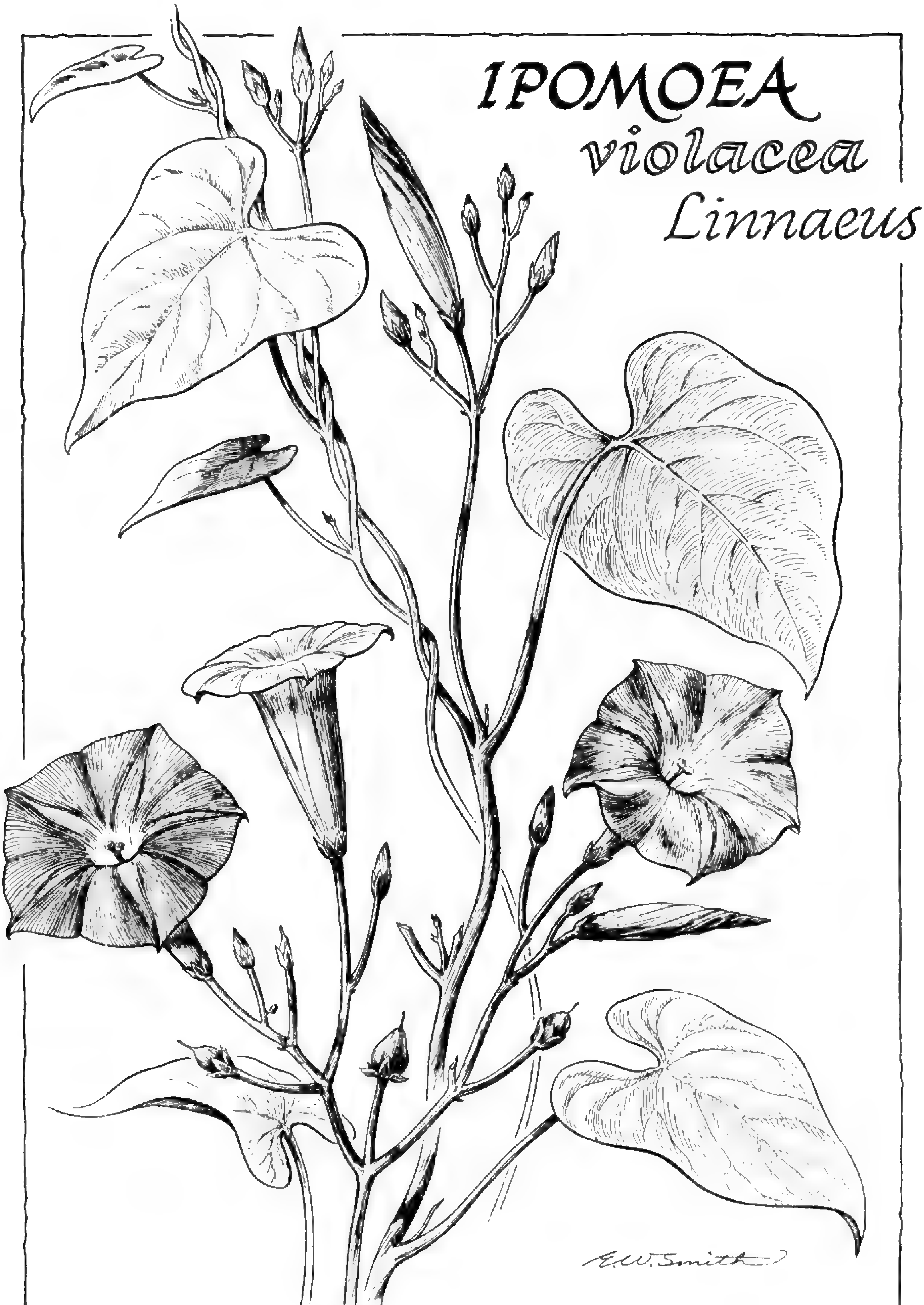
Photo by WASSON

of Ing. Weitlaner, have given us permission to use their notes and photographs for this article. We publish for the first time a map showing the villages in Oaxaca where they have found the *Ipomoea* seeds in use, a group of seven Zapotec villages visited by Don Tomás, and also six villages in the Chatino country visited at my express request by 'Chico' Ortega in 1962, as we had a suspicion that the black seed was used in that linguistic area.[26] The area of diffusion is certainly far wider than these villages, but this is a start.



The black seeds are called variously in the Zapotec country: *badoh negro* seems to be the prevalent name. But in the Zapotec dialect spoken in San Bartolo Yautepec they are called *la'aja shnash*, 'seed of the Virgen'. In this town Francisco Jiménez ('Chico Bartolo') took a series of photographs in the course of a routine vigil. A relative of his, Paula Jiménez, is a *curandera*, and she officiated, and also dictated an account of the steps taken in the rite. We give a paraphrase of what she said.

PLATE XXX



Drawn approximately one-half natural size.

Drawn by ELMER W. SMITH

First, the person who is to take the seeds must solemnly commit himself to take them, and to go out and cut the branches with the seed. There must also be a vow to the Virgen in favor of the sick person, so that the seed will take effect with him. If there is no such vow, there will be no effect. The sick person must seek out a child of seven or eight years, a little girl if the patient is a man, a little boy if the patient is a woman. The child should be freshly bathed and in clean clothes, all fresh and clean. The seed is then measured out, the amount that fills the cup of the hand, or about a thimble full. The time should be Friday, but at night, about eight or nine o'clock, and there must be no noise, no noise at all. As for grinding the seed, in the beginning you say, 'In the name of God and of the Virgencita, be gracious and grant the remedy, and tell us, Virgencita, what is wrong with the patient. Our hopes are in thee.' To strain the ground seed, you should use a clean cloth—a new cloth, if possible. When giving the drink to the patient, you must say three Pater Nosters and three Ave Marias. A child must carry the bowl in his hands, along with a censer. After having drunk the liquor, the patient lies down. The bowl with the censer is placed underneath, at the head of the bed. The child must remain with the other person, waiting to take care of the patient and to hear what he will say. If there is improvement, then the patient does not get up; he remains in bed. If there is no improvement, the patient gets up and lies down again in front of the altar. He stays there a while, and then rises and goes to bed again, and he should not talk until the next day. And so everything is revealed. You are told whether the trouble is an act of malice or whether it is illness.

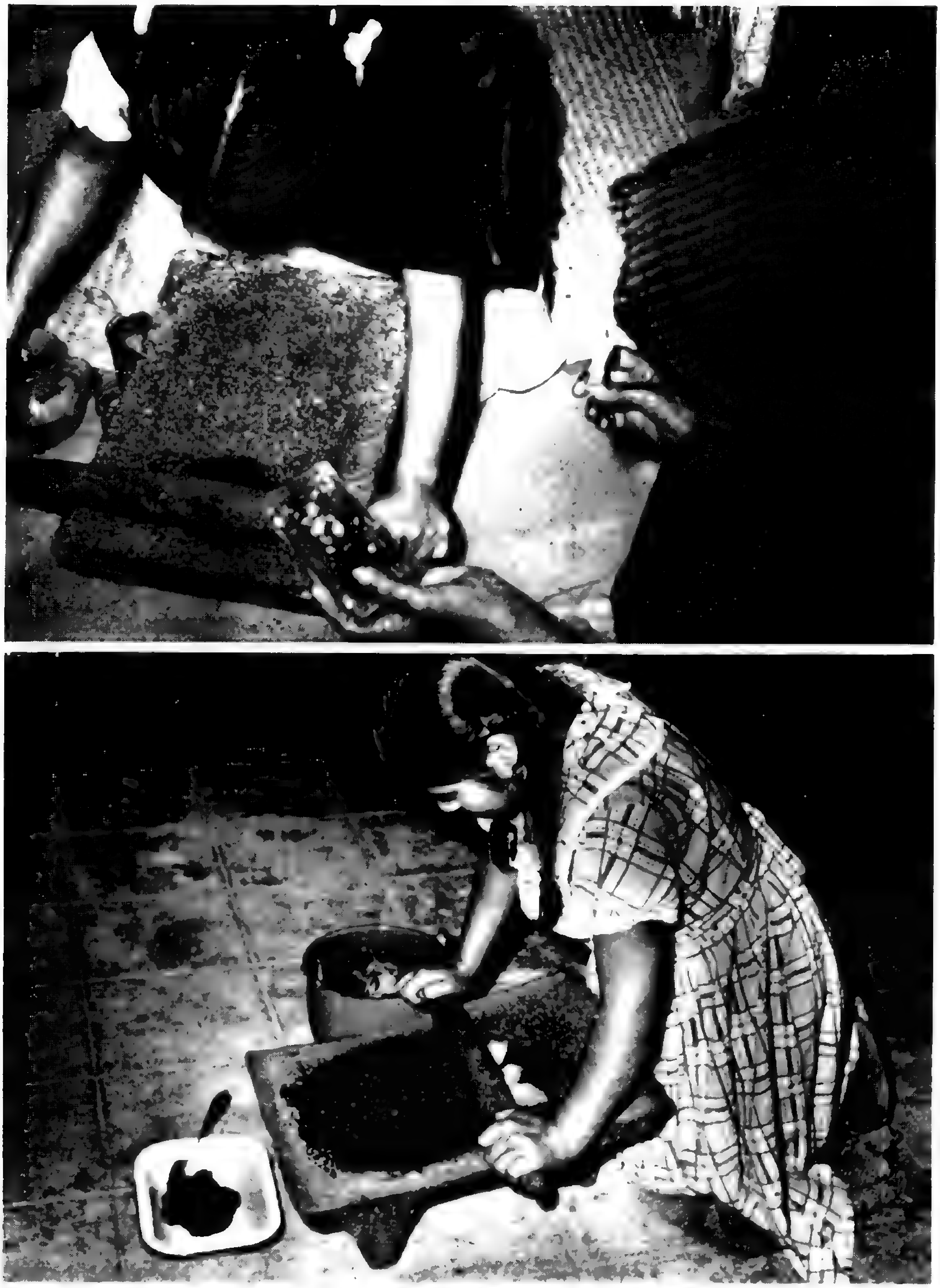
The photographs illustrate the *curandera's* account of a ceremony invoking the divine power of the morning glory seeds. A feature of this recital is the child who serves the beverage. He (or she) is ritually cleansed, a symbol of purity. I encountered this practice for the first time in 1960, in the Mixteca, in the Valley of Juxtlahuaca, when Robert Ravicz and I were looking for survivals of the mushroom cult. The mushrooms were to be gathered by a virgen, they were ground on the *metate* by a virgen.[27] In 1962, in Ayautla and also in San José Tenango, in the Sierra Mazateca, again a maiden ground the leaves of the *Salvia divinorum.* Here then is a general pattern, whether in the Sierra Mazateca, or among the

PLATE XXXI

(Left) Paula Jimenez, *curandera* of San Bartolo Yautepec, making infusion of *Ipomoea violacea* seeds. 1959. (Center) Child serving the infusion to patient, with incense burner. (Right) Patient taking infusion of *I. violacea* seeds, to be enlightened as to the cause and cure of his malady. *Photos by* CHICO BARTOLO

Mixtecs of the Valley of Juxtlahuaca, or among the Zapotecs of San Bartolo Yautepac, for the preparation of the divinatory agent, either the seeds of the morning glory or the mushrooms or the *hojas de la Pastora.* (Had we been warned in advance to look for this, perhaps we should have discovered the same custom in other regions, visited in years previous to 1960.) Suddenly it dawns on us that a deep-seated harmony exists between the role of the child in preparing the divine agent and the names circulating throughout the Nahuatl area for the sacred mushrooms themselves: we have found them called *los niños*, 'the children', and *los hombrecitos y las mujercitas*, 'the little men and the little women', and *los señoritos*, the lordlings.' Marina Rosas, *curandera* of San Pedro Nexapa, on the slopes of Popocatepetl, called the sacred mushrooms in Nahuatl *apipiltzin*, 'the noble princes of the waters', a singularly appropriate name, in which the prefix '*a*' conveys the sense of 'water'. And here we revert to the miraculous plant that we think is the *Salvia divinorum*, called (as we believe) in Nahuatl *pipiltzintzintli* in the records of the Inquisition dating from 1700. This is obviously related to the name for the sacred mushrooms used by Marina Rosas. Dr. Aguirre Beltrán translates it as 'the most noble Prince' and relates it to *Piltzintli*, the young god of the tender corn. In the accounts of the visions that the Indians see after they consume the sacred food — whether seeds or mushrooms or plant — there frequently figure *hombrecitos*, 'little men', *mujercitas*, 'little women', *duendes*, 'supernatural dwarfs'. Beginning with our maiden at her *metate*, here is a fascinating complex of associations that calls for further study and elaboration. For example, are these Noble Children related perchance to the Holy Child of Atocha, which gained an astonishing place in the hearts of the Indians of Middle America? Did they seize on this

Plate XXXII



(Top) Young girl grinding sacred mushrooms (*Psilocybe mexicana* Heim) in Juxtlahuaca, Oaxaca, in Mixteca), 1960. (Bottom) Young girl grinding *Salvia divinorum* leaves, Ayautla, Sierra Mazateca. Sept. 1962.

Photos by Wasson

Catholic image and make it a charismatic icon because it expressed for them, in the new Christian religion, a theme that was already familiar to them in their own supernatural beliefs?

The tradition of the *doncella* at the *metate* is of venerable age. Jacinto de la Serna, writing his *Manual para Ministros* toward the middle of the 17th Century, said in his Chap. XV:3 about *ololiuhqui* and *peyotl:*

> como para algunas medicinas es menester molerlo, dicen que para que haga éste effecto à de ser molido *por mano de doncella.*

Nor is this citation unique. An Indian afflicted in his nether limbs was told to take *pipiltzintzintli*:[28]

> que la había de beber *molida por una doncella*, desleída en agua tibia, en ayunas, habiendo confesado y comulgado antes de tomarla y ayunado viernes y sábado y el día siguiente beberlo en el nombre de la Santísima Trinidad y de la Virgen de Guadalupe y de San Cayetano . . . y que el aposento había de estar muy abrigado, sin luz, ni aire, ni ruido, y que no se había de dormir, sino estar en silencia aguardando a ver dichas figuras (un viejecito vestido de blanco y unos muchachos pequeñitos vestidos del mesmo color) que ellas lo untarían y desengañarían si tenía remedio su mal o no.

What an extraordinary recapitulation of the salient features of the divinatory ritual as practiced in Middle America! There is the interweaving of Christian elements and pagan. There is the maiden grinding the divine element, and the preparation of the suppliant, confessing and communicating before he consults the Mediator. There is the sheltered spot,—protected from sound and light. There is the consultation on an empty stomach. There is the clear intimation as to what one sees: a little old man clothed in white and little boys garbed in the same. Finally there is the august pronouncement whether the affliction of the suppliant can or cannot be remedied. All these features are always present, regardless of the divinatory plant that is consulted.

PLATE XXXIII

Two views of mushroom stone in Namuth collection; early pre-classic, B.C. 1000–500. The figure emerging from stipe is believed to be that of a young woman before *metate* or grinding stone. Note her breasts. *Photos by* HANS NAMUTH

Perhaps there is testimony far older than the colonial records of the Inquisition. In the collection of Hans Namuth of New York is a 'mushroom stone' of extraordinary features.[29] The cap of the mushroom carries the grooved ring that, according to Stephan F. de Borhegyi, is the hallmark of the early pre-Classic period, perhaps 1000 B.C. The stone comes from the Highlands of Guatemala. Out of the stipe there leans forward a strong, eager, sensitive face, bending over an inclined plane. It was not until we had seen the *doncella* leaning over a *metate* and grinding the sacred mushrooms in Juxtlahuaca in 1960, that the explanation of the Namuth artifact came to us. The inclined plane in front of the leaning human figure must be a *metate*. It follows that the face must be that of a woman. Dr. Borhegyi and I went to see the artifact once more: it was a woman! A young woman, for her breasts were only budding, a *doncella*. How exciting it is to make such a discovery as this: a theme that we find in the contemporary Mixteca, and in the Sierra Mazateca, and in the Zapotec country, is precisely the same as we find recorded in Jacinto de la Serna and in the records of the Santo Oficio. Again it is precisely the same, if our interpretation of the silent witness in the New York studio of Mr. Namuth be correct, as in a stone carving that dates back perhaps 2,500 years!

NOTES

Abbreviations:

AGN: Archivo General de la Nación, ramo Inquisición.

AB: Gonzalo Aguirre Beltrán: Medicina y Magia, 1955, Mexico. (A thoughtful monograph with numerous quotations from AGN, indispensable for every student of its subject.)

1. *Vide, e.g.*, AGN, vol. 340, folios 354–359.
2. The Caribs were also called Canibs or Calibs. From 'Canib' the English-speaking world derived 'cannibal', which is preferred by it to 'anthropophage'. Shakespeare in his *Tempest* took his foul monster Caliban from the 'Calibs'.
3. There is a well known sentence in Sahagún, Bk. X, Chap. XXIX, 2, that is usually read as follows: 'Hay otra hierba como tunas de tierra que se llama peyotl . . . ' According to Professor Charles E. Dibble, the Florentine Codex, folios 129v–130r, reads thus: 'Ay otra yerva, como turmas de tierra, que se llama peyotl . . . ' *Turmas* is a Spanish word of ancient lineage and obviously makes sense. It was more familiar in Mexico in Sahagún's time than now. *Vide* Joan Corominas: *Diccionario Critico Etimológico de la Lengua Castellana*, entry *turmas*.
4. AB, Chap. 7, Area Cultural and Foco de Difusión.
5. a) Lewis Lewin: 'Über Anhalonium Lewinii', Arch. für experim. Path. und Pharma., 24:401: 1888. In translation this article also appeared in the same year in the *Therapeutic Gazette*, London. In these initial articles there was a misunderstanding about which species of cactus *peyotl* was.

   b) Havelock Ellis: 'A Note on Mescal Intoxication.' *The Lancet*, No. 3849. June 5, 1897.

   c) S. Weir Mitchell: 'Note upon the Effects of Anhalonium lewinii.' *Brit. Med. Journal*. Dec. 5, 1896.

   After their initial papers these three authors continued writing on the subject in books and articles. Lewin in his 1888 paper did not report on human experiences with *peyotl:* the first such report appeared in *The Therapeutic Gazette*, on Sept. 16, 1895: 'Anhalonium Lewinii (Mescal Buttons). A study of the drug, with especial reference to its physiological action upon man, with report of experiments', by D. W. Prentiss and Francis P. Morgan.
6. *Vide* Weston La Barre: 'Twenty years of peyote studies', *Current Anthropology*, Vol. 1, No. 1, Jan. 1960.
7. AB, Chap. 7, Etimología.

8. *Vide* V. P. Wasson and R. G. Wasson: *Mushrooms Russia and History*, Pantheon Books, N.Y., 1957, pp. 311, 313, and 315.

9. 'Teo' means 'god' in Nahuatl; no Nahuatl word is more richly documented than this. The resemblance to the Latin and Greek word for 'god' is one of those fortuitous convergences of sound and meaning that occur in language studies. Given the multiplicity of languages in the world and the limited number of sounds that the human voice can utter, they are inevitable. 'Nacatl' means 'flesh', and 'nanacatl' is used for mushroom, a plural form of the word for 'flesh'. This interpretation of the word was accepted from the beginning: three early colonial sources take it for granted. No modern Nahuatl scholar disputes it.

10. 'Identification of the Teonanacatl, or "Sacred Mushroom" of the Aztecs, with the narcotic cactus, *Lophophora*, and an account of its ceremonial use in ancient and modern times', an address delivered May 4, 1915, before the Botanical Society of Washington. Published as 'An Aztec Narcotic (Lophophora Williamsii)' in *Journal of Heredity*, Vol. 6, July 1915.

11. For Reko references *vide* my bibliography on the hallucinogenic mushrooms published in the Botanical Museum Leaflets, Harvard Univ., Sept. 7, 1962, Vol. 20, No. 2, Entries 144–147. Second edition, with corrections and addenda, March 10, 1963, No. 2a.

12. 'The Elements of Mazatec Witchcraft', Gothenburg Ethnographical Museum. *Ethnographical Studies 9*, 1939, pp. 119–49. Also 'Some Notes on the Mazatec'. Lecture before Sociedad Mexicana de Antropología, Mexico, Aug. 4, 1938, published by Editorial Culture, 1939. In both papers Johnson speaks of the Mazatec practice of consuming an infusion of a plant known as *hierba María* for divination purposes. This is surely the plant that we have called *hojas de María*, 'leaves of the Virgen Mary', and that has lately been named *Salvia divinorum* Epling & Játiva: we suppose it is the *pipiltzintzintli* of Colonial Nahuatl. Incidentally Ing. Weitlaner discovered a Mazatec informant in the Chinantla who gave him the most extensive testimony about this plant that we had had until it was identified in 1962. See 'Curaciones Mazatecas', AINAH, Vol. IV, No. 32, 1949–50.

13. *Vide* Harvard Botanical Museum Leaflets, Feb. 21, 1939, Vol. 7, No. 3, p. 38 ftnt.

14. *Vide* Roger Heim and R. Gordon Wasson: *Les Champignons Hallucinogènes du Mexique*, Archives du Muséum National d'Histoire Naturelle, Series 7, Vol. VI, p. 184.

15. *Vide* above, Note 8. Also 'Seeking the Magic Mushroom', *Life*, May 13, 1957: International Edition, June 10; 'En Busca de los Hongos Magicos', *Life en Español*, June 3. Also 'I Ate the Sacred

Mushroom', by Valentina P. Wasson, *This Week*, May 19, 1957.

16. *Vide* Harvard Botanical Museum Leaflets, Sept. 7, 1962, Vol. 20, No. 2; also second edition, with corrections and addenda, March 10, 1963, No. 2a.
17. Sahagún: X:24:27. Juan de Cárdenas: De los problemas y secretos maravillosos de las Indias, Mexico, 1591, folio 243v. Also AB: Chap. 5, Note 9, and Chap. 7, Note 97.
18. AB: Chap. 5, *Pipiltzintzintli.*
19. Harvard Botanical Museum Leaflets, Dec. 28, 1962. Vol. 20, No. 3. Carl Epling and Carlos D. Jativa-M.: 'A New Species of Salvia from Mexico.
20. V. P. Wasson and R. Gordon Wasson: *Mushrooms Russia and History*, pp. 324–6; also Plate LIV. Also Roger Heim and R. Gordon Wasson, *Les Champignons Hallucinogenes du Mexique*, Chap. III, Fig. 15 bis.
21. 'The Psychotropic Active Principles of *Ololiuqui*, an ancient Aztec Narcotic', lecture delivered at the IUPAC Symposium on 'The Chemistry of Natural Products', in Melbourne, August 18, 1960.
22. 'A Contribution to our Knowledge of *Rivea corymbosa*, the narcotic ololiuqui of the Aztecs', published by Botanical Museum of Harvard University, Cambridge, Mass., 1941.
23. Thomas MacDougall: '*Ipomoea tricolor:* A Hallucinogenic Plant of the Zapotecs', published in Boletín del Centro de Investigaciones Antropológas de México, No. 6, March 1, 1960.
24. AB: Chap. 6, El Complejo del Ololiuhqui, Para. 7. The author did not know of the use of *Ipomoea* seeds when he published his book; in fact, he associated *ololiuhqui* with the *Solanaceae* rather than the *Convolvulaceae*. He explained the blackness of the seeds as an attribute caused by age.
25. For example, V. J. Kinross-Wright: 'Research on Ololiuqui: The Aztec Drug.' *Nuero-Psychopharmacology*. Vol. 1. Proc. 1st. Inter. Cong. of Nuero-Pharmacology, Rome, Sept. 1958. pp. 453–56. Also 'Das Mexikanische Rauschigift Ololiuqui,' by Blas Pablo. *El México Antiquo*. Vol. III. Nos. 3/4. Dec. 1934. pp. 1–7; especially p. 6. But for a powerful reaction see Humphrey Osmond: 'Ololiuqui: the ancient Aztec Narcotic,' published in *Jour. of Mental Science*, Vol. 101, No. 424, July 1955.
26. *Vide* R. Gordon Wasson: 'The hallucinogenic fungi of Mexico: An inquiry into the origins of the religious idea among primitive peoples.' Harvard Botanical Museum Leaflets, Vol. 19, No. 7, Feb. 1961., pp. 152–3, ftnt., last sentence.

Chico's visit to the Chatino country served a dual purpose. In *Beyond Telepathy* (Doubleday, N.Y., 1962) Andrija Puharich on

p. 20 had said this: 'The author was also informed by certain Brujos among the Chatino Indians (living in Southern Caraca) that they used the *Amanita muscaria* for hallucinogenic purposes. The proper dose is one-half of a mushroom.

If true, this would be sensasional. It is not true. *A. muscaria* is the hallucinogenic mushroom of the Siberian tribesman in their rites. It is not used in Mexico.

When we first began visiting the Indian country of southern Mexico, we were expecting to find that the hallucinogenic mushroom there was *A. muscaria.* For ten years we have combed the various regions and we have invariably found that it played no role in the life of the Indians, though of course it is of common occurrence in the woods. We had visited the Chatino country, where we were accompanied by Bill Upson of the Instituto Linguistico de Verano, who speaks Chatino. Later he likewise helped Puharich, but he informs us that no *brujo* in his presence testified to the use of a mushroom answering to the description of *A. muscaria.* After the Puharich statement had appeared, I gave Bill a photograph in color of *A. muscaria*, and he returned to Juquila and Yaitepec. An informant named Benigno recognized the mushroom at once and identified the stage of development that it had reached, as would be expected of a countryman intimately familiar with his environment. He said the people in his area do not take that kind of mushroom. Chico Ortega is a Zapotec Indian of mature years, keen intelligence, high sense of responsibility, and vast experience throughout the villages of the State of Oaxaca. In the summer of 1962 I sent him, with the color photo, to sound out Chatino villagers as to the use they made of it. Discreetly, he went from village to village. The results were uniformly and unanimously negative.

Puharich in *The Magic Mushroom* as well as in his most recent book is unduly impressed with the occurrence of *A. muscaria.* Wherever the species of trees occur with which it lives in mycorrhizal relationship, it is common. It is one of the commonest of fungi in North America and Eurasia. Puharich quotes at length as an authority Victor Reko, a notorious *farceur*, not to be confused with his cousin, Blas Pablo Reko.

Puharich does not identify the spot where he met his *brujos*, though it seems probable that he did not get beyond the mestize town of Juquila. He does not identify his *brujos.* He does not explain how he put his question to them, how he explained over a double linguistic barrier what *A. muscaria* looked like. He does not explain what precautions he took to avoid a leading question that would almost certainly produce his desired answer.

27. *Vide* Robert Ravicz: 'La Mixteca en el Estudio Comparative del Hongo Alucinante.' AINAH, Vol. XIII, 1960 (1961), pp. 73–92; see pp. 79, 80, 86.

28. AB: 'La Familia de los Solanos,' ftnt. 45.

29. It is important to note that the nine miniature mushroom stones found at Kaminaljuyu, Guatemala, and reported by Borhegyi, 1961, figure 1, were found in a sealed cache together with nine miniature legless *metates* accompanied by *manos*. The fact that the *metates* were found together in association with the mushroom stones indicates the possibility that they were used together in ceremonials, probably for crushing or grinding mushrooms or ololiuhqui seeds.

    (Stephan F. de Borhegyi: 'Miniature Mushroom Stones from Guatemala', *Amer. Antiquity*, Vol. 26, No. 4, pp. 498–504, April 1961.)

THE ACTIVE PRINCIPLES OF THE SEEDS OF *RIVEA CORYMBOSA* AND *IPOMOEA VIOLACEA*

BY

ALBERT HOFMANN*

Background of the present investigations

THE preceding article by R. Gordon Wasson described the history and ethnobotanical aspect of ololiuhqui and emphasized the significant position that this drug occupies in relation to the other Mexican divinatory agents. The following account will consider the chemical investigations that led to the isolation of the active principles of this old Aztec magic drug and to the elucidation of its chemical structure.

The road that led to the discovery of the active principles of ololiuhqui is both remarkable and significant. It is, therefore, excusable to preface the chemical report with a short account of the background and results of these investigations.

It all started exactly 20 years ago, when I was engaged in the synthesis of lysergic acid derivatives in the pharmaceutical-chemical research laboratory of Sandoz Ltd. in Basle, Switzerland.

Lysergic acid is the foundation stone of the ergot alkaloids, the active principles of the fungus-product *ergot*. Botanically speaking, ergot is the sclerotia of the filamentous fungus *Claviceps purpurea* which grows on grasses,

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* Sandoz Ltd., Basle 13, Switzerland. This article is dedicated to Robert J. Weitlaner on the occasion of his 80th birthday.

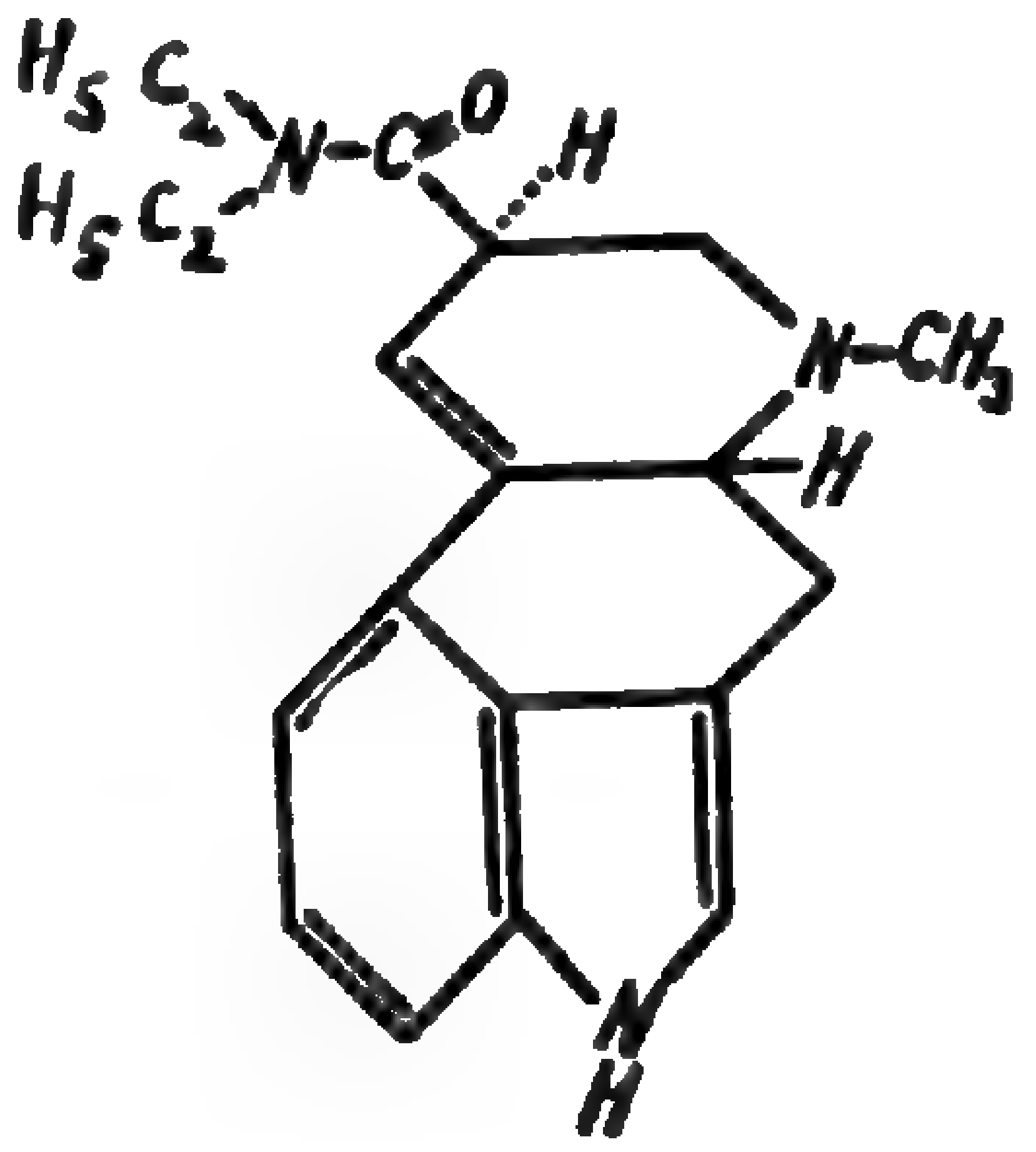
especially rye. The ears of rye that have been attacked by the fungus develop into long, dark pegs to form ergot. The chemical and pharmacological investigation of the ergot alkaloids has been a main field of research of the natural products department of the Sandoz laboratories since the discovery of ergotamine by A. Stoll in 1918. These investigations have resulted in a variety of useful pharmaceuticals which find wide application in obstetrics, in internal medicine, in neurology and psychiatry.

On the 16th of April 1943, upon recrystallizing d-lysergic acid diethylamide tartrate, which I had produced from natural lysergic acid and diethylamine by way of the lysergic acid hydrazide and azide, I suddenly became strangely inebriated. The external world became changed as in a dream. Objects appeared to gain in relief; they assumed unusual dimensions; and colors became more glowing. Even self-perception and the sense of time were changed. When the eyes were closed, colored pictures flashed past in a quickly changing kaleidoscope. After a few hours, the not unpleasant inebriation, which had been experienced whilst I was fully conscious, disappeared. What had caused this condition? Subsequent systematic self-experimentation with the chemicals that I had used on that day were to provide the answer. Lysergic acid diethylamide was tested, amongst other substances, as it was possible that a drop had fallen on my fingers and had been absorbed by the skin. I commenced my experiments on this compound by taking 0.5 ml. of a 0.5 per mille aqueous solution, corresponding to 0.25 mg. of d-lysergic acid diethylamide tartrate. This extremely small quantity proved to be a substantial overdose. A state of inebriation, lasting for a number of hours and filled with dramatic experiences, which have been described in former publications,[1] [2] followed. This is how the most active psychotomimetic hallucinogenic compound known up to the present was discovered, a compound which subsequently attained great importance under the name of LSD 25 (Delysid ^{R}) in experimental psychiatry and recently also in psychotherapy as well.

Lysergic acid diethylamide (formula I) was produced during the course of large scale investigations on semi-synthetic amides of lysergic acid after d-lysergic acid L-propanolamide-(2) (formula II), which was found to be identical with the natural alkaloid ergometrine (also known as ergonovine), had been synthesized. This was the first synthesis of a natural ergot alkaloid.[3] After the discovery of the psychotomimetic activity of LSD, a great number of further simple lysergic acid amides were synthesized in our laboratories[4] so as to ascertain the relationship between chemical structure and psychic activity in this group of compounds. The unsubstituted d-lysergic acid amide (=ergine) (formula III) and the d-isolysergic acid amide (isoergine) (formula IV), were amongst these semi-synthetic analogues of LSD. Ergine, isoergine and ergometrine were later, as will be shown below, found to be active principles of ololiuhqui.

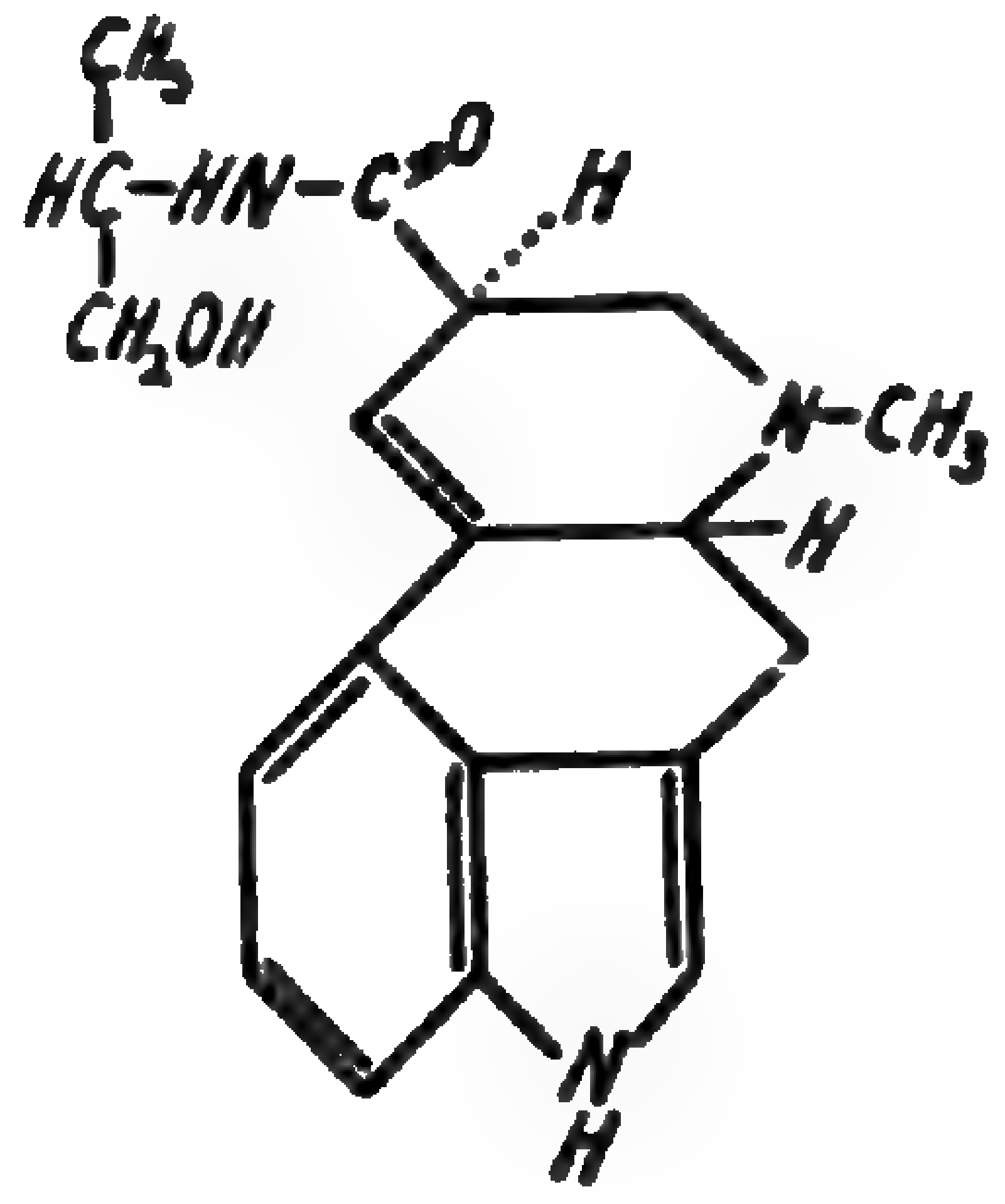
The discovery of LSD and subsequent research in the field of psychotomimetics caused the Mexican fungi to be brought to our laboratories. The history of the discovery of these fungi and the contribution to it by engineer Roberto J. Weitlaner and his daughter Irmgard Weitlaner-Johnson, the work of Reko and of Schultes, as well as their rediscovery by the husband and wife team of Valentina P. and R. Gordon Wasson in collaboration with the mycologist Professor Roger Heim, were described in the preceding article. After chemical analysis in a Paris laboratory had proved unsuccessful, Professor Heim sent a few of the hallucinogenic fungi to us in Basle on the assumption that the necessary conditions for a successful chemical investigation would be present

PLATE XXXIV



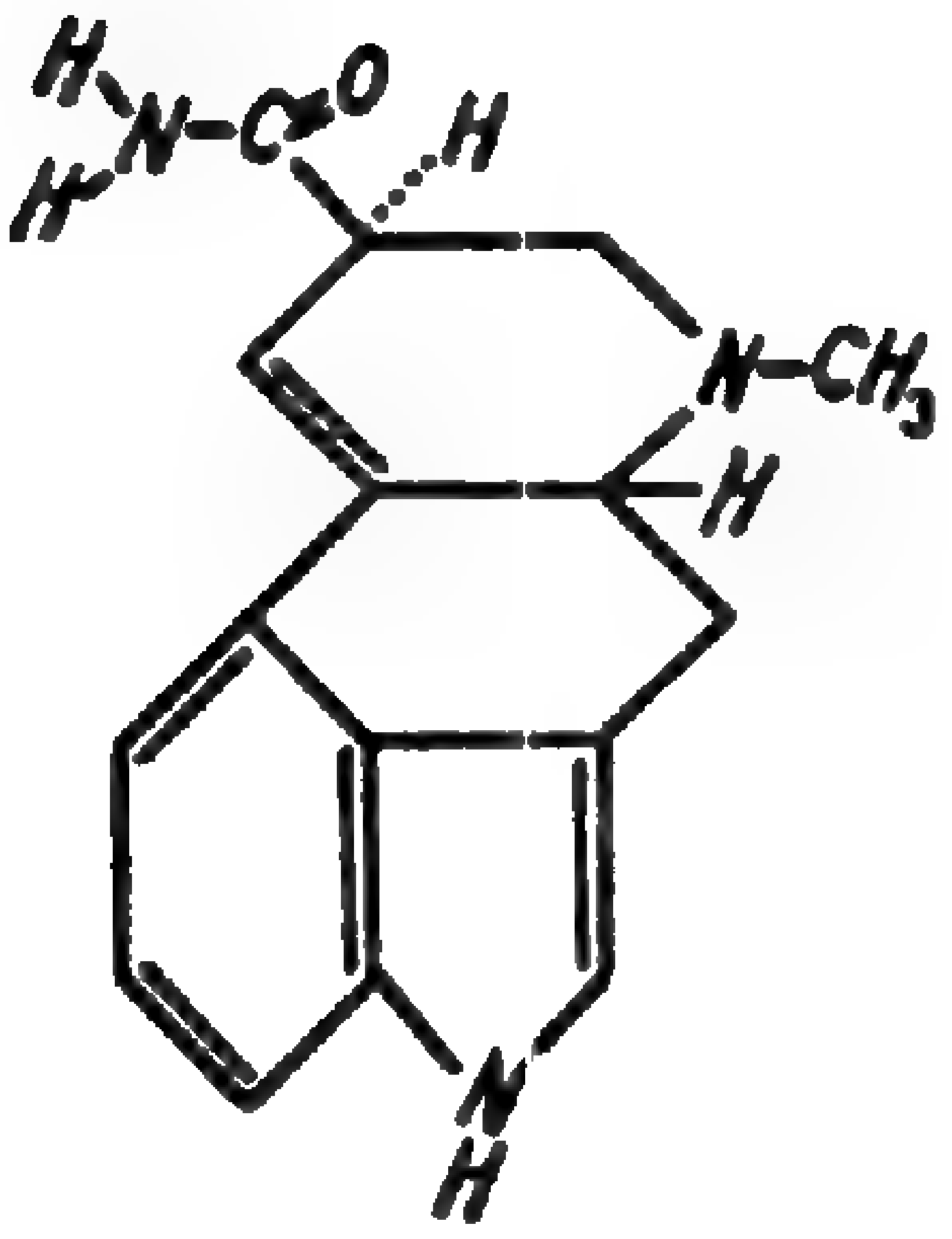
LSD

I



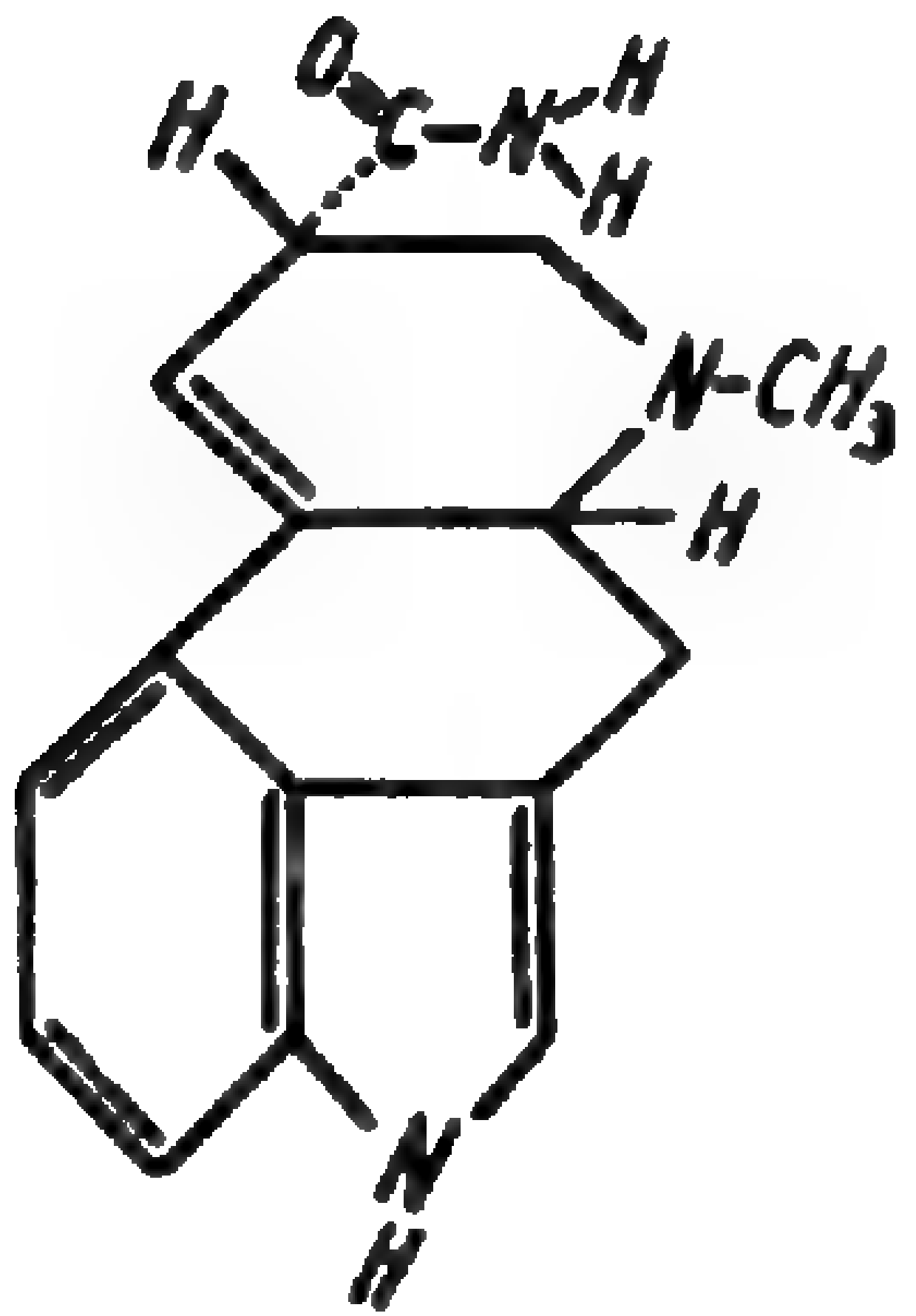
Ergometrine
(Ergonovine)

II



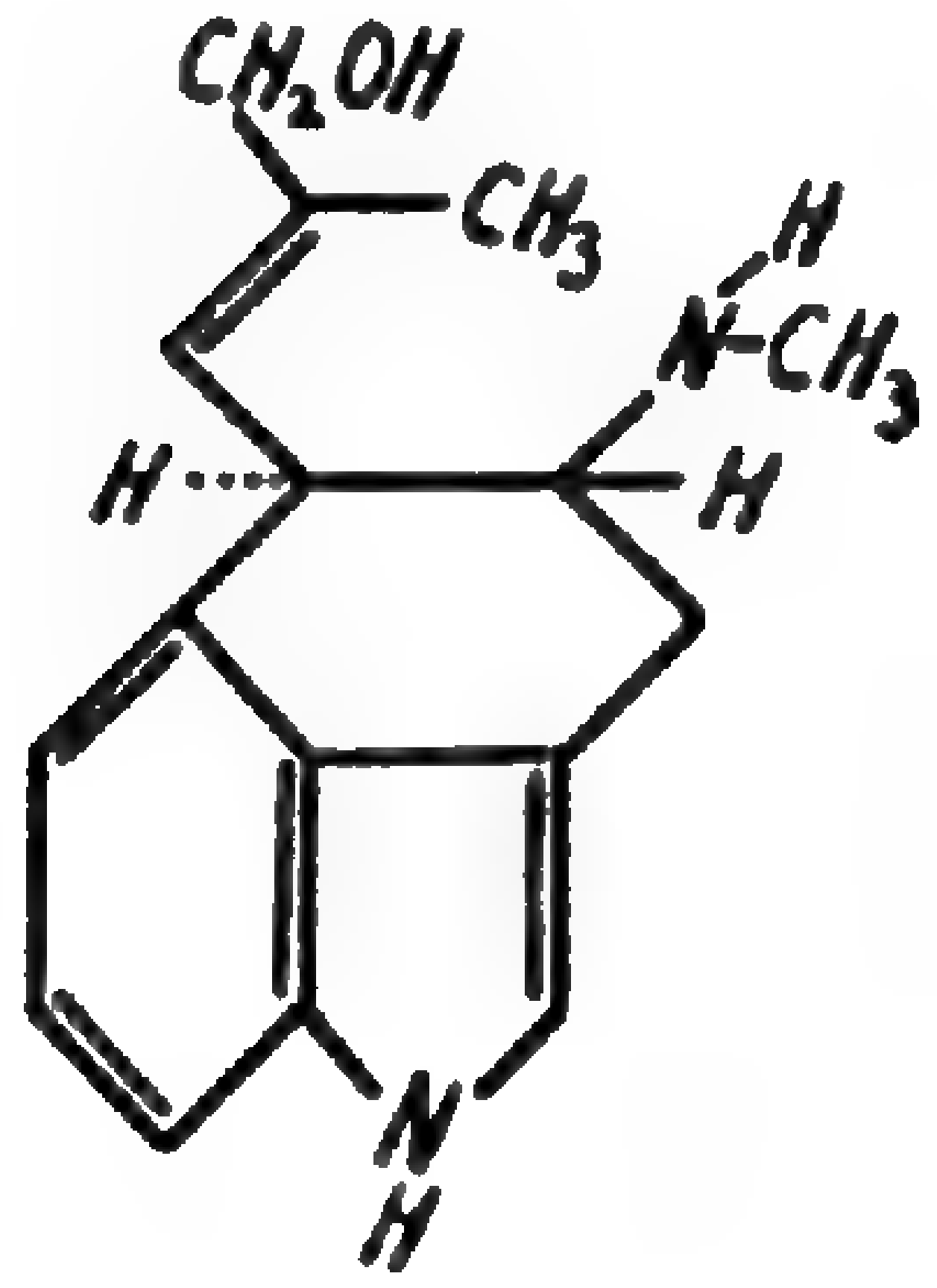
Ergine

III



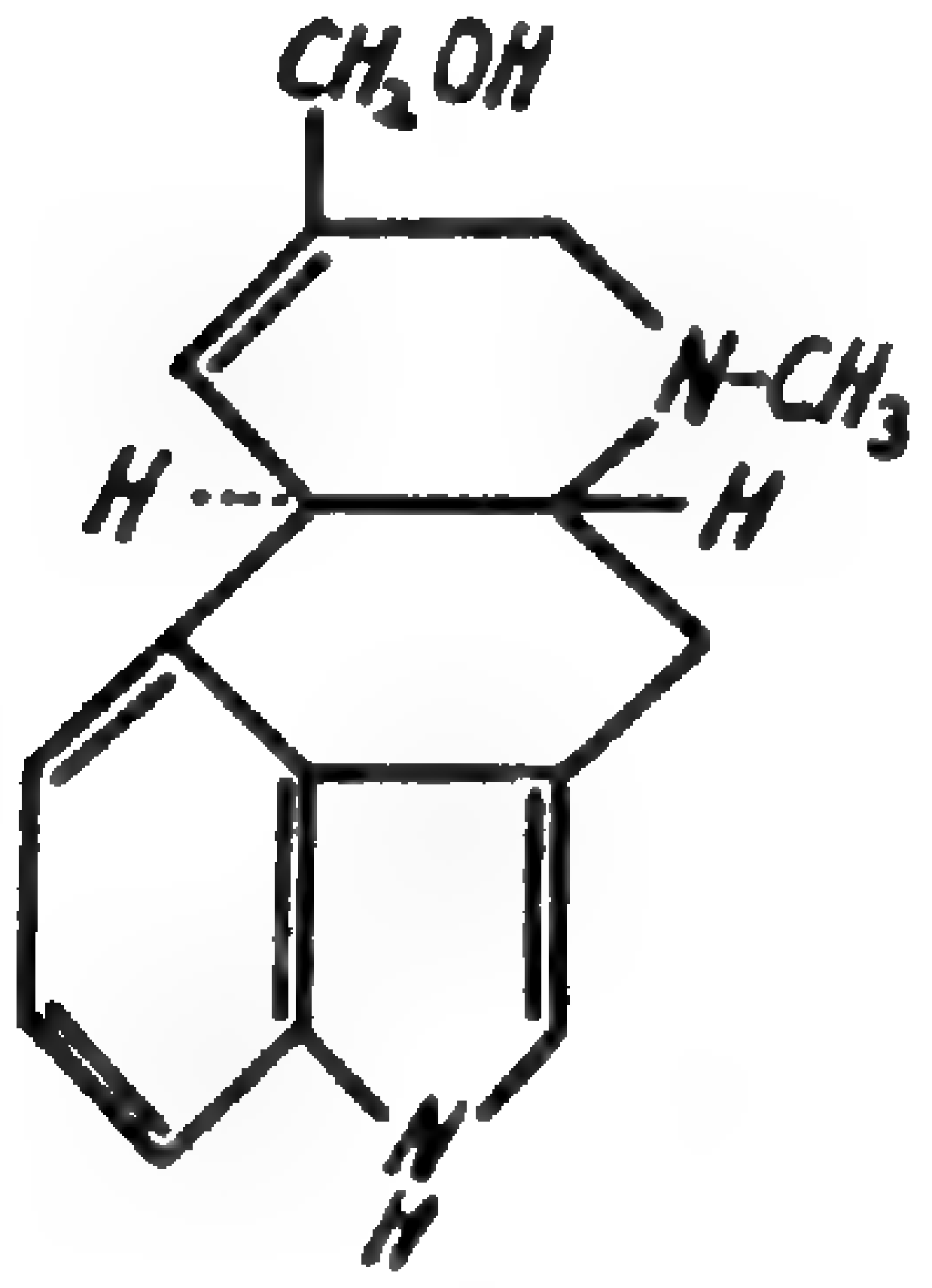
Jsoergine

IV



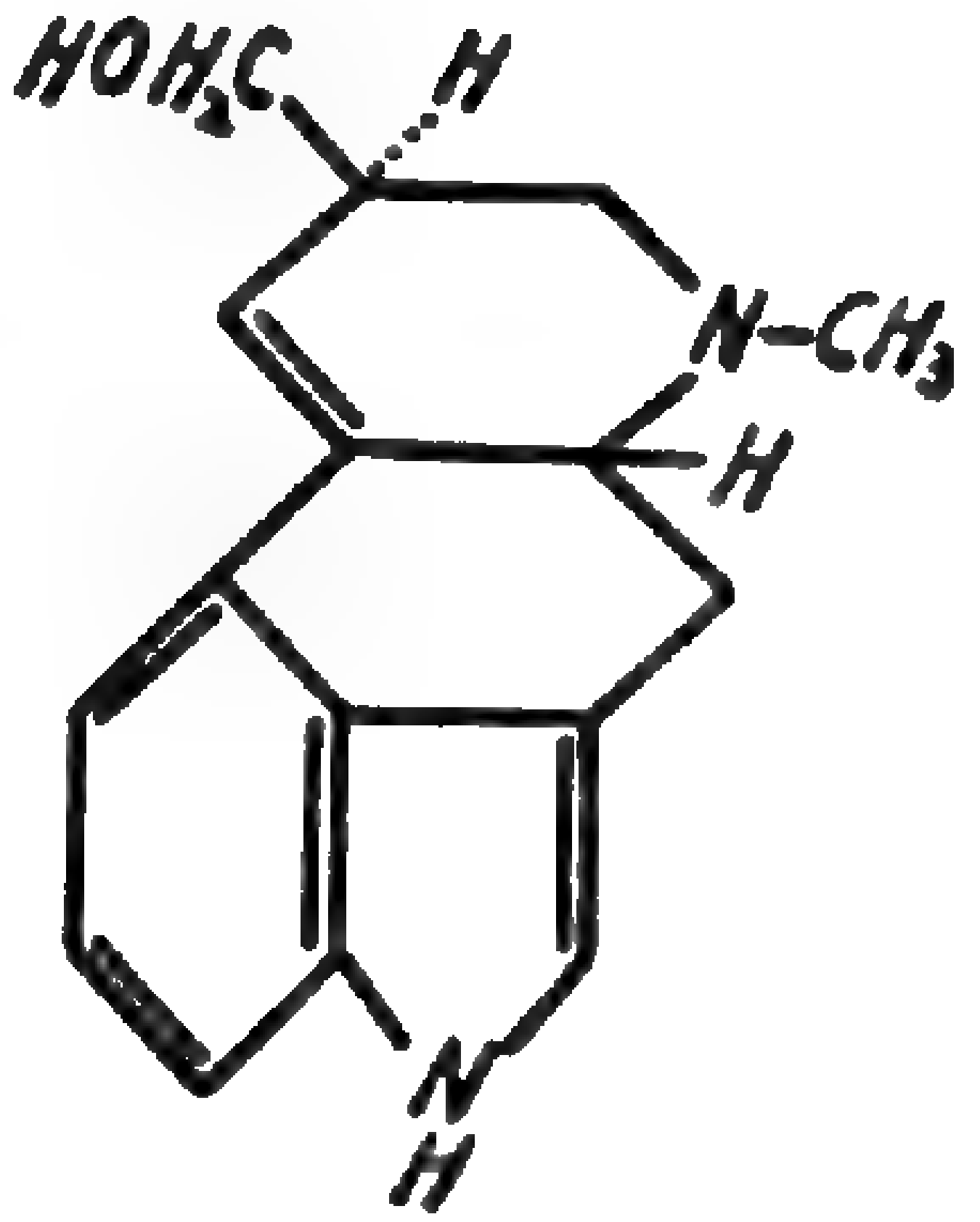
Chanoclavine

V



Elymoclavine

VI



Lysergol

VII

in the laboratory in which LSD was discovered. During the course of chemical studies on ''teonanácatl'', psilocybin and psilocin were discovered as active principles of the most important hallucinogenic fungi.[5] Thus it was that the present investigations were crowned with success within an unusually short time, as these two active principles are indole compounds that are structurally related to LSD and ergot alkaloids. In the chain of events that led to the ololiuhqui problem, the most important factor was that the writer came into personal contact with Wasson as a result of investigations on the active principles of ''teonanácatl''.

Fired by the discussions with this outstanding expert on the Mexican magic drugs and encouraged by our successes with the hallucinogenic fungi, we decided to tackle the chemical investigation of the third most important Mexican psychotomimetic after ''peyotl'' and ''teonanácatl''—namely ''ololiuhqui''. With the help of Wasson, we obtained authentic ''ololiuhqui'', as he sent us two samples from his expedition in Mexico in the late summer of 1959. With the samples, he wrote from Mexico City on August 6, 1959, the following: ''. . . I am sending you . . . a small parcel of seeds that I take to be *Rivea corymbosa,* otherwise known as ''ololiuhqui'', well known narcotic of the Aztecs, called in Huautla ''la semilla de la Virgen''. This parcel, you will find, consists of two little bottles, which represent two deliveries of seeds made to us in Huautla, and a larger batch of seeds, delivered to us by Francisco Ortega (Chico), the Zapotec guide, who himself gathered the seeds from the plants at the Zapotec town of San Bartolo Yautepec . . . '' The first mentioned light brown, roundish seeds (see Plate XXXVI, top left) from Huautla (21 g.), upon botanical investigation, were found to be *Rivea corymbosa* (L.) Hall.f., whilst the black and angular seeds (see Plate

XXXVI, bottom left) were found to represent *Ipomoea violacea* L. (204 g.).

The first small samples were sufficient for a number of chemical-analytical experiments, which showed the presence of indole compounds. This interesting result induced us to order greater quantities of these two seeds from Wasson. This second, large contingent of seeds (12 kg. of seeds of *Rivea corymbosa* and 14 kg. of *Ipomoea violacea*) was obtained with the aid of the Weitlaners, about whom Wasson gave the following information to the writer in a letter of 10th December 1959: "Robert Weitlaner is an Austrian, a naturalized Mexican citizen . . . He is a field anthropologist and likes being in the field much better than lecturing to the students in the Instituto Nacional de Antropología e Historia, where he has a post. He is past 70 already, but still goes out for months at a time with almost no luggage, living in the villages. Irmgard is his daughter, the native-textile expert of the Museo Nacional . . . " These Rivea seeds obtained with the aid of the Weitlaners were gathered in the vicinity of Ocozocoautla (Chiapas), the Ipomoea seeds in the Zapotec region by Thomas MacDougall and Francisco Ortega.

In 1960, MacDougall published his important discovery that, especially in the region of the Zapotecs, the seeds of a second twining species, which he found to be *Ipomoea violacea*, were used in conjunction with or instead of ololiuhqui.[6]

By using the large quantities of seeds of *Rivea corymbosa* and *Ipomoea violacea*, which we received in the early part of 1960 in the manner already described, we were able to isolate the main active principles and identify these chemically during the course of the summer. This isolation and identification will be reported in detail below. In a number of ways, the results of these investigations were surprising. The active principles of the Mexican morning glory drugs proved to be ergot alkaloids. The two main components were, in the case of both seeds, d-lysergic acid amide (ergine) and d-isolysergic acid amide (isoergine), whilst four additional alkaloids were present. The former are closely related to d-lysergic acid diethylamide (LSD), which we had, as has already been mentioned, produced synthetically and investigated many years before. From the phytochemical point of view, this finding was unexpected and of particular interest, because lysergic acid alkaloids, which had hitherto been found only in the lower fungi in the genus *Claviceps*, were now, for the first time, indicated for the higher plants, in the phanerogamic family *Convolvulaceae*.

The isolation of lysergic acid amides from ololiuhqui closed what is in reality a most strangely coincidental circle of research.

It was with the discovery of lysergic acid diethylamide (LSD) as a highly active psychotomimetic agent, during investigations on simple lysergic acid amides, that our research in the field of hallucinogenic compounds commenced. It was within the framework of this activity that the sacred Mexican fungi came to our laboratories. It was during the course of these investigations that I made personal contact with Wasson. And it was as a result of this contact that the investigations of ololiuhqui were conducted. In this sacred drug, lysergic acid amides, which made their appearance in the initial stages of our psychotomimetic research, were again found as active principles.

Former investigations on ololiuhqui

In the classical study of the ololiuhqui problem by R. E. Schultes, published in 1941[7] (in which the historical, ethnographical and taxonomical aspects are treated in an excellent manner), the only chemical investigation that had been done on the active principles of the seeds of *Rivea corymbosa* before the studies carried out by us, is discussed. It was carried out by the pharmacologist, C. G. Santesson, in Stockholm in 1937.[8] He was, however, unsuccesful in isolating defined, crystallized compounds. Certain reactions seemed to suggest the presence of gluco-alkaloids.

Following Schultes' work, only two original publications have appeared that deal with the psychic action of ololiuhqui seeds on volunteers. In 1955, a Canadian psychiatrist, H. Osmond, conducted a series of experiments on himself. After taking 60 to 100 Rivea seeds, he passed into a state of apathy and listlessness accompanied by increased visual sensitivity. After about four hours, there followed a period in which he had a relaxed feeling of well-being, a feeling that lasted for some time.[9] In contrast to this result, V. J. Kinross-Wright in 1958 published the results of experiments performed on eight male volunteers who had taken doses of up to 125 seeds administered without any ascertainable effect in a single case.[10]

Isolation and chemical identification of the active alkaloidal principles

Plate XXXVI shows the seeds of *Rivea corymbosa* (L.) Hall.f. and of *Ipomoea violacea* L., the origin of which has been given above and which were used for the chemical investigations now described. Plate XXXV shows plants in bloom that were cultivated from these seeds.

We started our extraction studies with *Rivea corymbosa*. Since we knew nothing of the chemical nature and sensitivity of the active principles, only neutral solvents were used and all extracts were evaporated carefully at low temperature. The finely powdered seeds were extracted with methanol, and the evaporated methanol extracts were defatted with petroleum ether. The defatted residue was tested for various kinds of alkaloids, especially for indolic compounds, since the indole structure was known to occur in psychotomimetic agents. Indeed, when paper chromatograms of this Rivea extract were developed by spraying with a benzene solution of p-dimethylamino benzaldehyde and subsequently treated with hydrochloric acid gas, violet-blue spots appeared, indicating the presence of indolic compounds. In order to assess whether this indole fraction actually represented the active principle, we collected some milligrams of this fraction from a great number of paper chromatograms and my laboratory assistant H. Tscherter and I tested it on ourselves. After my experience with LSD, I have become cautious: we started by taking doses as small as 0.1 mg., gradually increasing the dosage. With 2 mg. of this crude indole fraction we got clear-cut psychic effects: a dream-like state resulted with drowsiness and alterations in the perception of objects and colors. This showed that the indole fraction of the Rivea extract contained the psychic active principles.

The paper chromatographical testing of the extract of *Ipomoea violacea* showed that here, too, the same or a similar indole compound was present. An even better separation than by the paper chromatogram was attained by thin layer chromatography. In Plate XXXVI, right, the chromatograms of the extracts of *Rivea corymbosa* and *Ipomoea violacea*, which were obtained on plates with aluminum oxide layer, using chloroform containing 5% of methanol as the moving phase, are shown side by side. The indole compounds were made visible by spraying with a 5% solution of p-dimethylamino benzaldehyde in concentrated hydrochloric acid and treating with the fumes of aqua regia.

PLATE XXXV

Rivea corymbosa

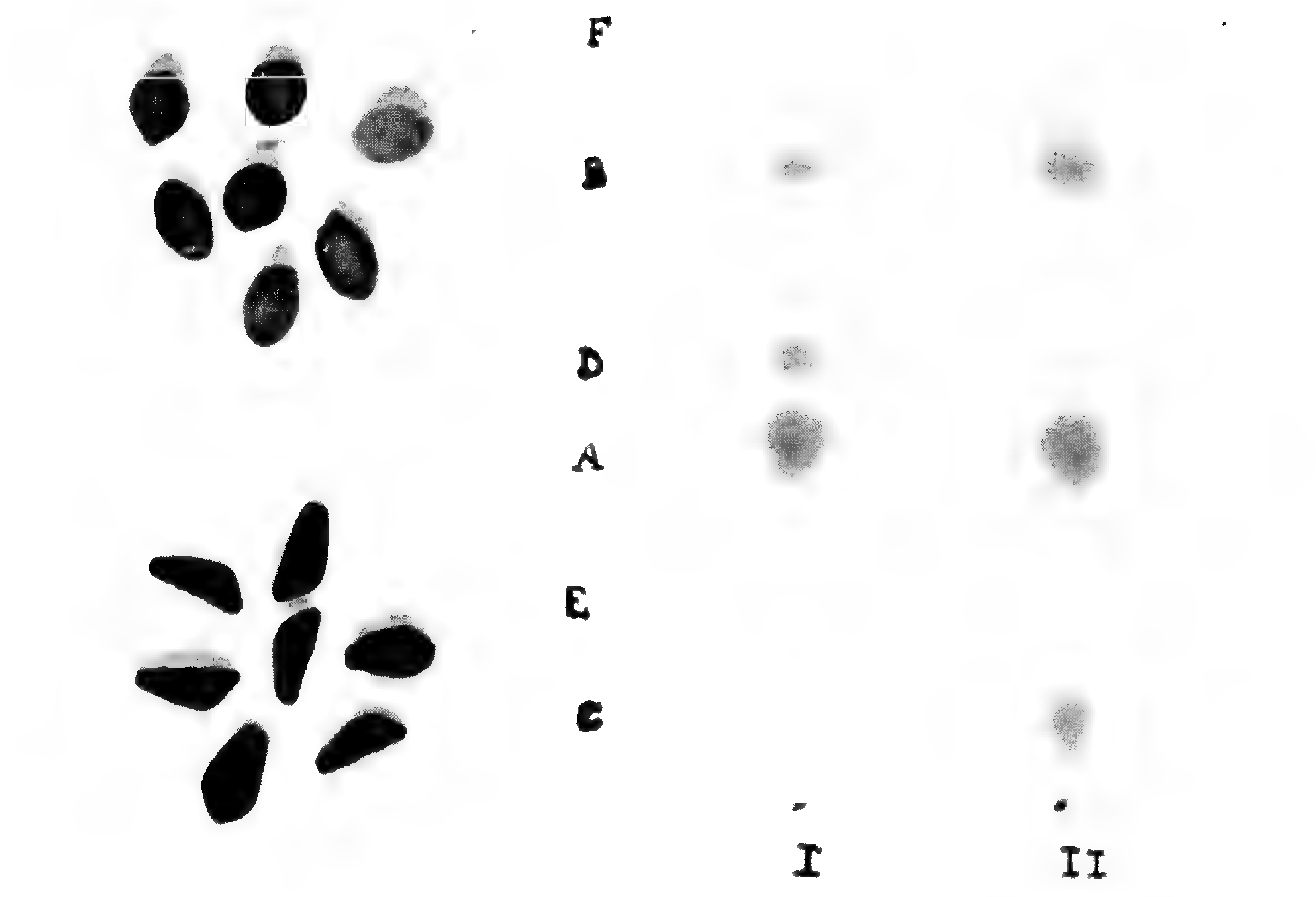
Ipomoea violacea

When larger quantities of seeds of *Rivea corymbosa* and *Ipomoea violacea* were available, the indole compounds could be obtained in preparative quantities. It was found that they were alkaloidal in nature and that they could be isolated by the usual methods used for the extraction and purification of alkaloids. For this purpose, the finely ground seeds were made alkaline with sodium bicarbonate, then extracted with ethyl acetate. The alkaloids were then removed from the extracts, which had been concentrated to a small volume in vacuum, with aqueous tataric acid from which they were again shaken with ethyl acetate after making the mixture alkaline with a sodium bicarbonate solution. From the alkaloid fractions thus obtained, the individual components visible in the thin layer chromatogram could be separated by fractional crystallization, chromatography on aluminum oxide columns and thin layer plates with aluminum oxide and silica gel layers, on a preparative scale. The separated compounds were obtained in crystalline form and could be identified chemically. For further details, the reader is referred to our chemical publications.[11 11a 12 13] Only the results of the chemical investigations can be summarized briefly within the scope of this article. These are given in Table I.

The fact that *Ipomoea violacea* contains a greater total of active principles than does *Rivea corymbosa* explains why the Indians used smaller quantities of badoh negro (Ipomoea) than of badoh (Rivea).

Identification of the individual indole bases showed that ergot alkaloids were present. The main component of the alkaloid mixture in the Rivea and Ipomoea seeds, which corresponds to spot A, is d-lysergic acid amide (ergine) (formula III), a compound that was first obtained as a cleavage product upon alkaline hydrolysis of ergot alkaloids[14] and then also by partial synthesis from

PLATE XXXVI



Seeds of *Rivea corymbosa* (top, left) and *Ipomoea violacea* (bottom, left). (Right) Thin layer chromatogram of the alkaloidal fraction, each 25γ of *Rivea corymbosa* (I) and *Ipomoea violacea* (II).

TABLE I

Alkaloids of *Rivea corymbosa* and *Ipomoea violacea* seeds.

Thin layer chromatogram (Plate XXXVI, right)		*Rivea corymbosa* (ololiuhqui, badoh)	*Ipomoea violacea* (badoh negro)
A	d-Lysergic acid amide (ergine)	0.0065 %	0.035 %
B	d-Isolysergic acid amide (isoergine)	0.0020 %	0.005 %
C	Chanoclavine	0.0005 %	0.005 %
D	Elymoclavine	0.0005 %	0.005 %
	Lysergol	0.0005 %	—
	Ergometrine	—	0.005 %
	Total alkaloid content (colorimetrically determined calculated on a mol. weight of 300)	0.012 %	0.06 %

lysergic acid and recently as a genuine alkaloid from the ergot of *Paspalum* grass.[15] The alkaloid corresponding to spot B in the chromatogram was found to be identical with d-isolysergic acid amide (isoergine) (formula IV) which, as in the case of ergine, was already known as the hydrolysis product of ergot alkaloids[16] and as a natural alkaloid. The third alkaloid, chanoclavine (formula V), which forms spot C in the chromatogram, had been discovered by us in ergot of the tropical millet cob *Pennisetum typhoideum.*[17] Elymoclavine (formula VI), contained in spot D, was first isolated from the ergot of the wild grass *Elymus mollis.*[18]

Ergometrine (formula II), the alkaloid which is mainly responsible for the uterotonic hemostatic action of the ergot drug, could only recently be identified as one of the active principles of *Ipomoea violacea.*[19] Together with elymoclavine, it forms spot D in the thin layer chromatogram (Plate XXXVI), right. The seeds of *Rivea corymbosa* either do not contain this compound or else only traces thereof. Instead, we found lysergol (formula VII) in the last mentioned seed, an alkaloid absent from the seeds of *Ipomoea violacea.* Lysergol was produced synthetically[20] in our laboratories (as were d-lysergic acid amide, d-isolysergic acid amide and ergometrine) before it was discovered as one of the active principles of a Mexican magic drug. The compounds corresponding to spots E and F are present in such small quantities that they have hitherto not been identified.

In Plate XXXIV, the structural formulas of the six alkaloids now isolated from ololiuhqui and badoh negro are depicted. These formulas clearly show the close relationship between ololiuhqui's active principles and the most active hallucinogenic agent known thus far, the synthetically produced LSD (formula I).

As has already been pointed out, the discovery of ergot alkaloids in the higher plants is a most unexpected phytochemical discovery. In view of the uniqueness of these findings, other investigators found it necessary to ascertain whether these alkaloids were actually produced by plant tissue or whether they were produced by fungi or bacteria present in the seeds. Before publishing our results, we examined our seed samples for attack by fungus and found that they were healthy and had not been infected. Furthermore, we had detected the alkaloids in fresh leaves, stalks and roots of *Ipomoea violacea* and, to a very small extent also, in the leaves of *Rivea corymbosa.*[19] These were results that showed that ergot alkaloids were in fact produced by tissues of *Rivea corymbosa* and *Ipomoea violacea* and not by fungi infecting the seeds.

Our results were confirmed by the detailed investigations of W. A. Taber and R. A. Heacock who ascertained that the alkaloids are concentrated in the embryo of the seeds and are absent from the shells that had occasionally been attacked by fungi.[21] The occurrence of small quantities of alkaloids in the leaves and stems of *Rivea corymbosa* was also confirmed.[22] W. A. Taber, L. C. Vining and R. A. Heacock then also investigated the seeds of a number of commercially available varieties of Morning Glory (*Ipomoea* and *Convolvulus* spp.) and were able to trace the presence of alkaloids in a number of these ornamental plants.[23] The quantitative determination and the identification of clavine and lysergic acid alkaloids, however, was done only colorimetrically or by means of paper and thin layer chromatography. In no instance were the individual alkaloids isolated and crystallized by the authors.

Pharmacological and clinical activity of the isolated alkaloids

There is no doubt that the alkaloids isolated from the seeds of *Rivea corymbosa* and *Ipomoea violacea* are the active principles of these magic plants. Aside from the described alkaloids, a large quantity of a new glucoside, which was named turbicoryn by M. C. Pérezamador and J. Herrán, was isolated from the seeds of *Rivea corymbosa.*[24] [25] It is most improbable that the presence of this glucoside has anything to do with the psychotomimetic action of ololiuhqui as, according to our observations, the seeds of *Ipomoea violacea,* which are stronger than the Rivea seeds, contain none of this glucoside or only small traces of it. On the other hand, the high pharmacological and psychic activity of the lysergic acid amides, as well as of elymoclavine and lysergol, is certain.

D-lysergic acid amide (designation of compound undergoing tests: LA 111) was tested pharmacologically and clinically during the course of investigations on d-lysergic acid diethylamide (LSD 25) and related compounds long before it was known to be a component of ololiuhqui. Already at that stage we had, in experiments on ourselves, ascertained a psychotomimetic activity with a marked narcotic component with dosages of 0.5 to 1 mg. The following paragraph is taken from a hitherto unpublished record of the first experiment which the writer performed upon himself with LA 111 on 30.10.1947.

10.00 h: Intramuscular injection of 0.5 ml of 1 per mille solution of LA 111 (=0.5 mg d-lysergic acid amide).
11.00 h: Tiredness in the neck, slight nausea.
11.05 h: Tired, dreamy, incapable of clear thoughts. Very sensitive to noises which give an unpleasant sensation.
11.10 h: Desire to lie down and sleep. Genuine physical and mental tiredness, which is not experienced as an unpleasant sensation. Slept for 3 hours.
15.00 h: Return of normal condition with full capacity for performing work.

This action of d-lysergic acid amide was later confirmed by the comparative systematic investigation of H. Solms.[26] [27] He describes the action as follows: LA 111 induces indifference, a decrease in psychomotor activity, the feeling of sinking into nothingness and a desire to sleep . . . until finally an increased clouding of consciousness does produce sleep.

Clinical investigations have been initiated with d-isolysergic acid amide but no results are available yet. Upon taking 2 mg. of isoergine himself, the writer experienced tiredness, apathy, a feeling of mental emptiness and of the unreality and complete meaninglessness of the outside world.

Elymoclavine and lysergol elicit an excitation syndrome in various animals that is caused by a central stimulation of the sympathicus.[28] The results of clinical testing are not, as yet, available.

Psychotomimetic effects are unknown for ergometrine, which is used to a large extent in obstetrics as a uterotonic and hemostatic agent. When using the small dosages which are administered for this purpose, the alkaloid apparently has no action on the psychic functions. Its occurrence in the alkaloid mixture of *Ipomoea violacea* can thus have no significant effect on the action of badoh negro. Furthermore, chanoclavine, which has no outstanding pharmacological activity, appears to play no part in the occurrence of the psychic effects of badoh and badoh negro.

According to the results of experiments performed thus far with pure alkaloids, it appears as though d-lysergic acid amide, elymoclavine and lysergol and possibly also d-isolysergic acid amide are mainly responsible for the psychic effect of ololiuhqui.

Systematic comparative investigations are presently being performed with the pure alkaloidal principles of ololiuhqui and total extracts from the seeds so as to ascertain the psychic effect on humans. These will show whether the alkaloids described alone are responsible for the psychotomimetic effects, which, in view of our present knowledge, seems probable, or whether other factors play a part.

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A NEW GOSSYPIUM FROM THE CAPE VERDE ISLANDS

BY

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DURING the course of our investigations on the evolution and distribution of diploid and tetraploid cotton,[3] we have gradually assembled living collections of the wild and cultivated species of the genus *Gossypium*. Through the efforts of Dr. Thomas Kerr, Cotton Branch, Agricultural Research Service, United States Department of Agriculture and of Director Professor A. Quintanilha and Ing. L. A. Grandvaux Barbosa of Centro de Investigação Científica Algodoeira, Moçambique, we received in 1961 a packet of seed collected by Mr. Barbosa on one of the Cape Verde Islands, where he had been asked to look for *G. capitis-viridis* Mauer, an endemic species known only from the type collection. From these, one plant was grown in a greenhouse at Raleigh, and it soon became evident that we had neither *G. capitis-viridis* nor any other known species of the genus. In recognition of Mr. Barbosa's special effort to find this unusual *Gossypium* material, we name the species for him.

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Gossypium Barbosanum *Phillips & Clement sp. nov.*

Frutex perennis, erectus, usque ad 2 m. altus, cum ramis paucis, gracilibus, patentibus; rami frugiferi uni- vel biarticulati. Folia in lobos quinque ad septem ovato-ellipticos profunde divisa, cum nectario subtus in nervo medio. Corolla infundibuliformis, fulva cum macula purpurea in dimidio inferiore. Calyx post anthesin marcescens, cum bracteolis linearibus in lobos lanceolatos tres vel quattuor divisis. Capsula circiter duplo longior quam latior, rostellata, tri- vel quadrilocularis, glandulis atris prominentibus maculata. Semina circiter duplo longiora quam latiora, atrofulva, glabra, stratu unico fibrarum fulvarum circiter 6 mm. longarum obtecta.

TYPE: Plant grown in greenhouse, North Carolina State College, Raleigh, North Carolina, from seed collected by L. A. G. Barbosa at Monte do Trigo, near Tarrafal, Ilha de Santo Antão, Cape Verde Islands. *Phillips & Clement 891* (U.S. Nat. Herb.; Econ. Herb. Oakes Ames).

Upright perennial shrub 1–2 m. tall; branches slender, flexuous, spreading, becoming glabrate in age, the young twigs dotted with darkly pigmented glands, strigose; petioles 3–4 cm. long, sparsely strigose; leaves ca. $\frac{7}{8}$ cut into 5–7 ovate-elliptic lobes, stellate-pubescent above and below, an elongate-elliptic nectary on mid-vein 2–3 mm. long; fruiting branches usually 1–2 jointed; pedicels 1–2 cm. long, gland-dotted, strigose; corolla funnel-form, petals cream with a magenta spot covering lower half, sparsely gland-dotted over entire surface but glands more numerous along one side, stellate-pubescent on portion exposed in bud; staminal column ca. 1 cm. long, 0.5 cm. wide, antheriferous throughout, unpigmented; style projecting $\frac{1}{2}$ length of androecium above uppermost anthers, sparsely gland-dotted, stigmas united to top; calyx cupulate, minutely stellate-pubescent, gland-dotted, 8–10 mm. long, tube ca. 5 mm. long, lobes 3–5 mm. long, deltoid, subequal, entire calyx becoming necrotic following formation of an abscission layer at its base shortly after anthesis; bracteoles narrow, stellate-pubescent, gland-dotted, $\frac{1}{2}$–$\frac{2}{3}$ cleft into 3-(4) lanceolate lobes, subtended by a nectary; capsules about twice as long as broad, glabrous, acuminately beaked, 3–4 locular, dotted with prominent darkly-pigmented glands, sutures forming partial, false septa at base and bearing a few long hairs above, ovules 4–6 per locule; seeds ca. twice as long as broad, covered with a single layer of brown fibers ca. 6 mm. long; seed coat dark-brown, smooth.

The affinities of *G. Barbosanum* are with the species of Section *Anomala,* which contains the botanically well-known *G. anomalum* Wawra and Peyr. and *G. triphyllum* Hochreutiner, as well as *G. capitis-viridis,* known only from the type specimen (which we have not seen). The major differences between the species of Section *Anomala* are indicated in Table I. Characteristics for *G. capitis-viridis* are taken from the type description, those for the other species from living material.

One *G. Barbosanum* characteristic is worthy of special note since it distinguishes this species from all other species of *Gossypium.* Shortly after anthesis, an abscission layer forms at the base of the calyx, leading to its gradual and progressive necrosis; by the tenth day after anthesis the calyx is completely necrotic.

The gametic chromosome number of *G. Barbosanum* is 13, the basic number of all the known diploid species of the genus.

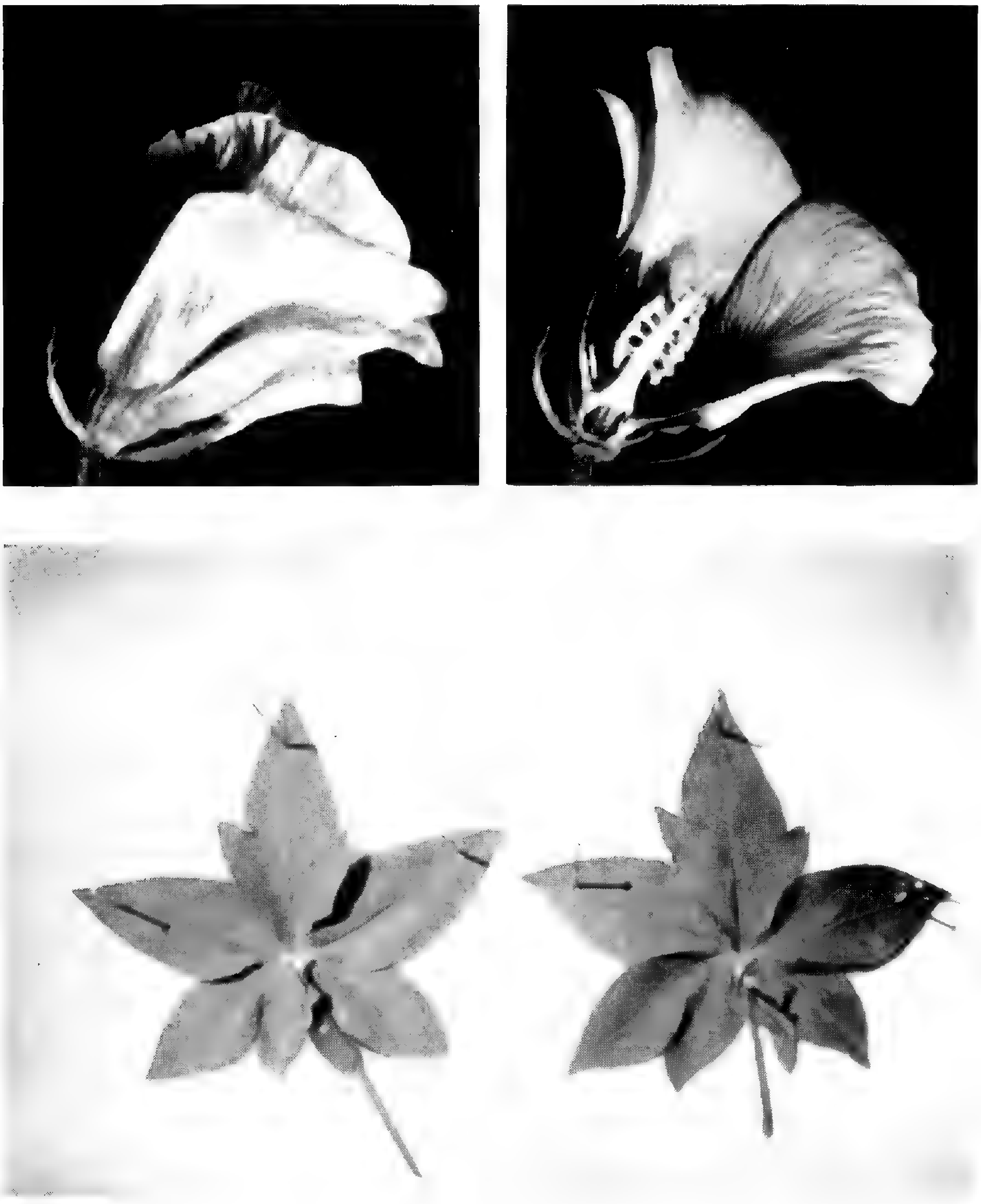
On the basis of comparative cytology (Beasley, 1942), each species of *Gossypium* is assigned to one of six genome groups (A, B, C, D, E, or AD); *G. anomalum* and *G. triphyllum* have thus been assigned to the B genome group as B_1 and B_2, respectively. Preliminary cytologi-

TABLE I

Comparison of the Species of Section Anomala

	G. anomalum	*triphyllum*	*Barbosanum*	*capitis-viridis*
Plant pubescence	usually villous	short tomentose	sparsely strigose	sparsely strigose
Climax leaf shape	3/4–4/5 cut into 3–5 ovate lobes	3-foliolate, leaflets sublinear	7/8 cut into 7 ovate-elliptic lobes, mid-lobe usually secondarily lobed	unknown no. (prob. 4–5) ovate lobes
Foliar nectaries	3	1	1–3	3
Bracteole shape	entire to 3–4 toothed	entire	3(4) teeth, one-half to two-thirds cleft	2–3 toothed
Corolla	cream, occasionally with magenta flush	cream with lavender flush	cream	yellow
Petal spot	large	large	large	absent
Capsule locule no.	usually 3-locular	3-locular	3–4 locular	5-locular

Plate XXXVII



Upper left: Flowers at anthesis, nearest bracteole removed (× 1). Upper right: Same flower, partially dissected (× 1). Lower: Two typical climax leaves (× 2/3).

cal analyses of *G. Barbosanum* × *G. anomalum* hybrids indicate a close homology between the chromosomes of the two species, and *G. Barbosanum* is therefore assigned the genome symbol B_3.

ACKNOWLEDGMENT

We wish to express our thanks to Mr. Charles Schweinfurth of the Botanical Museum for preparing the Latin description.

LITERATURE CITED

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PLATE XXXVIII

Portion of flowering branch (× 1.6).

PLANTAE COLOMBIANAE XVI

SAURAUIAE PROVINCIAE PUTUMAYONIS SPECIES NOVA

BY

RICHARD EVANS SCHULTES

SELDOM in a large genus such as the dilleniaceous *Saurauia* does a new species appear with a distinguishing character so sharp as that in the following hitherto undescribed concept.

Saurauia Alvaroi *R. E. Schultes sp. nov.*

Arbor aliquid robusta, usque ad quadraginta pedes alta. Rami fusci, lepidoti, squamis minutissimis, albis subcrystallinisque. Ramuli similes. Foliorum lamina petiolata, valde coriacea, obovata, apice acuminata, basi cuneata, minute et irregulariter (apicem versus praecipue) serrulata, supra vivo atroviridis et glabra, infra (in nervis densiore) minutissime stellato-pilosa, nervi centralis partem basalem versus laciniis duabus vexilliformibus ad perpendiculum directis 6.5 cm. longis, usque ad 1.2 cm. altis extremis ambis cohaesis ex lamina prorumpentibus atque septum canaliculatum formantibus, usque ad 35 cm. longa, 16 cm. lata; nervis plusminusve duodeviginti, subparallelis; petiolus robustus, 3–5 cm. longus, 5 mm. in diametro. Inflorescentiae multiflorae, foliis breviores, usque ad 25 cm. longae; pedunculis aureofuscis, lepidotis; bracteis siccis, subulatis, setosis, usque ad 5 mm. longis. Flores subsessiles, aromatico-fragrantes, alabastro 5–6 mm. in diametro. Sepala quinque, aurea, in maturitate sicca atque persistentia, obovata vel subrotundata, 6–7 mm. lata, plusminusve 9 mm. longa, extus dense aureo-setoso-scabrida, inter setis minutissime et densissime albido-subcrystallino-squammata, margine minutissime ciliata, intus glaberrima. Petala quinque, alba, fere usque ad basim libera, membranacea, glabra, subquadrangulate rotundato-ovata, margine undulata, plusminusve 7 mm. lata, 7 mm. longa. Stamina plusminusve quadraginta, corollae basi valde adhaerentia, basi longe et dense lanato-barbata. Staminum filamenta 2.5–3 mm. longa; antherae flavae, versatiles, 3 mm. longae. Ovarium globosum, quinque-partitum, glabrum, 2.5 mm. in diametro, quinque cum stylis carnosis parvisque. Fructus adhuc ignotus.

Saurauia Alvaroi may be distinguished from all other known concepts of the genus by a most curious canal-like pouch which is formed by two conspicuous vexilliform flaps arising perpendicularly from the base of the leaf blade along the midrib and which are joined together at their apical and basal ends. The purpose of this unusual structure is not clear. In none of the many leaves examined on the type tree and others was there evidence that the flaps might in any way be concerned with insect habitation. In all examples, the canal was empty. This species, which I can relate closely to no known concept, likewise differs from most Colombian species of *Saurauia* in its large number of stamens and in having an almost entirely glabrous upper surface of the leaves.

The exceptionally rich cloud forest which clothes the Portachuelo or Sachamates range between the Valley of Sibundoy and the great Amazonian *planada* beginning east of Mocoa constitutes one of the botanically most virgin areas of Colombia. The genus *Saurauia* is relatively well represented in the parts of this forest lying

PLATE XXXIX

SAURAUIA ALVAROI *R. E. Schultes.* 1, flowering branch, approximately one half natural size. 2, basal portion of leaf, showing flap, approximately one half natural size. 3, flower, approximately twice natural size.

Drawn by DOROTHY H. MARSH

between about 2100 and 3400 meters, where typical species are *S. brachybotrys*, *S. portachuelensis* and *S. putumayonis*. *Saurauia Alvaroi* appears to be limited to an altitudinal band of perhaps 150 meters near the lowest range of the genus in this mountain chain. In spite of its limited altitudinal range, the species is well represented in the forest. A large number of individuals, mostly not in flower, were studied along a very short stretch of the automobile road leading to the town of Mocoa.

Saurauia Alvaroi is named in honor of my Colombian colleague, Dr. Alvaro Fernandez Pérez, botanist, chemist and plant explorer, Curator of the Herbario Nacional Colombiano of the Instituto de Ciencias Naturales, Universidad Nacional, Bogotá, Colombia. Dr. Fernandez has advanced the cause of science in Colombia not only through his own extensive field work and research but also through willing and efficacious help to foreign botanists who visit Colombia for the purpose of studying its unequalled tropical flora.

COLOMBIA: Comisaría del Putumayo. Road from San Francisco to Mocoa, at ten kilometers above Pepino Camp. Cloud forest. About 2250 m. "Tree up to 40 ft. tall. Leaves with basal flap. Flowers aromatic, white." July 27, 1960, *Richard Evans Schultes 22551* (TYPE in Herb. Gray; DUPLICATE TYPE in Herb. Nac. Colomb.; Econ. Herb. Oakes Ames; Herb. Chicago).

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PRESENT STATUS OF BOTANICAL STUDIES OF AMBERS[1]

BY

JEAN H. LANGENHEIM

DESPITE the fact that amber is known to be fossilized resin, there is a general lack of knowledge regarding the plants from which it was derived, as well as the kinds of forests and environmental conditions in which the source trees lived. The following discussion is a survey of existing botanical investigations of ambers, and a discussion of approaches and present progress in studies of amber from Chiapas, Mexico.

Since the earliest stages of man's social development, ambers have had esthetic appeal. They also have long been used to ward off evil powers, as well as to cure illnesses such as rheumatism, stomach disorders, asthma, toothaches, etc. In some measure, the attribution of these special powers to amber may be a result of the negative electrical properties exhibited when most ambers are rubbed. Thales recognized these electrical properties, and they were reported early in the annals of electricity.

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[1] Grateful recognition is made to the American Association of University Women Educational Foundation for the Margaret L. Wiley post-doctoral fellowship which enabled me to carry out this study. Support from the Radcliffe Institute for Independent Study likewise is acknowledged. Thanks are due to Professor J. Wyatt Durham, Professor Elso S. Barghoorn and Dr. Virginia Page for critically reviewing this manuscript and offering valuable suggestions.

In fact, the term "electricity" evolved from "electron," the Greek name for amber.

There was much speculation in the classical literature regarding the origin of amber. One of the first allusions to its botanical origin may be traced to the Greek myth in which amber was considered to be the coagulated tears of Phaethon's sisters, who were turned to poplars while weeping about his death. Pliny, in his *Historia Naturalis* (77 A.D.), was of the opinion that "amber is produced from a marrow discharged by trees belonging to the pine genus, like a gum from the cherry, and the resin from an ordinary pine" (Bostock and Riley, 1857). The first author to deal in any satisfactory manner with botanical origin, however, was Philip Hartman, who published "Succini Prussici Historia Physica et Civilis" in 1677. So great was interest in the botanical aspects of amber that the ideas in this treatise were presented before the Royal Society in 1697 by Robert Hooke. Hooke's subsequent and more nearly complete discourses were published in 1705 (Williamson, 1932).

The beautiful preservation of organisms or fragments of them (spiders, insects, small lizards, flowers, leaves, etc.) within a mass of resin has interested scientist and layman alike. The earliest work containing figures of plants in amber is Nathaniel Sendel's "Historia Succinorum Corpora Aliena. . . . " (1742), which describes collections in the Dresden Museum. Although amber is a plant product, botanists have paid less attention to its study than have either entomologists or mineralogists. Insect inclusions often are more prominently abundant and more completely intact than plant remains. Certainly entomologists have pursued more diligently the taxonomic description of insects, and their phylogenetic implications, than have the botanists with regard to plant remains. Relatively entire flowers, fruits, and leaves do occur, but not so commonly as fragments of plant tissues and organs. These fragmentary remains have created little enthusiasm on the part of botanists. Pollen and spores may be present, but they have received only limited attention. This results probably from the fact that the microflora is difficult to see except in thin section, and that palynology has developed as a science since the great period of work on amber. Since evident inclusions are not common in some fossil resins and since these resins qualify as gems, mineralogists took on the task of routine physical and chemical characterization. Because the mineralogist's interest did not lie specifically in the plant source of the resinous material, and as a result of the inherent difficulties of its determination, relatively little attempt has been made to synthesize botanical with chemical evidence for this purpose.

CLASSIFICATION OF AMBERS

Fossil resins from many parts of the world have been described in terms of some of the physical and chemical properties. Not only has the question of the plant source often been neglected, but the geological age of the deposits frequently is not well documented. One of the most widely used classifications of fossil resins divides them into two series, with the succinites containing succinic acid and the retinites lacking it (Dana, 1895; Hintze, 1933). More recently, Steuzel (1931) and Hey (1950) not only distinguished the succinite from the retinite series on the presence or absence of succinic acid, but set off a tasmanite series consisting of sulphur-bearing resins. Plonait (1935) and Hilterman (1949) indicated that these properties vary within the same species and should not be used as a basis of classification. Paclt (1953a) stated that the main criteria should be botanical derivation and the geologic age of the deposits. Accordingly, he presented a system based upon: 1) resins derived from coniferous sources, 2) resins derived from angiosperm sources, 3) resins of uncertain geologic age and unknown botanical derivation or otherwise inadequately characterized. Unfortunately, as previously noted, the botanical derivation often is not known or well substantiated; hence Paclt's criteria of classification are difficult to apply. His recognition of these characters as primary criteria, however, may have a useful influence upon future investigations.

The term "amber" has been variously used. In its strict sense, it has been synonymous with the succinites; various other names have been used for the retinites. On the other hand, in a wide sense, "amber" is used for all fossil resins. It is in this broad sense that I shall employ the term in this paper.

Part of the difficulty in establishing a classification of fossil resins or ambers has been the chaotic state of modern resin nomenclature. This has resulted probably from the complex nature of the material. In the study of ambers, the distinction between gums and resins is significant. The former are water-soluble carbohydrates; the latter consist of substances soluble in hydrocarbons. If the material is entirely water-soluble, it is not likely to become fossilized. Some gums are only partially water-soluble, and hence are known as gum-resins. The principal constituents of resins are resin acids, with aromatic and aliphatic acids also present in some cases. Free or combined with these acids are two somewhat different kinds of alcoholic compounds called resinols and resinotannols or, collectively, resin alcohols. The third primary constituent is a resene, which is usually less abundant than the resin alcohols and quite inert. The resene appears to act as a protective colloid, and its effect on the behavior of the resin toward solvents seems great (Barry, 1932). Essential oils occur in some resins, but they are usually lost by oxidation in the fossilization process.

In most studies of fossil remains, it has not been feasible to carry out detailed structural analyses of the constituent acids, alcohols and resenes. It has been more practical to determine hardness, specific gravity, degree of solubility, kind of fluorescence, as well as elementary analyses such as carbon, hydrogen and oxygen ratios. The range of differences within these properties, however, is neither sufficient to provide key characters for a classification system nor very helpful in the determination of plant source. For example, although there is some variation, the empirical chemical composition of most ambers approaches $C_{10}H_{16}O$. The hardness varies from 1 to 3 on Mohs scale or as soft as can be scratched by a fingernail to that scratched by a pocket knife. The degree of hardness may depend not only on chemical constitution, but also on the environmental conditions under which the resin dried or on the geological processes to which it has been subjected. Whether the resin remains tacky for a long period of time or dries readily may determine its degree of hardness. Furthermore, as Kirchner (1950) pointed out, hardness is greater in amber associated with wood than in that with aquatic inclusions. Submersion in water obviously provides conditions for solidification very different from those in the atmosphere, where each layer hardens as it emerges from tissues of the trunk. Resin contained in the roots solidifies under soil atmospheric conditions which may produce still another variation in hardness.

Specific gravity may vary from 1.00 to 1.25, but it commonly averages between 1.05 and 1.08 and hence is not a good distinguishing character. Melting points range from 150° C to 420° C; consequently, there is more variation evident here than in many other properties. Melting point, however, does not appear to be a useful property in defining categories, although the extremes might be suggestive of plant source. Degree of fluorescence under ultraviolet light varies appreciably with surface as well as with kind of material. Solubility also varies from nearly insoluble to almost completely soluble in various hydrocarbons such as chloroform, benzol, ether, acetone and various alcohols. Comparative behavior in different solvents may be helpful in determining plant sources, but this has not as yet been carefully evaluated. Thus, the presence of relatively large amounts of succinic acid (3 to 8%), which so strikingly sets off most of the Baltic amber from most other fossil resins, has appeared to provide a good distinguishing character for classification of all fossil resins. Nevertheless, as viewed now, not only succinic acid, but other resin acids typical of certain kinds of trees, should be taken into account if plant source is to be determined. As Barry (1932) emphasizes, most of the classic methods of chemical examination of resins are of limited application. In analysis of amber, consequently, further investigation directed toward understanding the relevance of specific chemical and physical properties to the problem of plant source and related post-depositional conditions is urgently needed.

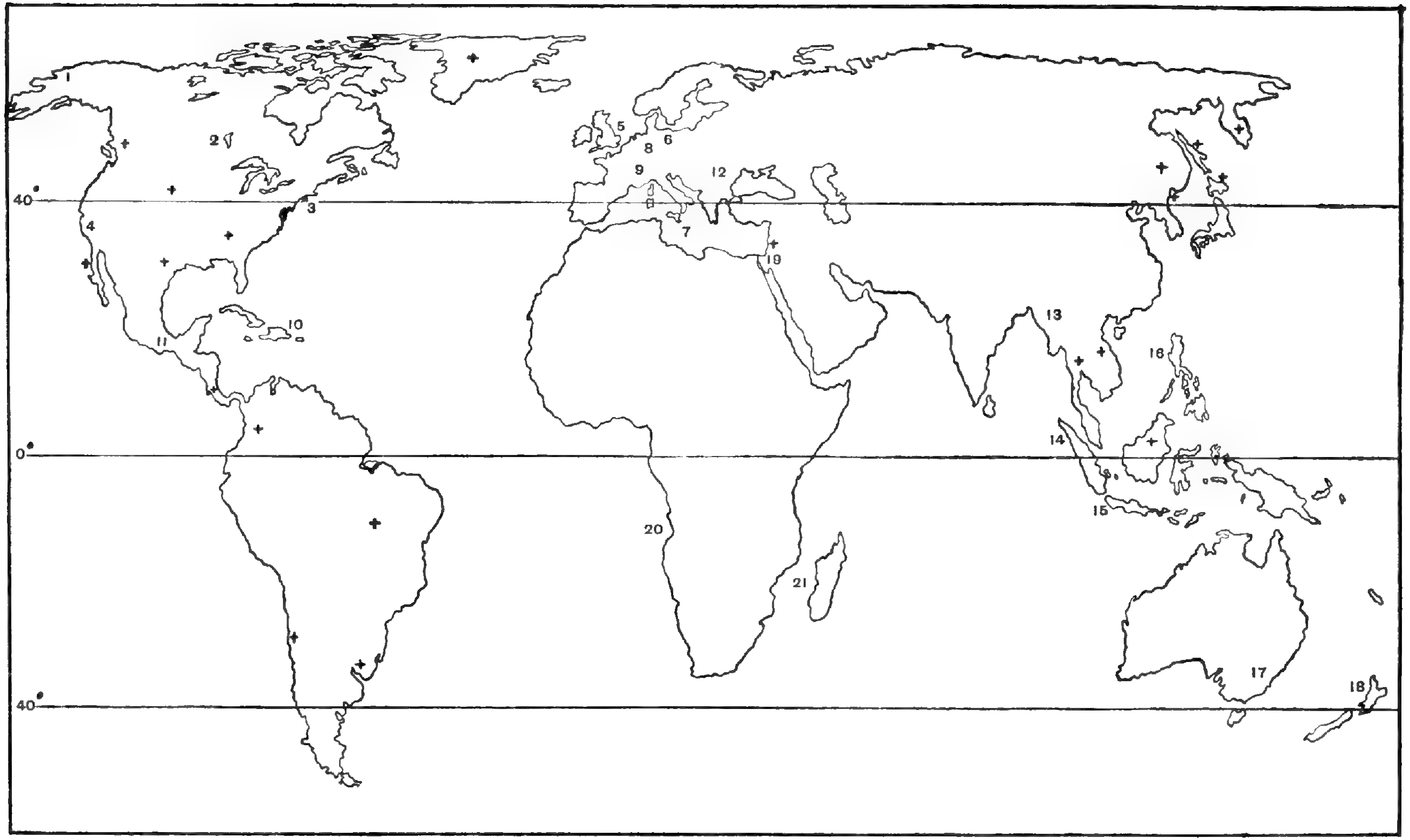
SURVEY OF OUTSTANDING AMBER DEPOSITS

Ambers have been reported from deposits of Carboniferous to Pleistocene age, but they appear to be best represented in Cretaceous and Tertiary strata (Plate XL). Some question has arisen regarding the nature of the so-called resin rodlets reported from Carboniferous coal. Since the prevailing opinion holds that these are transformation products either of pollen exines or of cuticle rather than true resins (Freund, 1952), this material does not appear pertinent to our discussion of ambers.

Amber has been reported from several North American Cretaceous deposits. Langenheim, Smiley and Gray (1960) discussed one of the oldest occurrences of amber known from late Early Cretaceous beds along rivers on the Alaskan Arctic Coastal Plain. The inclusions in the amber have not been studied as yet, but they appear to be pollen, spores and possible fungal mycelia, as well as other fragmentary plant parts. This amber likewise has been analyzed neither chemically nor physically. Several lines of evidence seem to indicate that the Cretaceous rocks containing the Alaskan amber are of non-marine origin. This Alaskan amber has never been found with florules lacking taxodiaceous remains (*Taxodium* or *Parataxodium*). Although pollen of the Pinaceae constitutes the most abundant single microfloral remains, there is a conspicuous lack of megafloral evidence of the pines. Langenheim, Smiley and Gray assumed that pine pollen was derived from upland areas, and that its great abundance reflects the enormous production of pollen and its wind dissemination. On the other hand, the presence of abundant taxodiaceous-like grains augments abundant foliage remains. These authors think that the close association of the amber with these taxodiaceous remains suggests the source of the resin. They, therefore, concluded that the fossil resin might have been derived from taxodiaceous trees growing in proximity to lakes, coastal swamps and other bodies of water.

Late Cretaceous amber is known from several localities along the Atlantic Coastal Plain. Knowlton (1896) described amber from Cape Sable, Maryland, where it was found in the interstices of logs determined as *Cupressinoxylon bibbinsi* Knowl. (considered synonymous with a *Sequoia* at that time). Other small deposits include those at Gay Head at Martha's Vineyard, Massa-

PLATE XL



Geographic distribution of the best known amber deposits (see explanation on opposite page).

PLATE XL

	Locality	*Age*
1.	Alaskan Arctic Coastal Plain (Kuk, Koalak and Ketik Rivers)	Early Cretaceous
2.	Cedar Lake, Manitoba, Canada	Late Cretaceous?
3.	Atlantic Coastal Plain (Mass. to Maryland)	Late Cretaceous
4.	Simi Valley, California	Eocene
5.	Southeast Coast of England	Eocene
6.	Baltic Coast (Denmark to Estonia)	Eo-Oligocene
7.	Sicily	?
8.	Rhine Valley (German Brown Coals)	Eocene–Miocene
9.	Savoy, France	Oligocene
10.	Dominican Republic	Late Oligocene
11.	Chiapas, Mexico	Oligo-Miocene
12.	Roumania	Miocene
13.	Burma	Miocene
14.	Central Sumatra	Miocene
15.	West Java	Pliocene
16.	Luzon, Philippine Islands	Pliocene
17.	Victoria, Australia	Pliocene
18.	North Island, New Zealand	Quaternary
19.	Israel	Pleistocene
20.	West Africa (Angola and Congo)	Quaternary
21.	East Africa (Tanganyika, Zanzibar and Madagascar)	Quaternary

Localities in which plant origin is discussed in the text are numbered. Other small occurrences mentioned, but with neither geologic nor botanic data, are indicated by a cross.

chusetts; near Trenton and Camden, New Jersey; along the Chesapeake and Delaware Canals; etc. The most extensive of these deposits is at Kreischerville on Staten Island, New York, where the amber occurs with lignites. Leaves of *Sequoia heterophylla* Vel. and *S. reichenbachii* (Gein) Heer, *Widdringtonites*, *Juniperus* and questionably *Dammara*, as well as a few remains of *Pinus*, occur in close association with the amber. Hollick (1905) concluded that the most probable source was *Sequoia*. This was also the conclusion concerning the source of amber occurring in Japan.

Other amber (chemawinite) of presumed Late Cretaceous age has been reported from Cedar Lake, Manitoba, Canada (Harrington, 1891; Walker, 1934; Carpenter et al, 1938), although the source rocks from which this material is derived are not definitely known. A considerable concentration of amber occurs with fragments of decayed wood along the shores of the lake. Neither the plant fragments in the amber nor the wood have been investigated. Lack of succinic acid, difference in reaction with solvents, and a greater resistance to heat led to the conclusion that it was distinct from Baltic succinite (Harrington, 1891). It contains more carbon and less oxygen; in this respect, Harrington believed that it more closely resembles walcowite and some of the more recent copals from India. Smallness of the amber grains (58% being less than eight mesh and only 3% being larger than two mesh) was pointed out by Walker (1934) as differing from the larger size of the masses characteristic of the Baltic deposits. He further suggested that this might indicate conifers of the types yielding little resin when wounded, in contrast to those which produced copious resin in the Baltic forests. Consequently, although the material appears different from succinite, no specific plant source has been demonstrated.

Other small occurrences of Cretaceous amber have been reported from: Hardin County, Tennessee; the Black Hills of South Dakota; Cañon Diablo of Arizona; the coals of Eagle Pass and Terlingua Creek in Texas; and Baja California. Coals from Coalmont, British Columbia, also contained amber which is used commercially for varnish. There has not been a general investigation as yet of these ambers, and no plant source has been indicated.

By far the most extensive deposits of amber thus far discovered occur in more or less isolated basins of Eo-Oligocene strata along the shores of the Baltic Sea from Estonia to Denmark. The largest amber mines were located in the basin on the Samland Peninsula at Palmnicken. Because this amber has been studied more intensively than any other, it has provided the classical concept of amber for most laymen and even for most scientists. In fact, it has led to preconceptions concerning the botanical sources of ambers in general. For these reasons, the Baltic amber will be discussed separately in a later part of this paper and in more detail than the other deposits.

Copalite or Highgate resin occurs as irregular pieces of pale, honey-colored material in the Eocene London Clay formation from the southeast coast of England. Whitaker (1889) stated that this amber resembles "copal" in hardness, color, transparency and relative insolubility in alcohol. There is some semantic confusion, as the term "copal" is used to connote resins from different families of plants. Probably reference here is made to African copal of commerce which comes from such leguminous genera as *Trachylobium* and *Copaifera*. The affinities of the London Clay Flora are considered by Reid and Chandler (1933) and Chandler (1961) to be predominantly tropical, with most of the flora allied to genera inhabiting present-day tropical or montane rain-forests of Indo-

Malaya. Members of the Leguminosae, however, occur sparingly in this fruit and seed flora. Furthermore, the Dipterocarpaceae, which generally characterizes the Indo-Malayan forests and which produce such copious amounts of resin, are significantly lacking. Seeds of members of the Burseraceae, closely related to such abundant resin producers as *Protium* and *Canarium*, occur and would represent possible sources. No systematic attempt, however, has been made to study the plant source of this resin.

Succinite has also been reported from the east coast of England from Essex to Yorkshire. Conwentz (1896) has assumed that the beds in which the amber was originally deposited were continuous with those along the Baltic from Denmark eastward to the Samland Peninsula. Therefore, the general conclusion is that the plant source was the same as for amber from the Baltic deposits.

Amber from Eocene (Domingene) strata in Simi Valley, California, has been found in association with fossil woods. The woods were determined as *Quercus* and "a heavy dicotyledonous type, possibly a legume" (Murdoch, 1934). The physical and chemical properties appear relatively similar to succinite; therefore, because the woods were not coniferous, it was assumed that the amber did not originate from the trees which produced them. This reasoning is based probably upon the conclusion that Baltic amber (succinite) is derived from members of the Pinaceae, or at least conifers. Because the physical and chemical properties obtained are not necessarily indicative of pines, however, it seems important that a number of leguminous trees should be taken into account as the possible source.

Another well known amber (burmite) is mined from lignites and a blue earth in Burma. It is characterized by its ruby-red color, its high degree of fluorescence and its small amount of succinic acid. Only a few insect and leaf inclusions have been found in burmite, and the plant source has not been indicated (Tschirch and Stock, 1936). Williamson (1932) reported that in addition to burmite, other fossil resins are mined in Asia at Vladivostock, in Siam, Cochin-China, Manchuria, Kamchatka and Sakhalin. Neither the age nor the plant derivation of the ambers has been discussed.

Brown coals of both Eocene and Miocene age are widely distributed throughout Europe, but have been exploited particularly in Germany. Because of their commercial importance, much is known about them. There has been considerable study of the wood in the Rhine coals (Jurasky, 1931, 1938; Schönfeld, 1958), as well as of fruits and seeds (Kirchheimer, 1936, 1937, 1957; Weyland, 1934 et al.), of leaf cuticles (Krausel and Weyland, 1951, 1954) and of pollen (Potonié and Venitz, 1934; Pflug, 1957; Thomson, 1958 et al.). Resin apparently constitutes about 3% of most humic brown coals (Henderson, 1953). Reports of resins from European brown coals have been relatively common (Steinbrecher, 1935; Tschirch and Stock, 1936 et al.), although these resins have not received the attention that Baltic succinite has. Steinbrecher contrasts two types of resin from the brown coals: "Bitumenharze" and retinite. The Bitumenharze are mixed in the coal with waxes and isolated only by solution of the coal matrix. Among the retinites he lists eosmite, sheibite, kranztite, muchite, trinkerite, hartite, ixolite, and Greenland bernstein. In comparing their specific gravities, melting points and carbon, hydrogen, oxygen ratios, he concluded that they should be considered different types. Because of their relatively poor quality and their dispersion as small pieces throughout the coal, there has been little investigation of these resins. These occurrences are of particular importance in studies of plant sources of the resin, however, because of the availability of correlative botanical information.

Three types of moors have been recognized in recent attempts to reconstruct the vegetation types that produced the German brown coals (Thomson, 1951; Teichmuller, 1958). One is the Reidmoor (marsh), similar to that existing in the Everglades of Florida today. Another is the *Nyssa-Taxodium* swamp woods compared with those presently found in the Mississippi Delta, Florida, Georgia and North Carolina. Several reports of taxodiaceous resin from the Rhine brown coals have been reported, and the derivation has been substantiated by wood associated with it (Jurasky, 1931; Tschirch and Stock, 1936). A third type is described by Teichmuller as a *Myrica-Cyrilla* moor accompanied by *Sequoia* woods. The *Myrica-Cyrilla* moor has produced more peat in the lower Rhine brown coals than any other vegetation type. Here *Liquidambar* played a significant role. Seigburgite from these coals has been considered by Klinger and Pitschi (1884) to be derived from *Liquidambar*, because it produced cinnamic acid and styrolene upon distillation. Jurasky (1931) has also reported resin from sections of wood referred to *Juniperoxylon*. Relatively few statements regarding botanical derivation have been made for the retinites, although some of the physical and chemical characteristics have been described. It seems possible that a systematic attempt to relate all relevant chemical and botanical information about this material might, in some cases, indicate the plant sources.

Allingite from upper Oligocene deposits in Savoy is called Swiss amber. It appears to differ from Baltic succinite in the presence of both sulphur and nitrogen, and a resin acid differing from succinic acid (Tschirch and Stock, 1936). The botanical source has not been discussed.

Amber from the Dominican Republic, presumed to be late Oligocene in age, was first reported by Christopher Columbus during his second voyage to the West Indies. This amber contains small fragments of wood, leaves and flowers, as well as insects. The plant source again is not known, but Sanderson and Farr (1960) indicated the possibility of pines, as the amber possesses a strong pine-like odor when sawed or scratched with a file. Small traces of amber also have been noted in a core sample from a lignite deposit in the Central Plateau of Haiti.

Simetite occurs in outcrops along streams in the central part of Sicily, near Mt. Etna, where it is associated usually with lignites. It is famous both for its beautiful colorss being ruby-red to opalescent-blue, and also its strong fluorescence. These characters, in addition to its hardness, the presence of sulphur and little succinic acid, distinguish it from succinite (Helm, 1881). Neither the geologic nor plant source has been discussed, although Helm questioned whether it differs essentially from the Baltic succinite or merely has been altered by geologic processes.

Rumanite is mined from a blue earth in Miocene sandstones in several localities in Rumania (Protescu, 1937). Although these are not extensive deposits, the amber has been known and used for centuries. Amber is known also from the Ukraine (Khandros, 1941), and a resin similar to rumanite has also been found in Poland (Helm, 1891). Rumanite has a wide color range varying from yellow, rose-red, to dark smoky-gray. It contains many cracks, giving it an iridescent aspect, and it is highly fluorescent. These and other physical and chemical characters led Helm to believe that rumanite was different from succinite. Organic remains appear to be rare, and specific botanical derivation characteristically has not been discussed.

Amber of a dark reddish-brown color and an impure earthy nature, containing insects, occurs in Miocene deposits of central Sumatra (Durham, 1956). A similar amber has been observed in western Java, but it is more common in Pliocene than in Miocene rocks. Pieces of an amber of like characteristics have also been reported from Pliocene deposits on Luzon Island in the Philippines. In both Java and Sumatra, and possibly by analogy in Luzon, the amber occurs erratically in the marine sedimentary section with no local concentrations being reported. I have dissolved the Sumatra amber in methylene chloride, and it appears to contain pollen and spores which have not been studied as yet. The physical nature of this amber is distinctive from that of the Baltic succinite. There are many copious resin producers in the general Indo-Malayan region. Good prospective candidates are members of the Dipterocarpaceae from which resin, varying in age from recent to fossil, is excavated from the ground around the trees (Howes, 1949). Also Tschirch and Stock (1936) reported a ''kind of copal'' from brown coals in Java, derived supposedly from *Agathis alba* (Lamb.) Foxw.

Ambrite, occurring in masses as large as a human head, is found in the Hawakawa coal deposits in the province of Auckland, New Zealand (Tschirch and Stock, 1936). It resembles the resin of *Agathis australis* (Lamb.) Steudel, or Kauri pine, which abounds on the island and which is often exported with ambrite. Paclt (1953a) pointed out, however, that ambrite differs from agathocopalite in being wholly insoluble in ether or alcohol. Fossil Kauri resin is found in both hilly clay ranges and in peat swamps on the North Island of New Zealand.

Another resin of this general type has been reported from Victoria, Australia (Watson, 1925; Hills, 1957). A large specimen, weighing 34 pounds, with impressions of dicotyledonous leaves as well as a leaf of *Agathis*, ants, beetles, etc., was found in a formation of black clays. Detailed chemical analysis shows that this amber is comparable with resin of *Callitris*, *Araucaria*, or *Agathis*. Hills stated that all the fossils suggest moist climatic conditions. *Agathis* is perhaps the best climatic indicator among the fossils and today is restricted to tropical and subtropical regions. Its presence indicates a climate very different from that existing in the area now. Although there is some evidence that this material might be Pleistocene, Hills regards it as Pliocene.

Fossil "copals" occur abundantly in Africa, where natural resins have been extensively exploited commercially. The age of these materials is not presented definitely (Tschirch and Stock, 1936; Paclt, 1953a), but they are considered to be post-Tertiary. Paclt referred to these fossil copals as "legumocopalite." He considered most of the West African (Angola and Congo) legomocopalites to be derived from either *Guibourtia*(*Copaifera*) spp. or *Daniella* spp. The occurrence of some of these fossil resins, however, coincide with the geographical distribution of *Adansonia digitata* L., a member of the Bombacaceae. The East African (Tanganyika, Zanzibar and Madagascar) legumocopalites appear to be derived primarily from *Trachylobium verrucosum* (Gaertn.) Oliv.

Paclt (1953b) described jaffaite, probably Pleistocene in age, from Israel. It is characterized chemically as a gum-resin of the resene series, and contains some trichomes which resemble those from *Pistacia lentiscus* L. He concluded, however, that the resin was derived probably from *P. palaestina* Boiss., which is now known to occur on the Plain of Sharon where jaffaite was found. Another amber of unknown plant source is reported from southern Lebanon by Tschirch and Stock (1936).

Reports of amber from Central and South America include those from Costa Rica, Colombia, Brazil, Ecuador, Chile and Uruguay (Tschirch and Stock, 1936). In none of these cases, however, has the geologic age been established nor has the plant source been indicated. The deposits of amber from Chiapas, Mexico, will be discussed later in this paper.

Other sporadic occurrences of amber have been reported, but an exhaustive review here is not intended. I want merely to attempt to show the status of botanical investigations of the better known or what might appear to be more botanically significant deposits.

BALTIC AMBER

Amber from the Baltic region varies in its physical and chemical properties, although most of the material is considered to be succinite. It varies in color from yellow, typical amber-colored to black and from transparent to cloudy or bony-opaque. Hardness ranges from soft and brittle to that which permits scratching with a knife. Some of it melts at approximately 350° C; some carbonizes without melting. Some is practically insoluble, whereas 20–30% of the other pieces may be dissolved in alcohol, chloroform or ether. On the basis of these differing chemical and physical properties, and the absence of succinic acid, ambers other than succinite (beckerite, gedanite, stantienite, glessite and krantzite) have been described from the Baltic deposits.

The Baltic amber occurs within a relatively restricted sequence of greenish glauconitic sands, a "blue earth" and lignites. Although amber occurs scattered through all of these beds, it is most concentrated in the blue earth at the base of the green sands. The blue earth layer varies from one to seven meters in thickness, and amber occurs here so plentifully that yields of several thousand kilograms were obtained from an area of ten square meters

(Black, 1919). The blue earth is a marine deposit of late Eocene to early Oligocene age, according to the paleontologic evidence. Most commonly the deposit is assigned to an early Oligocene age (Czeczott, 1960). Czeczott has inferred that, because the amber is considered to be reworked, it must be somewhat older than Oligocene and hence Eocene in age. Nevertheless, Kirchner (1950) has reported the occurrence of coral polyps and other marine organisms in some specimens of amber, indicating that the resin had not hardened before entering the marine environment. This suggests that no significant amount of time was involved in the transportation of at least some of the amber, and that therefore, geologically speaking, it is of the same age as the enclosing beds. Thus it appears that reworking prior to the amber's deposition in the blue earth and immediately adjacent beds may have been overemphasized in the literature. Suggestions such as those by Black (1919) and Czeczott (1960) seem to indicate the transportation of essentially contemporaneous detrital materials from land into the marine environment, a process which, geologically speaking, is essentially contemporaneous.

Amber from Schleswig-Holstein has been given a Miocene age. Wetzel (1939) thought that this amber in the western Baltic region was formed from trees on a separate land mass from that in the eastern area. Andrée (1942), on the other hand, concluded that the amber was formed during the Oligocene in the eastern Baltic area and that it was transported and reworked into the Miocene deposits in the western area.

Carvings of amber, and especially beads found in caves and tombs, indicate its significance in human activities since the Stone Ages (Williamson, 1932). Amber trade routes crossed Europe from the Baltic to the Adriatic and Black Seas in the Bronze and Iron Ages, as well as during the Roman and Greek periods. It has even been postulated that, together with tin, it was one of the chief objects which led the Romans to penetrate the Gallic regions to the west and north of the Mediterranean. Amber provided a distinctive and imperishable barter item. As stated by Harris (1925), ''The luxuries of life went out in search of the necessities,'' as the ''uncivilized North sent treasures to the civilized South.'' Previous to the 14th Century, amber was the property of the finder, and it was sought among seaweeds or washed up along the shores, especially after heavy November storms along the Baltic. Following this time in Prussia, however, the ''Rittenorder'' (Order of Knights) made themselves the owner of all amber. Amber was considered of sufficient value that, in 1466, any withholding of amber collected was punishable by hanging. The Order promoted the formation of guilds of amber-turners, erected warehouses and conducted sales over a large part of Europe. Until the last war, the largest commercial production and sale of amber was from mines on the Samland Peninsula. In earlier times, the ''gold of the sea'' was collected commercially along the shores by amber fishermen with specially constructed nets (Plate XLI) by men on horseback and later by divers. Extensive development of commercial operations began in 1837, when the state farmed out the mining to private companies. In 1860 the amber trade received additional impetus from the enterprising mining techniques developed by the Stantien and Becker Firm. Complaints were so great against their monopoly, however, that the amber industry returned to the hands of the Prussian State in 1899. Many thousands of pounds were excavated by steam dredging, as well as by techniques involving quarrying out large open pits and subsequent washing by electrical machinery. At one time amber was sorted into about 200 grades, distinguished partly by size and partly by color and purity for three primary uses: 1) smoking items, 2) jewelry, 3) varnish.

With the great tonnage of amber taken from the Baltic deposits, more opportunities for obtaining pieces with inclusions, seemingly so rare or lacking in other deposits, have been possible. The scientific importance of the inclusions was recognized by the state corporation, so that pieces with inclusions were sorted and carefully saved for study. This resulted in the availability of material that otherwise would have been lost for investigation. Even in the case of the Baltic amber, the percentage of pieces that have obvious inclusions is relatively small. This points to the fact that inclusions depend upon the liquid resin's being exposed in such a manner that insects or plant fragments might become incorporated. These conditions vary greatly with different kinds of trees as well as their habitat conditions.

Faunal inclusions, particularly insects and spiders, are much more common than obvious plant remains. The insects have been studied exhaustively by many investigators, with the studies brought up to date by Anders (1942) as well as summarized by Bachofen-Echt (1949). Fifty-one percent of the known animal remains are flies, 5% are bees and wasps, 6% mayflies, 5% beetles, and 5% spiders. Some of these inclusions have botanical significance in that a few taxa indicate particular forest habitats.

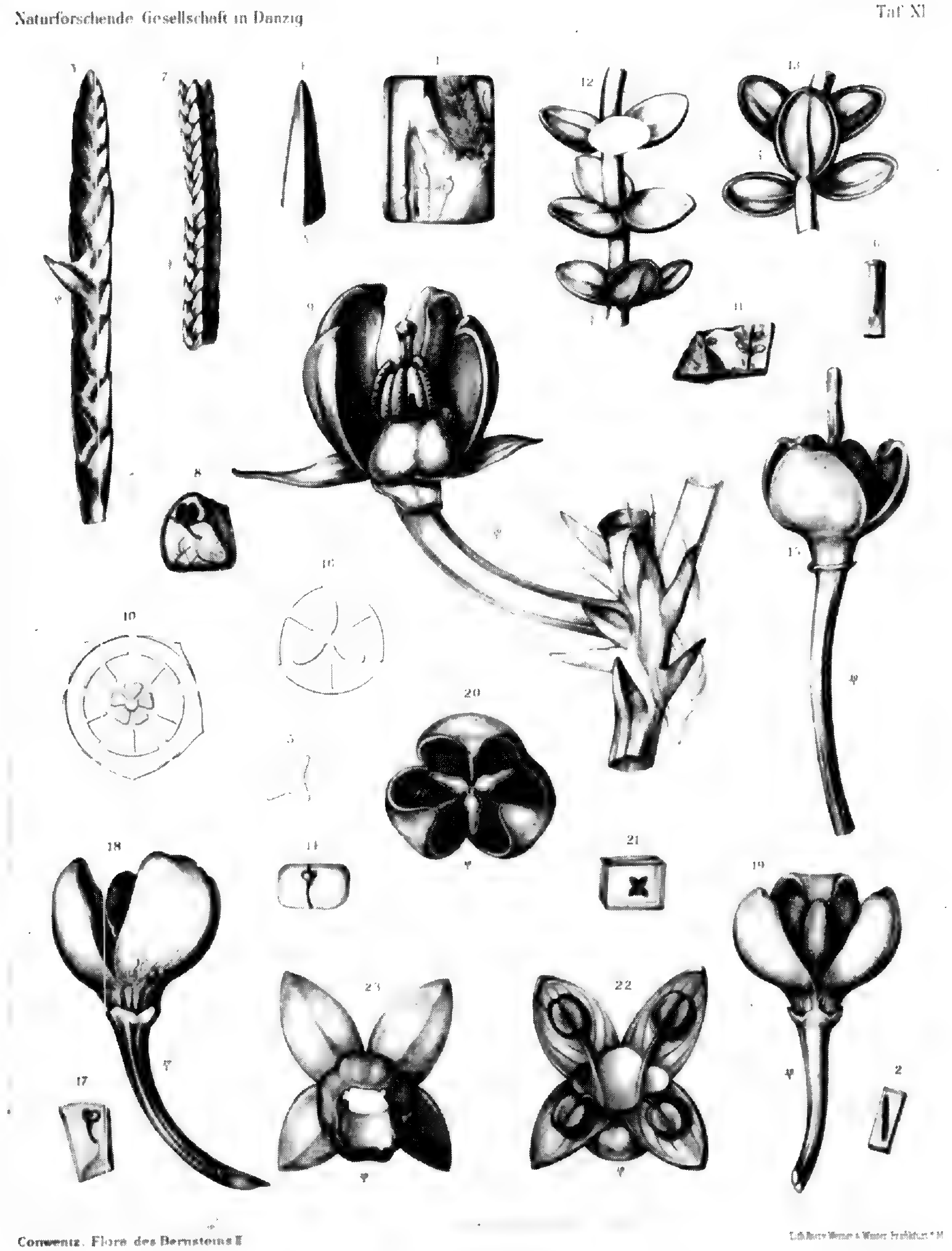
Between 1830 and 1937, approximately 750 specific names of plants and generic names without specific identification appeared in such outstanding floristic works as those of Goeppert and Berendt (1845), Goeppert and Menge (1883), Conwentz (1886a, 1890) and Caspary and Klebs (1907), as well as in about 70 smaller contributions. In a reevaluation of these taxonomic entities, Czeczott (1960) has reduced the 750 entities to 216. The inclusions represent a uniquely restricted sample of the original forest, and differ from that presented by either a leaf or a fruit and seed flora. Unfortunately, aside from amber inclusions, a few ligneous remains are the only other indication of the amber forest. Czeczott pointed out that an amazing number of cryptogams are preserved. Five species of bacteria, a slime mold, 18 types of mushrooms, two lichens, 18 hepatica, 17 mosses and two ferns have been described (Caspary and Klebs, 1907; Blunck, 1929; Magdefrau, 1957). The most common inclusions are conifers with 33 species recognized at present. In the Pinaceae, there are eight species of *Pinus*, one of *Picea* and one of *Abies*. In the Taxodiaceae, there is one species of *Glyptostrobus* and three of *Sequoia*. There are 18 species of five genera recognized in the Cupressaceae (three *Widdringtonia*, four *Thuites* — including *Thuja*, *Thujopsis* and *Biota* — one *Libocedrus*, four *Chamaecyparis* and two *Juniperus*). Most of the conifers were identified on the basis of male fructifications, a few on female cone, and some on needle or scale leaves.

The angiosperms are represented by seven species in seven monocotyledonous genera, and 94 species in 57 dicotyledonous genera (Plate XLII). Forty-seven percent of the angiosperm inclusions are flower or flower parts, and leaves also are relatively prevalent. The most abundant angiosperm remains are stellate hairs of oak which are almost as common as conifer remains. That extensive evidence of pollen has not been recorded seems rather surprising, particularly since male inflorescences are common. Von Duisberg (1860, 1863) was one of the first workers interested in the microflora, although Goeppert had indicated in 1853 that pollen should be found. Pollen was not rare in Von Duisberg's collection, but it was difficult to observe in the relatively thick sections

Seventeenth Century amber fishermen with nets and leather cuirasses for collecting "Schöppen" among seaweeds along the shore of the Baltic Sea (from Hartmann, 1677).

of amber. Goeppert and Menge (1883) and Conwentz (1890) illustrated only a few pollen grains in their monographic systematic studies. Kirchheimer (1937) obtained pollen by grinding the amber into small grains, dissolving these in alcohol and centrifuging the material. Unfortunately, he did not identify the pollen obtained in this manner. He reported that angiosperm pollen was distributed in amber and he intended to discuss this subject further in a subsequent paper. Wetzel (1953) reported pollen and fern spores in amber from Schleswig-Holstein. As it was impossible to dissolve completely this amber to free the pollen and spores, preparations for microscopic study of the microflora were made of small amber particles remaining from partial solution of the material in a mixture of alcohol and xylol. The most abundant spores found are members of the Polypodiaceae; the most common pollen is *Sequoia* and a form closely related to *Quercus*. There are also specimens that are possibly *Pseudotsuga*, *Tsuga*, as well as a member of the Ericaceae and another of the Compositae. Schubert (1961) pointed out that pollen apparently was not found in thousands of pieces of amber in the collections of the University of Könisberg, nor in his own specimens containing wood and bark. He suggested that this absence might be a result of these collections consisting primarily of "brack" amber. "Brack" is a refuse grade and, although it may contain numerous inclusions, such as wood and bark, it is not the best type of amber in which to observe pollen. Schubert, therefore, indicated that it might be possible to find pollen in especially clear grades, e.g. "Schlauben," using the lackfilmmethode (Voigt, 1936), a technique which frees inclusions from the amber matrix. It also seems probable that a considerable accumulation of pollen and spores might be located in the outer crust of the amber. This crust unfortunately has generally been re-

PLATE XLII



Example of angiosperm remains from Baltic amber. Plate from Conwentz' monograph of 1890. 1, Papilionaceae. 2–20, Ericaceae. 21–23, Myrsinaceae.

moved in the process of commercial preparation of the amber by rotating the pieces in a barrel with sand and water, thus simulating the polishing action of surf on a sandy shore. Kirchheimer and Schubert agree that a search for pollen and spores should be made and, if these structures can be properly studied, may yield valuable information regarding the composition of the amber forest.

The total inclusion flora, as revised by Czeczott (1960), has almost twice as many tropical families represented as temperate (23% versus 12%). Tropical plants belonging to such families as Palmae, Olacaceae, Lauraceae, Myrsinaceae, Apocynaceae, Theaceae, Dilleniaceae, etc. are typically mixed with more temperate elements such as representatives of families as the Aceraceae, Saxifragaceae, Umbelliferae, Rosaceae and Hamamelidaceae. The largest number of families (46%), however, are cosmopolitan, e.g. Gramineae, Liliaceae, Geraniaceae, Oaxalidaceae, Ericaceae, Aquifoliaceae, etc.

Various reconstructions of the amber forest and its environmental conditions have been attempted (Heer, 1860, 1869; Conwentz, 1890; Caspary and Klebs, 1907; Bachofen-Echt, 1949; Anders, 1942; Schubert, 1953, 1958, 1961; Czeczott, 1960, et al.). Because the most prevalent remains are of pines and oaks, the amber forest has generally been considered to have been primarily a mixture of these genera. Conwentz (1890) indicated that the oaks characterizing the forest were evergreen. Anders (1942), however, was puzzled by this conclusion, because so few of the many oaks could be shown to be evergreen. Bachofen-Echt (1949) and Schubert (1953) suggested that the forest was probably comparable to the present hammock vegetation of Florida with *Magnolia*, *Cinnamomum* and *Sabalites* occurring in patches amid pines and oaks. *Thuites* and *Ilex* were also abundant. Bachofen-Echt emphasized that the many inclusions of grass show that there must have been a grass understory. Members of the Ericaceae, especially *Andromeda*, must also have occurred in the understory immediately under the pines, because flowers, fruits and leaves were all preserved in the resin. Schubert (1958) emphasized that the dry condition of the forest was particularly indicated by the narrow annual rings in many of the small branches of pine. Czeczott (1960), however, agreed with Anders that the Florida hammock-type forest is more xerophytic than is indicated by both the overall nature of the amber flora and many members of the insect fauna. They believe that the mixed oak-pine forest was dense and moist. Other deciduous trees occurred on the outskirts of the oak-pine forest and in open glades. The more tropical plants lived on the southern slopes of an area that must have been partly mountainous. On the basis of additional wood and bark studies, Schubert (1961) emphasized that there was not just one forest-type, but that there probably were pine-palm, pine-oak, and pine-hardwood types forming a mosaic pattern on mountain slopes. He holds, nonetheless, that his studies (Schubert, 1958; 1961) support an hypothesis of a warm-dry woods of a savannah-type. He compares the amber forest to the situations now occurring in mountainous areas in Cuba (Lotschert, 1957), as well as possibly in southern Mexico, Guatemala, and British Honduras (Martínez, 1948; Loock, 1950; Schwerdtfeger, 1953).

It was suggested by Heer (1860, 1869) and followed by Tornquist (1910) that the amber forests covered an extensive area. Tornquist thought that the southern boundary of the forest extended across what is now central Sweden eastward through Finland into western Russia, whereas the adjacent northern sea occupied not only what is now northern Germany but also the region drained by the Vistula and Dnieper Rivers as far as the

Black Sea. Heer gave a more southern boundary to the amber forests, inferring their occurrence in the area of present northern Germany. He was convinced that the resin had been carried in mountain torrents to the lowlands and shores of the sea. This view of the topography of the amber country received confirmation from the work of Ulmer (1915) on caddisflies. He concluded that fully 35 genera with 73 species from the amber passed their larval stages in torrents, that 14 genera with seven species lived in quiet water and that seven genera with seven species were probably indifferent to their aquatic habitat.

Brues (1933, 1947) concluded from Ulmer's studies, as well as from his own work on amber Hymenoptera, that the amber forest type was close to that occurring in the mountains of New England today. He thought that the presence of pines, spruces, oaks, beeches, chestnuts, etc., as well as a similarity of amber insects with modern insects collected on tanglefoot fly paper at Petersham, Massachusetts, indicated that "the ecological conditions are rather closely reproduced in the hilly forested areas of New England at the present time. . . . the flora and the fauna were quite similar to those now existing in that region." Thus, in his conception that the forest was similar to our present boreal ones, Brues did not provide an explanation for the tropical elements.

Wheeler (1915) was impressed with the predominance of the boreal (Palearctic) affinities of the ants, although there were numerous specimens of ants with Indian, Malayan and Australian affinities. Rather than explain the mixed tropical and boreal assemblages by altitudinal or latitudinal variation, he believed that the tropical and boreal ants probably did not occur simultaneously. If the boreal types were being washed in from the uplands, he thought they would not be more numerous than the lowland, tropical forms. He suggested that the climate was probably warmer during the early part of the existence of the amber forest, and that the shift to a fauna typical of a cooler area is indicated by the later predominance of boreal types. He did not deny, however, that in some instances the representation of ants might be due to coexistence of habitats at different altitudes.

Wetzel (1953), on the basis of a pollen flora, presented evidence for an entirely different kind of amber forest in the Schleswig-Holstein area than in the areas to the east. He indicated that the forest in the western Baltic region was dominated by *Sequoia*, *Quercus* and *Pseudotsuga* in contrast to the eastern forests which were dominated by "Pinus and Abietineen types." He further thought that these two forests occupied different land masses. Since the Schleswig-Holstein amber occurs in Miocene beds, he related these amber forests to the more extensive and better known Miocene brown coal forests, some of which contained *Sequoia*.

As with attempts to construct the composition of the amber forest, there has been much speculation regarding the trees which actually produced the great quantities of resin accumulated as amber. Despite the variety of coniferous genera represented in the inclusions, the general opinion has been that almost all of the amber was produced by pines. This conclusion has resulted largely from the association of resin with pieces of wood which were identifiable. Goeppert in 1853 distinguished eight amber-bearing species, but in 1883 he reduced this number to six species. In 1890, Conwentz included these six species of pine, as well as another species of pine and a species of *Picea*, within the inclusive concept of *Pinus succinifera*. In 1961, Schubert, after studying anatomically wood and bark collected from the entire Samland shore, suggested that *P. succinifera* should include only pines. Anatomical features do not supply evidence for distinguishing particular species of pine. The amber pines characteristically had low production of wood and strong production of bark. The production of resin occurred not only in the epithelial cells of the resin canals, but to still greater extent in parenchymatous cells of the inner living bark.

Although pines provide the most probable source of abundant resin among the genera known to have occurred in this forest, other trees occasionally have been suggested as possible additional contributors. The variety of chemical and physical properties evident in the amber produces suspicion of the possibility of several kinds of source trees for the resin. Examination for plant remains in stantienite, beckerite, glessite and gedanite, recognized for their distinctive chemical properties, unfortunately does not yield conclusive evidence of other kinds of trees.

Stantienite contains a few specimens of a three-needle pine, and wood and bark remains of maple. Beckerite has remains of *Sequoia*, ferns and a cycad. However, Schubert (1961) felt that this material has abundant insect larval debris and decomposition products that obscure its basic composition, and hence its composition might not be sufficiently different to have come from a tree other than pine. Fragments of wood, bark and leaves, as well as many insects, have been obtained from gedanite. Schubert (1961) again indicated that, despite the chemical and physical differences, the preponderant evidence from the remains is that of a pine-type. Therefore, he considered that the chemical differences must be explained in terms of some type of variation produced within the pine group. Glessite has practically no inclusions that have been observed, but it is thought to be chemically similar to "benzoin." This suggests a member of the Styracaceae. Remains similar to *Styrax ben-*

zoin occur in the brown coals, but no representative of the Styracaceae has yet been discovered in the Baltic amber.

Actually in abundance of foliage remains, specimens of the Cupressaceae, especially *Thuites*, exceed those of pines (Caspary and Klebs, 1907). Members of the Cupressaceae are known to be resinous, although they are not copious producers. Kirchner (1950) suggested that the producers of amber might have been swamp trees related to the "Tertiary swamp cypress." He presented this possibility on the basis of the high frequency of cupressoid twigs as well as on the presence of aquatic inclusions. The taxonomic discrepancy between "Tertiary swamp cypress" and "cupressoid," however, is puzzling. I assume that "swamp cypress" refers to *Taxodium*, which is not a member of the Cupressaceae. Schubert (1961) stated that *Taxodium* generally has not been detected, and Czeczott did not list this genus in her revised list of the amber flora. Schubert also pointed out that this apparent absence of *Taxodium* is in contrast to the German brown coal floras where remains of both *Taxodium* and *Sequoia* predominate. Kirchner's other point supporting the possibility of swamp vegetation is the large variety of aquatic inclusions obtained from the Palmnicken amber mines. Only a few aquatic inclusions had been found from the Königsberg collections, and these were considered to have been incorporated under fortuitous circumstances. However, the number and variety of both fresh water and marine organisms discovered at Palmnicken led to the conclusion that, under certain conditions, liquid resin must have entered the water and thence enclosed these plants and animals. Members of the Volvocales, Protococcaceae, Cyanophyceae, and radiolarians supposedly were caught in the viscous resin. *Discophyton electroneion*, considered to be a blue-green alga but not described systematically, provides 70% of the aquatic inclusions reported by Kirchner (1950). He further offered this alga as an indication of swamp vegetation, although the evidence does not seem conclusive. Some of the marine organisms included in the amber are part of a starfish, a young fish, a polychaete, some mussels and several corals, as well as various kinds of plankton. These remains suggest either that the trees were depositing resin directly into the water or, in some cases, that pieces of wood containing liquid resin were floated into sites where aquatic organisms could be picked up.

Explanations for the concentration of the amber found in the Baltic deposits have not been entirely satisfactory. It is evident from the discussion of other amber deposits throughout the world that particularly favorable conditions must have existed, not only for resin production but also for its preservation and accumulation. Amber is not of common occurrence under any circumstances, but the Baltic deposit is the only one known to have reached such an extraordinary extent. Conwentz (1890) was so overwhelmed with the quantity preserved that he assumed that the resin had to be produced by unhealthy forest conditions—"Es gab kaum einen gesunden Baum in ganzen Bernsteinwald—das pathologische war die Regel, da Normale die Ausnahme!" He even felt the necessity of using a special term for the excessive production of resin, calling it "succinosis." He tried to enumerate all the possible sources of injury that would increase flow of resin, such as violent storms, forest fires, swarms of insects, activities of birds, squirrels, fungi and other parasitic plants. Activity of hurricanes, tornados and thunderstorms (and consequently lightning-produced fires) might have been expected to reach high proportions during the Eo-Oligocene in the Baltic area. The forests occupying the Fennoscandian Mountains and the subtropical Tethys Sea occurring to the south provided an excellent opportunity at this latitude for the occurrence of violent storms, in part comparable to conditions which exist today along the Gulf Coast of North America. Of the various groups of insects, Bachofen-Echt (1949) suggested that bark beetles probably did the most damage to the trees (Schedl, 1947). Czeczott (1960) speculated that the unhealthy condition of the amber woods might have been reflected in their insect fauna. This point, however, apparently has not been discussed by the entomologists. Feathers of woodpeckers in the amber indicate possible effects of increased damage by birds. Likewise, the presence of such parasitic fungi as *Tremetes* and *Polyporus*, as well as members of the Loranthaceae, suggest these additional possibilities for physical injury.

As pointed out by Czeczott (1960), the picture of a vanishing amber pine forest was so masterfully presented by Conwentz that it hypnotized workers for almost sixty years. Schubert (1953, 1958) was the first to ask what factor might have induced the excessive yield of resin. He suggested the possibility that trees might be more susceptible to injury near the periphery of their distribution. He further suggested in 1961 that the abnormally intensified resin production must have been caused by a ''strong disturbance of physiological balance.'' As ''great specialists,'' *Pinus succinifera* might have reacted to the change in climate in the late Eocene with the abnormally strong production of resin. This change in climate for the northern part of Europe was produced supposedly by the transgression of a sea from the northwest. However, in order to try to discover the reasons for such abundant resin production among living pines, a series of experiments were initiated (Schubert, 1958). Pines from Florida and El Salvador are being grown under different ecological conditions to see what ''geological-climatological'' factors might determine abundant resin production. Studies were also made of the reactions of *Pinus sylvestris* L., *P. strobus* L., *P. nigra* Arn., *P. ellottii* Englm., *P. palustris* Mill, and *P. oocarpa* Scheid. to artificial wounding. Samples of wood and bark from wounded trees of different ages were studied physiologically by microchemical techniques. After a certain period of time, other samples were taken above and below the first wound for both anatomical and physiological investigations of the production of resin around the wound. These experimental approaches offer the best solutions to many of the unanswered questions, but they will have to be continued for considerable time before the answers are obtained.

Other investigators, such as Klebs (Kunz, 1903), have thought that "normal" trees could produce adequate amounts of resin to account for the amber accumulation. He compared the amount of resin produced commercially from such trees as *Pinus nigra* Arn., *P. maritima* Poir., *P. sylvestris* L. and *Abies excelsa* DC. He then calculated that approximately 11 kilos per cubic meter of amber was obtained from the blue earth in 1902. A tree of *P. nigra* between 60 and 80 years old requiring a surface of about ten square meters, produces 120 kilos, or over ten kilos more than the same surface area of amber pine. Furthermore, *P. nigra* does not produce as much resin as many other pines, especially certain species living in warm temperate regions. Klebs thus concluded that, when not just one pine but generations of them covering a vast area are considered, no special conditions appear to be needed to account for the concentration of amber. This does, however, assume that there were mechanisms for naturally injuring the trees comparable to that done commercially. Bachofen-Echt (1930, 1949) also thought that this material could be accounted for as a result of amber forests persisting over an extensive area for millions of years.

Chiapas Amber

One of the smaller, but potentially very significant, deposits of amber occurs in the state of Chiapas in southern Mexico. It has remained unknown largely because it occurs in a fairly inaccessible tropical region inhabited primarily by Indians. The amber has been noted in mineralogical discussions (Helm, 1891; Kunz, 1903; Tschirch, 1906; Hintze, 1933; Buddue, 1935; Tschirch and Stock, 1936) but not described physically and chemically in detail. The geologic occurrence was first recorded in 1905 by Böse. A coordinated scientific investigation was initiated by entomologists from the University of California at Berkeley in 1953, after receiving evidence that the material contained abundantinsect remains (Duby, 1957; Hurd and Smith, 1957; Hurd, Smith and Durham, 1962).

There are many indications that Chiapas amber was utilized for ornaments in pre-Columbian times (Blom, 1959). Amber found in one of the tombs at Monte Alban, Oaxaca, most likely came from Chiapas. The amber became known to the Spaniards almost at their first encounter with the Indians in Chiapas. Fray Tomas de la Torre reported in 1554 that the Indians had the cartilage of their nose opened and inserted a bead of amber that made their noses stick out like trunks. Fray Alonso Ponce stated in 1586 that there were mines of yellow, transparent amber from which the natives made rosaries and other objects. Furthermore, an expedition into the Lacandon forest in 1695–96 reported that the women used amber for earrings, nose ornaments and rosaries. The amber was sufficiently prized by the Aztecs that traveling merchants disguised themselves to barter for it before the conquest of Tzinacatlan. Tzinacatlan (Zinacantan) was the most important trade center, and the

Zinacantecas monopolized the trade with the Aztecs and probably also with other nations. They protected this trade by murdering the Aztec intruders when caught. The traders wanted the amber in order to make lip and ear plugs worn by warriors as a sign of bravery. Likewise the Aztecs used amber in their temple rites, and it was employed for a similar purpose in the Catholic churches in the early days of Spanish rule. Today, the amber is collected primarily from landslides (Plate XLIII) or along banks of rivers in central Chiapas, as rock exposures are infrequent in these densely forested areas. The natives pick it up when fresh exposures occur and occasionally mine it. They may carve it crudely into ornaments themselves or sell it to women who make jewelry, particularly in the environs of Simojovel. The Indians here feel that the amber brings health and especially that it will ward off the influence of the evil eye.

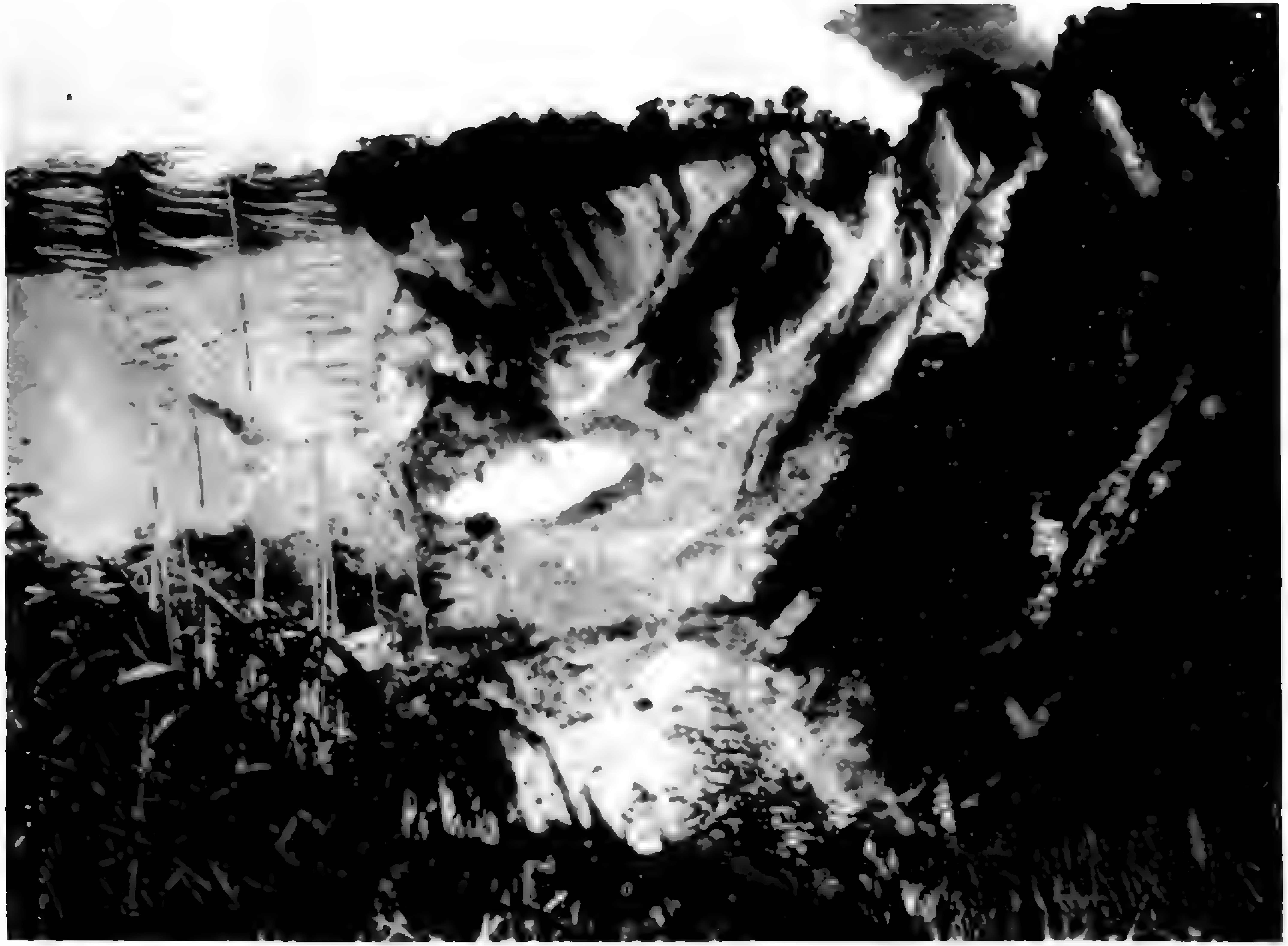
Because of the importance of establishing the geologic age of amber, systematic paleontologic and stratigraphic studies of the amber-bearing beds were initiated in 1956. The amber-bearing beds in the Simojovel area are in a sequence of primarily marine calcareous sandstones and mudstones. The associated marine invertebrate fossils are being studied in stratigraphic sequence by J. W. Durham and his students. All amber-bearing localities reported thus far are now considered to occur in latest Oligocene-earliest Miocene ("*Orthaulax* zone") beds (Licari, 1960; Hurd, Smith and Durham, 1962). For the most part, the amber seems to have been deposited near a coastline or at least in estuarine conditions, as evidenced by the interfingering of marine fossiliferous beds with lignitic seams and carbonaceous material. Often a lignitic zone occurs in close proximity to beds containing abundant amber, sometimes above and at other times below. No recognizable wood remains have been discovered in the lignites. In general, the amber which occurs in these deposits does not appear to have been reworked.

In one site, at the base of a younger non-marine tuffaceous sequence, a single piece of amber was found in a bed containing numerous fragmentary and some marine fossils that clearly indicate reworking. Much of the bedding in this sequence suggests a lacustrine environment, an inference which locally is substantiated by the occurrence of fresh water gastropods and charophytes.

Hurd, Smith and Durham (1962) reported that studies of faunal inclusions, made in cooperation with more than 50 participating scientists, have thus far revealed members of the following classes of animals: Myriopoda, Arachnida, Insecta, Mollusca and Reptilia. There are specimens representing one order of the Myriopoda and an anolid lizard among the Reptilia. Gastropods and pelecypods are represented among the Mollusca. The Arachnida, now known on the basis of ten families, are about equally divided between mites and spiders. The class Insecta, of which 15 orders have been recognized, is represented by 81 families. These include collembola, cockroaches, termites, earwigs, crickets, book lice, psyllids, leafhoppers, fugarids, true bugs, scorpion flies, thrips, dusty wings, caddis flies, moths, beetles, flies, ants, wasps and bees. It is obvious that some types of insects would be more prone to be trapped than others, and hence only a few of the many diverse insects that occurred in Chiapas at that time have been preserved. Some types such as the stingless bees, now represented by only more than 100 individuals, probably were more easily trapped as a result of their habit of utilizing resin in their economy. Also ants are readily caught in exuding resin, but it appears that most of the other insects were trapped only fortuitously. In an examination of the contemporaneous situations in Chiapas forests by Hurd, Smith and their students, almost all of the modern insects caught were small in size. Certainly this is the case in the fossil fauna, with 90% of the insects being small to minute flies, bees or wasps. The largest insect found thus far is an immature cricket, approximately 20 mm. in length. Most of the organisms identified to date belong to modern genera. Although present investigations indicate that most of the fossils differ from any hitherto described species, available information on the tropical biota is not sufficiently adequate to exclude the possibility that at least some species are still living. The habitats represented by the insect fauna will not be evident until the taxonomic studies approach completion, but this information could potentially contribute significantly to reconstruction of the amber-producing forests.

The plant inclusions, excluding pollen and spores, are not so common as those of animal origin, particularly small insects. The botanical study of this amber is especially significant, however, because the deposits occur in an area which probably has had tropical vegetation since late Mesozoic times. Despite topographic changes, some evolution as well as extinction of various elements of the vegetation, and some shifting and differentiation of vegetational patterns, there is high probability that the modern vegetation may provide important clues to the nature of the past vegetation and environment. Use of information about modern genera that produce resin abundantly seems to be particularly feasible. Trees that produce copious amounts of resin are not common, and it seems probable that, at the generic level at least, many of their characteristics would still be identifiable in the Oligo-Miocene. These genera are far more abundant in the tropics than in temperate regions. Thus, the study of the present ecological relationships of resin producers

PLATE XLIII



Santa Catarina landslide, Simojovel Area, Chiapas, where abundant amber has been collected.

and the variety of trees that are possible sources distinguishes the Chiapas investigation from those of the Baltic amber, as well as other deposits that are located at higher latitudes. In the latter cases, vast climatic and vegetational shifts since the time of amber deposition preclude comparison with present conditions in the same area.

Clues as to the kinds of plants that may have produced the resin, as well as to the composition of the forest, might be derived from several sources. The most obvious source is the included plant remains. These consist of a few complete flowers, isolated floral parts, a few leaves, stellate hairs, seeds, pollen and spores and some cryptogams. *Tapirira durhamii* (Plate XLIV) and *Acacia* sp. have been described (Miranda, 1963), but most of the remainder is still in the process of being identified. No specimen of wood has yet been found immediately associated with the amber. Even the lignites, the woody material thus far has appeared to have been sufficiently decomposed by tropical weathering to be unidentifiable. Pollen in the lignites is being investigated as it may be of some significance in determining the forest type. The insects, when they are adequately studied, may suggest important habitat preferences, just as they have in the Baltic amber.

Pertinent data concerning the plant source of amber may be obtained from chemical and resinographic analyses of the amber and compared with similar analyses of known modern resins. Comparison of fossil with modern resins is inherently difficult due to oxidation and polymerization in the fossilization process. Structural changes have taken place in the constituent acids, esters, alcohols, etc. The relative differences between the composition of resins in different genera may, however, be sufficient to find recognizable patterns. It is not feasible in this investigation to attempt detailed organic analyses of the components of the resins and ambers. The previous

PLATE XLIV

Flower of *Tapirira durhamii* from Chiapas amber.

Photograph by RAMON RIBA

characterization of ambers in terms of carbon, hydrogen and oxygen ratios, melting points, specific gravity, solubility in certain standard chemicals can be used in a general way to distinguish different fossil materials, but it does not permit comparison with modern resins. Tests for the presence or absence of succinic acid also are of relatively little help, as many plants contain small amounts of succinic acid, but none are known to have as high a percentage as occurs in succinite. It is possible that this high percentage is due to post-depositional oxidation or, perhaps, to techniques of analysis such as dry distillation. Recent techniques, such as infra-red spectrophotometry and gas chromatography, hopefully may provide distinctive patterns. Resinographic methods (Rockow, 1961), such as study of etch patterns or examination of natural, fractured or prepared surfaces of the whole material and of its separate phases by vertical reflected light are potentially valuable. Electron microscopy on the level of discrete, giant macromolecules may produce additional useful information. Collections of resins from living producers are necessary to establish comparative spectra, chromatographs, micrographs, etc. A survey of the described flora of Chiapas (Miranda, 1952-53) indicates possible sources not only among conifers but also among angiosperms (Howes, 1949). Among the conifers, there are numerous members of the Pinaceae, several of the Cupressaceae, and one representative of the Taxodiaceae. Among the angiosperms there are various genera of Leguminosae, Burseraceae, Anacardiaceae, Combretaceae, Styracaceae, Hamamelidaceae, Guttiferae, Rutaceae and Zygophyllaceae.

The next relevant question concerns which of these resin producers occupy habitats where resin could easily become incorporated into the geologic record. Information regarding the environmental relations of these trees and their occurrence in various vegetation types has been obtained from Miranda (1952–53) and supported by my field observations. Miranda's classification will be followed throughout the discussion of the vegetation types.

Chiapas today is characterized by considerable vegetational variation controlled partially by topographic diversity, which also controls many of the climatic conditions. Chiapas is bounded on the north and south by coastal plains. On the north the coastal plain is a prolongation of the extensive Tabasco plain; on the Pacific side it is only 20–30 kilometers wide. The greatest heights (1500–4000 m.) occur in the Sierra Madre, located immediately to the north of, and rising parallel to, the Pacific coast. The Central Mesa of Chiapas averages 1200–2200 m., but with local higher peaks. Between the Tabasco coastal plain and the Central Mesa, an abrupt, highly eroded hilly area ranges between 1400 and 1800 m. To the south of the Central Mesa, and between it and the Sierra Madre, is the large Central Depression with the altitude varying from 42 to 800 m.

The precipitation patterns are mainly controlled by the northeast trade winds and are modified by topographic effects. There are two definite wet seasons alternating with dry seasons. Relatively violent storms occur as "Nortes," and hurricanes are known to sweep in from the Gulf of Mexico and the Antilles. The highest annual precipitation recorded for Mexico (4–5 m.) occurs along the Chiapas and Tabasco coastal plain, and there are no truly arid conditions (less than 500 mm. annual precipitation) in Chiapas (Miranda, 1952). It is assumed, however, that relatively drier conditions exist locally now than existed in the Oligo-Miocene. This is a result of rain shadow effects of currently higher land masses and latitudinal extension of tropical conditions much farther north in the past then than they are today.

Along the coasts there is a fringe of Manglares (mangroves), succeeded inland by a narrow zone of Selva Baja Caducifolia. This predominantly deciduous forest type generally covers the sides of the highlands or almost flat land, especially in the Central Depression, where the annual precipitation is less than 1200 mm. Also prominent on the coastal plains and in the Central Depression are Sabanas and Selva Alta Subcaducifolia, occurring along the floodplains of the larger river valleys. The Sabanas are xerophytic grasslands with scattered low-growing trees typically developed in areas with an annual precipitation of about 1200 mm. The deep soils are often flooded during temporary rains, but during the dry season the water table is deep, and the top soil is very dry. During the dry season, this vegetation type, and others that have a dense grass cover, are constantly being burned. Palmares are often interspersed within the Sabana. The separate patches of palms are usually characterized by different species, and hence the groves vary from one locality to another.

The Selva Alta Subcaducifolia contains a number of trees that are common in both the Selva Alta Perennifolia and Selva Baja Caducifolia, and consequently appears to be a transition forest assemblage between the last two types. The most extensive humid lowland vegetation is the Selva Alta Perennifolia, which Miranda considers a northern extension of the equatorial tropical rain forests. He also believes that this vegetation type covered at least one third of Chiapas in recent times, but has been largely destroyed by human occupation. This forest develops in an area with an annual precipitation of at least 2000 mm. It has relatively few shrubs and herbs in the understory, and its composition varies greatly from one locality to another. Trees from temperate regions descend into the humid lowlands along the rivers.

This riverside vegetation also commonly tends to have abundant tall bamboo and cane-type grasses, such as *Guadua* and *Gynerium*, as ground cover.

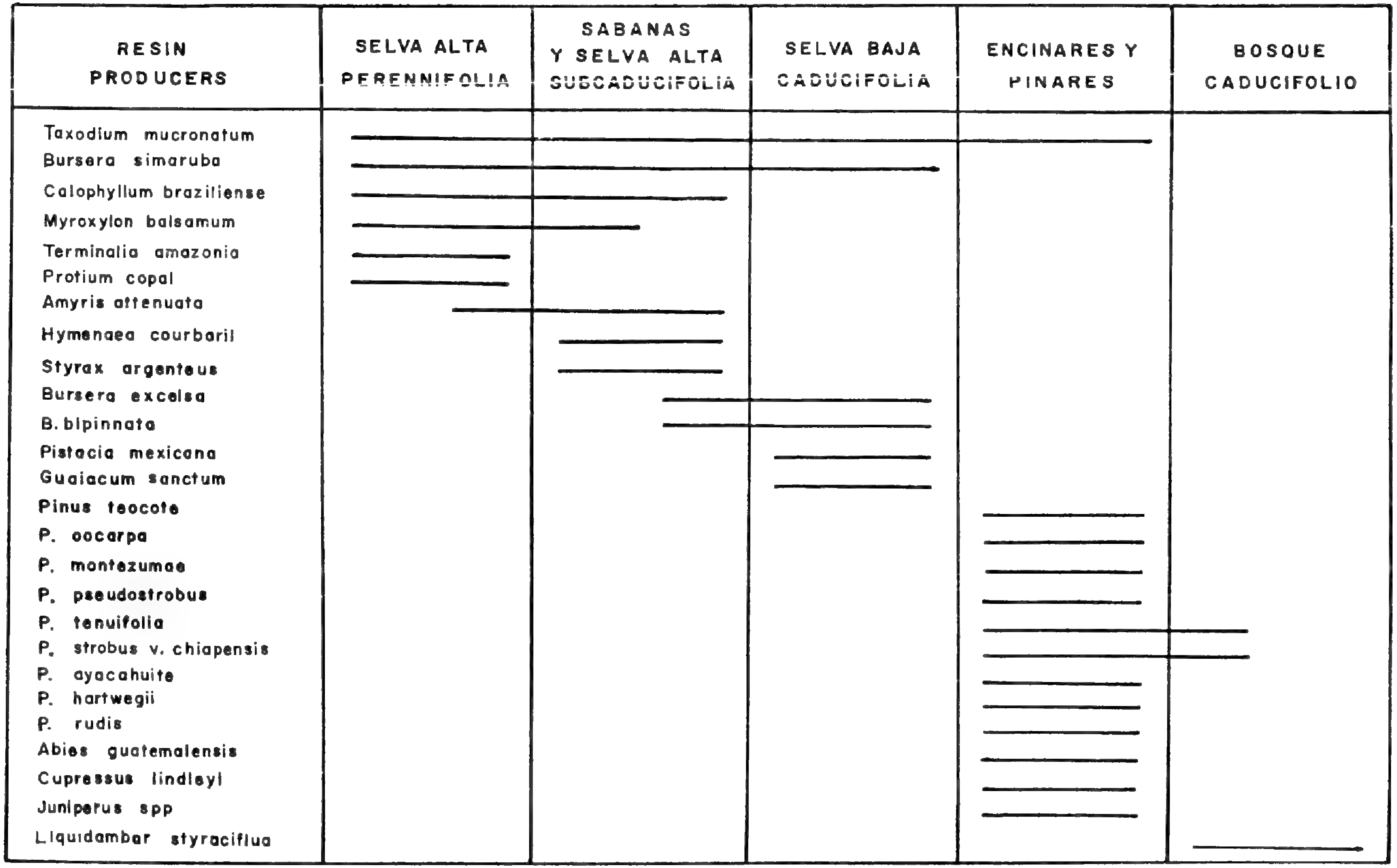
The most widespread vegetation in the temperate regions of Chiapas are Encinares and Pinares. Considerable areas of the mountains in the north, the Central Mesa and peaks of the Central Depression, and the Sierra Madre are covered with oak and pine forests. In most of these locations, oaks usually occupy the deep soils and pines the shallow soils, although the two types can be mixed with the pines occupying more area than the oaks. The oak forests are extremely variable in composition. Forests dominated by oaks may occur in contact with either the Selva Alta Perennifolia in the hot country or with the Bosque Caducifolio in temperate regions. Certain species of oak, however, occur in patches intercalated within the Selva Alta Perennifolia, and other species are a normal component in the Bosque Caducifolio. Both the oak and pine forests generally have a grass understory and are marked by repeated burning. The lower altitudinal limit of pines is in a transition area between hot and temperate zones. Pines extend to about 4000 m., which is the upper limit of tree growth. In the more humid areas at high elevations (2800–3500 m.), *Abies* and *Cupressus* may occur with the pines. Species of *Juniperus* form a low forest on dry sites between 1600–2200 m., as well as occurring in dense stands at tree line.

The Bosque Caducifolio is characterized by the clear-cut dominance of a relatively few tall, typically temperate, deciduous species. This type of vegetation occupies a considerable area in Chiapas, especially on the escarpments of the Central Mesa between 1000–2000 m., most exposed to northerly, moisture-laden winds.

Living producers of abundant resin in Chiapas occur in most of these vegetation types (Plate XLV). In some cases the trees range through several of these communities, whereas generally they are more restricted. *Taxodium mucronatum* Tenore forms Sabinales along river valleys in most of the vegetation types from hot to temperate regions. Sabinales are most common in the Sabanas, Selva Alta Subcaducifola and Selva Baja Caducifolia. The resin of *Taxodium*, which has a distinctive red color, is produced in moderate quantities in the bark. The color is of particular interest, as specimens of amber from a few Chiapas localities have this same red hue. *Bursera simaruba* (L.) Sarg., which produces large quantities of a gum-resin, also occupies a wide range of ecological conditions. It occurs commonly in the Selva Alta Perennifolia, Selva Alta Subcaducifolia and Selva Baja Caducifolia. It frequents upland sites but may occur along rivers.

Calophyllum brasiliense Camb. and *Myroxylon balsamum* (L.) Harms. occur frequently within the Selva Alta Perennifolia and Selva Alta Subcaducifolia. *Calophyllum* produces a yellow resinous material in considerable abundance. The resin of *Myroxylon* is used commercially, particularly in Honduras, although artificial stimulation is necessary for abundant production. *Terminalia amazonia* (Gmel.) Exell and *Protium copal* (Schl. and Cham.) Engl. primarily occupy the Selva Alta Perennifolia. *Terminalia* does not appear to produce large quantities of resin, whereas *Protium* produces sufficient amounts for it to be used commonly for incense, especially in Guatemala.

Three important resin-producing trees occur principally along the rivers in the Selva Alta Subcaducifolia. These include *Hymenaea courbaril* L., *Amyris attenuata* Standl. and *Styrax argenteus* Presl. *Hymenaea* is especially interesting, because it produces enormous quantities of resin which are used commercially throughout



Distribution of abundant resin producers in certain vegetation types of Chiapas.

Central and northern South America. The resin is obtained either from wounds in the bark and wood, or as hardened masses in the soil around the base of the tree. *Amyris* and *Styrax* produce only moderate amounts of resin. *Bursera simaruba* and *Calophyllum brasiliense* are often associated with *Hymenaea*, *Amyris* and *Styrax*. Thus, there are five resin-producing trees that occur along rivers in low, hot country in habitats that could be considered excellent sites for supplying resin capable of becoming incorporated in the geologic record.

Bursera excelsa (HBK.) Engl., *B. bipinnata* Engl., *Pistacia bipinnata* HBK. and *Guaiacum sanctum* L. grow principally in the Selva Baja Caducifolia, although these species of *Bursera* do appear in the Selva Alta Subcaducifolia. The narrow belt of Selva Baja Caducifolia, which occurs along the coast today, might well provide a favorable habitat for preservation of the resin. These species of *Bursera* and *Pistacia* produce considerable quantities of resin spontaneously, but large amounts of resin from *Guaiacum* are obtained primarily by artificial treatment of the heartwood.

The numerous species of pine have to be taken into account as a possible source of amber. Most of the pines here, however, occur at relatively high elevations, and hence the resin would have to be carried an appreciable distance to a lowland environment of sedimentation. *Pinus oocarpa* Scheide has the widest distribution, occurring from 350 to 3000 m. in somewhat dry localities. In more humid sites there also are *P. pseudostrobus* Lindl. and *P. tenuifolia* Benth., whereas at higher altitudes *P. montezumae* Lamb and *P. teocote* Schl. and Cham. become more abundant. Also at higher elevations, where precipitation likewise is high, *P. strobus* var. *chiapensis* Martínez and *P. ayacahuite* Eht. occur. *Pinus strobus* is likewise found in association with *Liquidambar styraci-*

flua L. on steep escarpments in the Bosque Caducifolio. *Pinus hartwegii* Lindl. and *P. rudis* Engl. occur above 2800 m. at the limits of tree growth, and on escarpments between 2800–3500 m. They may be accompanied by *Abies guatemalensis* Rehd. and *Cupressus lindleyi* Kluts. *Pinus pseudostrobus*, *P. montezumae*, *P. hartwegii*, *P. teocote* and *P. oocarpa* produce large quantities of resin, and hence are used for turpentine. The Pinares have a grass understory that is subject to periodic burning, and this provides a constant source of injury that increases resin production.

Thus, if one assesses the possible habitats in which resin producers occur today in Chiapas, some seem more likely than others to provide opportunities for preservation of resin. For this purpose, it is also important to consider the topographic and land-sea relations during the Oligo-Miocene to determine the environmental conditions in which the amber was being deposited. It appears that the Chiapas amber was deposited near the southern edge of a broad seaway that covered much of southeastern Mexico and northern Guatemala. The environment was primarily marine, but one in which oscillations of the strand line produced occasional intertonguing of non-marine sediments. Geological evidence indicates that the ancestral Sierra Madre mountains were in existence to the south at that time, although not as high as at present. It also appears that these mountains are the source of detrital materials in the amber-bearing sediments.

It might be assumed that pines occurring in the Sierra Madre could have contributed the resin in Chiapas, just as it has been suggested that the resin was derived from pines in a mountainous area near the Baltic Sea. It appears, however, that the proximity of the mountains was closer in the Baltic than in Chiapas, where they were quite distant from the site of deposition. It would seem logical, since the primary conditions in which the amber was deposited were coastal or estuarine, that trees which grew along the rivers near the coast would have been in a more favorable position to contribute resin than those from a distant mountainous source. Also, at one locality at least, relatively large pieces of amber have shells of marine organisms (clams, snails, etc.) embedded in the surface, indicating that the resin was still soft when it entered the marine environment. This suggests either that the source of the resin was trees growing along the seashore or that the resin was transported only very short distances before the shells were caught in it. Likewise, the fact that the Chiapas amber deposits are characterized by relatively small, dispersed accumulations of different kinds of material could possibly indicate a riverside environment with several kinds of resin producers contributing to the sediments. This is somewhat in contrast to the Baltic blue earth deposits, which consist of extensive concentrations of pieces of relatively comparable material, a situation suggesting that the resin was derived from a forest dominated by the resin producers.

It thus appears that such trees as ***Hymenaea***, ***Styrax***, ***Bursera***, ***Taxodium***, etc., which occur along the rivers in the present-day Sabanas and Selva Alta Subcaducifolia near the coast, would be a more probable source than the upland conifers such as ***Pinus***, ***Abies*** and ***Cupressus***. They also seem more probable than such trees as ***Myroxylon***, *Terminalia* and ***Protium***, that occur scattered through the Selva Alta Perennifolia, rather than either as dominants in this forest type or as riverside inhabitants. The occurrence of lowland pines in the Chiapas area during the Oligo-Miocene, however, cannot be discounted completely. Today in British Honduras, ***Pinus caribaea*** Morelet (or ***P.*** *hondurensis* Loock, depending upon taxonomic viewpoint) grows along the coast in savannahs and extends inland into the mountains to an elevation of about 100 m. In mountainous sites in both British Honduras and Guatemala, it grows with *Pinus oocarpa.* Although *Pinus caribaea* has not been found in Mexico, *P. oocarpa* does descend to 350 m. at one point along the Pacific coast in Chiapas. This population of *P. oocarpa,* as well as those occurring in other localities on the Tehuantepec Isthmus and in Guatemala, have been referred to *P. oocarpa* var. *ochoterenae* Martínez. *Pinus oocarpa* is closely related to the variable *P. caribaea* complex, and it is possible to speculate that this variety, in particular, might have occurred in lowland sites in the past. Also *P. strobus* var. *chiapensis* occurs at 250 m. in small isolated stands or mixed with the Selva Alta Perennifolia near Tlapacoyan, Veracruz. Here it occurs on the banks of streams and in ravines, sometimes growing very close to the water. Additional ecological investigation is necessary further to substantiate these possibilities.

The same sources of injury to the trees which could result in excessive production of resin, discussed for the Baltic amber, were possible in Chiapas. Hurricanes occasionally cross Chiapas today (Tannehill 1938), and similar tropical storm patterns might well have existed during the Oligo-Miocene. Damage from tropical storms could have initiated injuries which led to additional damage from parasitic plants, insects and other animal activity. More observations are needed regarding the degree of injury necessary to produce quantities of resin under "natural" conditions. Knowledge regarding resin production of most of the trees considered in Chiapas has come as a result of artificial wounding. Although some field observations have been made concerning natural agencies which induce resin production, more are needed to assess adequately the problem of whether or not trees must be diseased to produce sufficient resin for amber accumulations. Furthermore, present-day ecological studies need to be made on the types of material that become incorporated in resin, as well as on the conditions under which the resin is preserved.

SUMMARY AND CONCLUSIONS

Despite man's interest in amber from earliest times, relatively little is known about the plant sources of the resins and types of forests in which the trees lived. Evidence for the kinds of trees producing the resin may be derived from four sources: 1) chemical character of the amber; 2) inclusions in the amber; 3) fossils from the amber-bearing beds; 4) habitats and general nature of resin production from possible modern equivalents. Evidence for composition of the forest may be obtained from both the inclusions and the fossils in the amber-bearing beds, if these beds have not been secondarily deposited, and from the habitats and general associates of the possible modern equivalents. Because amber is considered a gem, the mineralogist has been largely responsible for its routine chemical and physical characterization, resulting in data which are usually not useful in determining plant source. Only recently has the desirability of including plant source as an important criterion in a mineralogical classification system been expressed.

Ambers have been reported from Cretaceous to Pleistocene deposits throughout the world. In most cases, however, the geological age is not well documented, and discussion of plant source is avoided. The primary interest, other than mineralogical description, has been discussion of insect inclusions. With the possible exception of the Baltic amber, synthesis of data pertinent to answering the botanical questions has not been attempted.

The Baltic deposits are the most extensive known and have been the most intensively studied. Because of commercial mining for centuries, large volumes of material have been available for examination. From 1845 to the present, more than 70 papers have presented systematic descriptions of plant inclusions, most of them written during the late 19th Century. Attempts to assess the total flora were not initiated until 1937, but 750 taxa had been reduced to 215 by 1960, and the geographical affinities of the flora were being discussed. The kinds of trees which produced the resin, the causes and nature of excessive resin production and the composition of the forest were considered in 1890, but there was little substantiating evidence. Recent work, using the lackfilm-method to study anatomically the bark and wood, reinforced the widely held view that the resin was produced by pines in the Baltic area. However, the variety of physical and chemical properties suggests a multiple source for at least some of the material. ''Swamp trees'' have been presented as possible resin producers on the basis of cupressoid foliage and aquatic inclusions. Possible modern equivalents of amber forests have been discussed recently, but no actual investigation of these equivalents has been made. Notwithstanding a relatively large background of information about plants in the Baltic amber, much still needs to be done in synthesizing the data and correlating them with present-day conditions.

A more thorough study of the resins associated with the German brown coals might produce illuminating results, because corroborative evidence from wood, fruits and seeds, leaf cuticles and pollen is available. Thus far, resins from taxodiaceous and cupressaceous sources, as well as from *Liquidambar*, have been identified.

Although little information is usually available regarding the plant sources of ambers from other geographic areas, a variety of trees seems to be indicated. The Cretaceous ambers from both the Alaskan Arctic Coastal Plain and the Atlantic Coastal Plain appear to be from taxodiaceous trees. In Alaska evidence points to *Taxodium* or *Parataxodium*, and along the Atlantic Coast to *Sequoia*. In both of these cases, inferences are made from fossils associated in the amber-bearing beds with no substantiation from either the nature of the resins or the inclusions in them. The source of Canadian amber has not been discussed, apparently because of the absence of obvious inclusions and of other fossils from the amber-bearing beds. Due to lack of succinic acid and other physical differences, it often is assumed that these ambers might come from a different source than that of Baltic succinite. Copalite from southeastern England has been referred to copal, thus inferring probably a member of the Leguminosae. However, associated fruits and seeds in the London Clay flora are more indicative of members of the Burseraceae than of the Leguminosae. Legumocopalite from West Africa is considered to have been produced by various species of *Guibourtia* (*Copaifera*) and *Daniella* and that from East Africa by *Trachylobium verrucosum*, all members of the Leguminosae. Amber from Israel appears to be derived from *Pistacia*, a member of the Anacardiaceae.

Agathis alba, the Kauri pine, seems to be the most probable source of amber from Australia and at least some of the material from New Zealand and Java. Physical properties of amber from Sumatra, other localities in Java and the Philippine Islands differ greatly from those of Baltic succinite. It seems probable that they are from members of various genera of the Dipterocarpaceae, as they are copious resin producers in the area today.

It has been assumed that amber in the Dominican Republic is from pines, although this assumption has no botanical support. Amber from California has been found in association with wood of *Quercus* and leguminous trees. Because the amber somewhat resembles succinite chemically, however, it has been considered to be of coniferous origin.

Coordinated efforts of geologists, paleontologists, zoologists, botanists and chemists in studying the amber from Chiapas, Mexico may provide an opportunity to solve some of the previously unanswered questions about ambers in general. Solution of a number of problems will result probably only from concomittance of evidence. The tropical location of Chiapas allows study of modern ecological conditions that provide clues to past conditions. This is true because: 1) genera which produce copious amounts of resin occur predominantly under tropical conditions, 2) despite evolution within species populations and some differentiation of vegetation patterns, there has probably been sufficient stability since Cretaceous times to provide a possible framework of comparison of the ecological conditions of the fossil and modern genera. In addition, study of the natural conditions under which trees produce excessive amounts of resin, the types of material included in it, and the ways in which it is preserved can be studied under conditions that may be similar to those that existed when the amber was being formed. Present evidence suggests that possible amber producers in Chiapas may have been from sources not considered in previous studies.

Modern techniques of analysis, such as infra-red spectrophotometry, gas chromatography, as well as resinographic methods, may provide additional corroboration of the plant source through comparison of modern resins with the fossil. Related studies concerning the nature of oxidation and polymerization which have taken place during fossilization will be helpful in understanding the chemical changes in the resin as well as possible alteration of the inclusions.

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TRIPSACUM AS A POSSIBLE AMPHIDIPLOID OF WILD MAIZE AND MANISURIS

BY

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and Floyd D. Hager[3]

An understanding of the origin and evolution of Tripsacum is important not only from the standpoint of theoretical cytogenetics but also because of the past and possible future contributions of this genus to the improvement of maize, the basic food plant of this hemisphere (Mangelsdorf, 1961).

Tripsacum has previously been considered to represent the product of collateral evolution with maize with both genera stemming from an ancient common ancestor. According to this view, the so-called diploid Tripsacum with 18 pairs of chromosomes is actually a polyploid species with a basic number of nine pairs. There is cytological evidence consistent with this view (Anderson, 1944; Randolph, 1955).

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[3] The embryo culture work which made these studies possible was accomplished by Dr. Hager as his tribute to the memory of the late Professor Edward Murray East. Dr. Hager notes that "It is satisfying that from the helpfulness he offered some 30 years ago in my lily work at the historic Bussey Institution, there developed a skill which made possible a contribution in a field that meant a great deal to him."

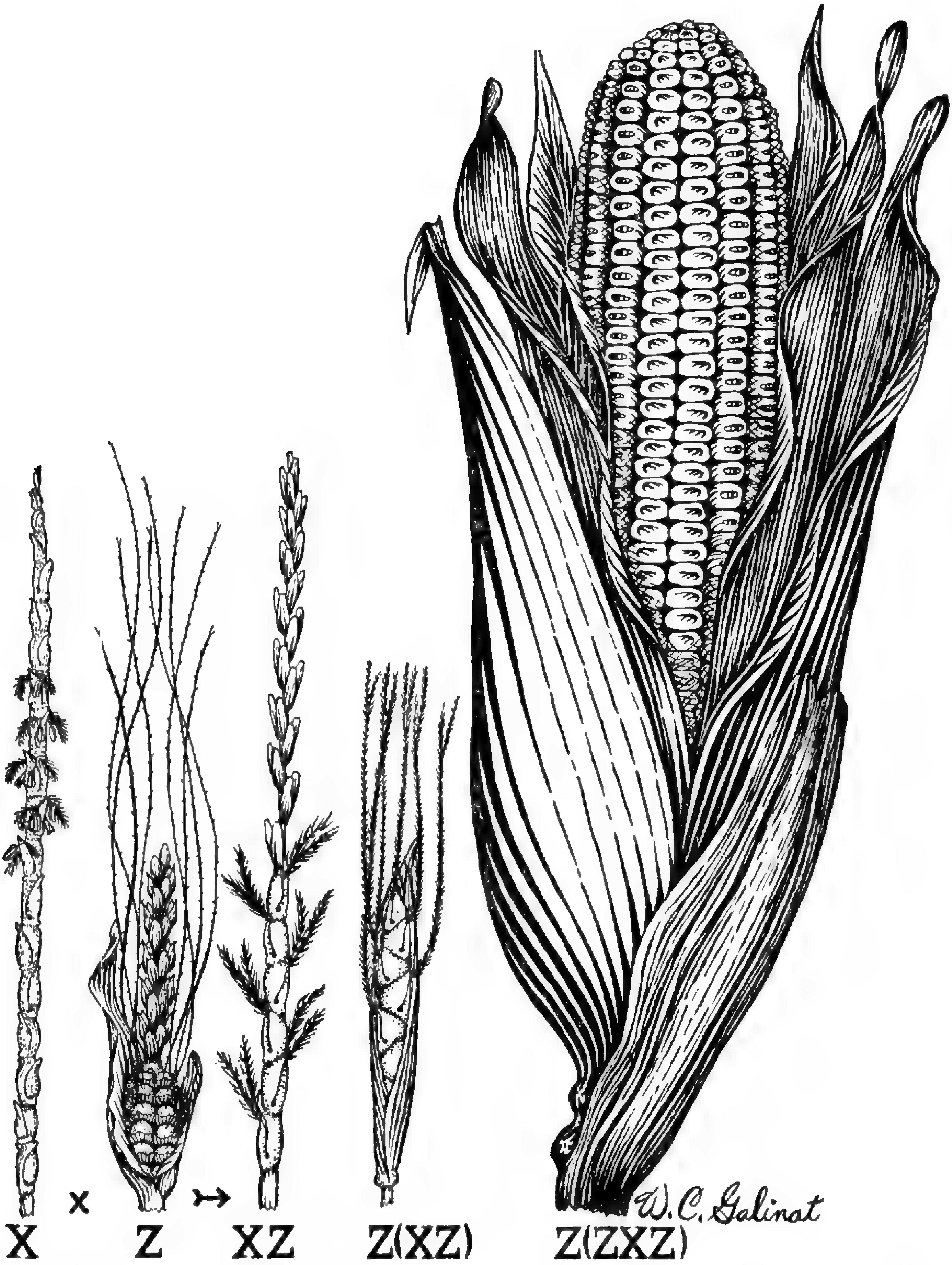
Data from studies of morphology and cytogenetics now seem to justify the presentation of a new hypothesis regarding the origin of Tripsacum, an hypothesis that has already been described in a preliminary statement by the senior author (Galinat, 1964). It now seems possible that Tripsacum has a closer relationship to maize than has previously been suspected; Tripsacum may be an ancient amphidiploid hybrid between wild maize and another grass, probably Manisuris (Plate XLVI).

MORPHOLOGICAL EVIDENCE

Even though evidence from histological characters has been essential in determining the probable phylogeny of certain grasses (Avdulov, 1931 and others), the early stage of our investigations permits consideration here of only the more traditional taxonomic characters based on gross morphology. In this case, however, they are supported by evidence from cytogenetics.

Previous taxonomical, morphological and cytological evidence suggests that Tripsacum is closely related to Manisuris and may even be a polyploid hybrid having Manisuris as at least one of its parents. Among the genera of the tribe Andropogoneae, Manisuris shows closest morphological relationship to the maize tribe, Maydeae, especially to Tripsacum (Weatherwax, 1935). Indeed, Manisuris has in the past been regarded by some taxonomists as a species of Tripsacum (Michaux, 1803—cf. Hitchcock, 1935). As noted by Mangelsdorf and Reeves (1939): "The most striking differences between the two genera are that Manisuris has perfect flowers and Tripsacum does not and that Tripsacum has the staminate and pistillate spikelets in separate portions of the inflorescence; and these differences may not be sufficient justification for considering the relationship of the two genera to be very remote." Two of the nine species of

PLATE XLVI



A pictorial and symbolic representation of the new hypothesis suggesting that Tripsacum, XZ, may have originated as an amphidiploid hybrid between Manisuris, X, and wild maize, Z, of the type illustrated here by the reconstructed prehistoric wild maize from Tehuacán, Mexico. Teosinte, Z(XZ), and modern maize, Z(ZXZ), would, on this same notation, represent two different evolved products involving Manisuris introgression into maize.

Drawn by WALTON C. GALINAT

Tripsacum, *T. floridanum* and especially *T. zopilotense*, have a delicate habit of growth approaching that of Manisuris, while the other species of Tripsacum are more maizoid (maize-like), especially *T. australe* and *T. maizar*. Tripsacum, like maize, is confined to the New World. A preliminary survey of seven species of Tripsacum was made by Cutler and Anderson (1941); and since then two additional species have been discovered (Hernandez X. and Randolph, 1950). Although taxonomically Manisuris is often confused with Rottboellia and Hemarthria, it is clear that Manisuris has a world-wide distribution (Bor, 1960) and that at least five of its 12 or 13 species are native to the New World (Hitchcock, 1930, 1935).

The differentiation of Tripsacum into nine diverse species distributed throughout much of the New World suggests a considerable age for this genus, perhaps as much as 2,000,000 years. On the same basis, Manisuris would seem to be even older, an obvious requirement for a parent of Tripsacum, since Manisuris has differentiated into an even greater number of species (12 or 13) and has a world-wide distribution.

The finding of nine chromosomes in *Manisuris cylindrica* by Reeves and Mangelsdorf (1935) suggested to them that this grass was related to Tripsacum. In further developing this idea, Anderson (1944) states: "The cytological evidence would suggest that the 18-paired Tripsacum might have a cytological formula of XXYY where X and Y stand for sets of 9 chromosomes, and that Manisuris might be XX on the same notation." On the basis of frequency of chiasma configurations per cell, Anderson postulated further "that the 36-paired varieties (of Tripsacum) arose as octoploids (XXYYXXZZ) between XXYY and XXZZ varieties." Anderson made no suggestion about the origin of the YY and ZZ genoms, and there is no reason to believe that the "Z" symbol in his notation was intended to designate a genom of Zea. We are, however, using it so "on the same notation" (Plate XLVI).

Assuming then that Manisuris is one parent of Tripsacum, one test of whether wild maize could be the other parent lies in a comparison of the recently discovered prehistoric wild maize to these other two grasses. Such comparisons were made by Mangelsdorf and Reeves (1939) in determining if teosinte might be a derivative from maize-Tripsacum hybridization, and by Sarkar and Stebbins (1956) in determining what characteristics the other putative parent of the tetraploid wheats must have possessed if Einkorn were one parent. They found that *Aegilops speltoides* met virtually all of the requirements. Studies of this nature have been based on the general rule that, where an intermediate condition is possible, the presumed hybrid should show at least a tendency to be intermediate.

An examination of Table I, which compares 18 of the important botanical characteristics which distinguish Manisuris, Tripsacum and Zea, shows that Tripsacum tends to be intermediate in most cases where an intermediate condition is possible. Some detailed consideration is needed, however, to explain the functional possibilities for intermediacy and one case of apparent evolutionary elaboration of a hybrid product.

Monoecism is not only the definitive characteristic which separates Manisuris of the tribe Andropogoneae from Tripsacum of the tribe Maydeae, but it is also one of the few characteristics of Tripsacum which is non-intermediate between its putative parents. The monoecism of Tripsacum could have come as a dominant trait from wild maize, as reconstructed from archaeological remains of this grass uncovered in the valley of Tehuacán in Mexico (Mangelsdorf *et al*, 1964) and illustrated in Plate XLVI. The dominance of monoecism might be expected, since this evolved trait is dominant within maize itself to certain recessive mutations, "anther ear" and "dwarf-1" which, among their effects, cause development of perfect flowers. Although monoecism occurs also in the Oriental Maydeae, these grasses can be ruled out as putative parents of Tripsacum because they are lacking in other essential characteristics, such as the thickened rachis with cupule development found in maize.

Long styles and large pollen could be derived better from maize than from any other known grass, although the wild maize which we are considering as a parent of Tripsacum probably had shorter styles and smaller pollen than any living race of maize, if the small size of archaeo-

TABLE I. A comparison of some of the important botanical characteristics which distinguish Manisuris, Tripsacum and Zea.

Characteristic	Manisuris	Tripsacum	Zea
1. Perfect flower *vs* monoecious	perfect flowers	monoecious	monoecious
2. Length of styles	short	intermediate	long
3. Styles, bifurcation	separate	basal fusion	fused
4. Styles, hairs	profuse	intermediate	sparse
5. Size of anthers	small	intermediate	large
6. Size of pollen	small	intermediate	large
7. Size of rachis	slender	intermediate	thick
8. Cupules in rachis	absent	present	present
9. Rachis abscission	present	present	absent
10. Rachilla to rachis	parallel	parallel (pistillate)	right angles (pistillate)
11. Glume texture	indurated	indurated	herbaceous[1]
12. Glume surface	smooth[2] or sculptured	smooth	smooth
13. Spikelets binate	1 fertile, 1 sterile	staminate	staminate & pistillate
14. Phyllotaxy	distichous	distichous	polystichous
15. Leaf width	narrow	intermediate	broad
16. Height of tillers relative to main stalk	tall[3]	intermediate[3]	short
17. Growth habit	perennial	perennial	annual
18. Root stocks	present	present	absent

[1] Herbaceous or nearly so in archaeological wild maize.

[2] Smooth first glumes in *M. aurita.* The other New World species are sculptured.

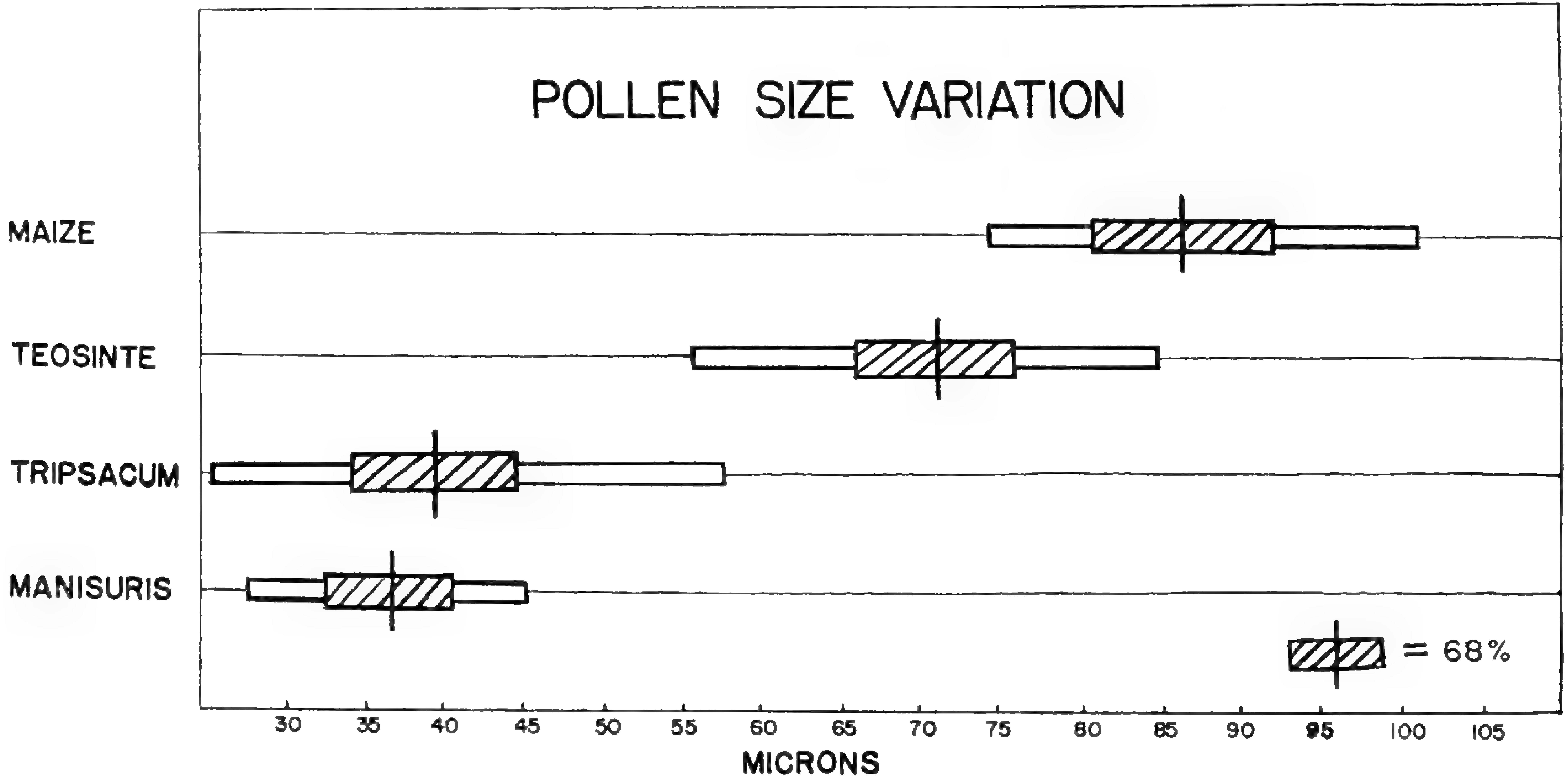
[3] On two year old plants.

logical wild maize ears and the present-day correlation between ear size and pollen grain size are indicative (Galinat, 1961). Our data (Table II and Plate XLVII) on the variation in pollen size of three species of Tripsacum, show that Tripsacum pollen is, on the average, larger than that of Manisuris, but not substantially so. This might be expected, if the wild maize parent of Tripsacum had pollen about the size of modern teosinte or slightly smaller, since the ranges of size variation of Tripsacum and teosinte do presently overlap.

The first 4 or 5 mm. of style length immediately above the pistil in Tripsacum are fused, a feature usually not observed because it is usually concealed by the outer glume. This partial fusion may be an expression of germplasm from maize since this grass is unusual in having its styles (actually stigmatic branches) fused for almost their entire length. In Manisuris, the bifurcation of styles is complete. The styles of Manisuris also have numerous long hairs presenting a feather-like appearance, while those of maize usually have sparse hairs; and here, too, Tripsacum is intermediate though extremely variable.

The cupulate fruit case of Tripsacum, a device which protects the grain by means of a complicated relationship between spikelet and rachis segment, appears at first to be a sudden development in an otherwise gradual trend in the tribe Andropogoneae leading towards its formation (Galinat, 1956). Its structure may be the result of an elaboration upon a combination of features coming in from both putative parents. From maize came the unique and essential feature of the cupule, a corneous cavity with wide lateral wings that develops in the rachis immediately above the attachment point of the pistillate spikelets. The specialization of the cupule in Tripsacum as a functional part of the fruit case may have occurred sometime after the origin of this species. Since the wild

PLATE XLVII



See Table II for details.

maize which would be one parent of the original hybrid with Manisuris was probably a form of pod corn and since the tunicate locus which is responsible for pod corn is dominant over the non-tunicate condition in hybrids of tunicate maize with both teosinte (Galinat, 1959) and Tripsacum (Galinat, unpub.), it seems probable that the original Tripsacum would have had the slender rachis with small cupules and the long herbaceous glumes characteristic of pod corn. Sometime during its evolutionary history, these may have been replaced by the thick rachis with large cupules and the indurated outer glumes characteristic of the non-tunicate condition and of modern Tripsacum.

Despite its slender rachis segments, Manisuris has a substitute for a cupule or a false cupule formed by the close position of sterile pedicels along alternate edges of successive rachis segments. Possessing this pedicel-formed cavity, it required only the true cupule from maize to form the cupulate fruit case characteristic of Tripsacum. Essentially unchanged from Manisuris might have come the sessile spikelets borne parallel to the rachis in a manner in which they could develop within the protective confines of a true cupule once it was introduced by maize germplasm. Also derived from Manisuris are the distichous arrangement of the spike and, at ma-

Table II. Pollen size variation in microns[1]

Grass	$\bar{X}$	Min.	Max.	σ	n
Manisuris cylindrica	37.4	28	46	4.10	93
Tripsacum[2]	40.4	26	58	5.28	489
Teosinte[3]	73.0	56	86	5.10	233
Maize (Chapalote)	87.2	74	102	6.12	228

[1] From stored pollen that has been swollen with 85% lactic acid and stained with IKI solution.

[2] Pooled data from *T. zopilotense*, *T. floridanum* and *T. dactyloides*.

[3] Pooled data from Florida teosinte and Arcelia teosinte.

turity, an extreme induration of the outer glume and rachis segment followed by rachis disarticulation with basal callus. The outer glume of Tripsacum and maize is smooth, while it is usually sculptured in native New World species of Manisuris, the exceptions being *M. aurita* of the New World tropics, and apparently certain variants of *M. cylindrica*. In any case, the smooth glume feature could have been derived as a dominant feature from maize.

Some vegetative features of Tripsacum, such as its broader leaves or capacity to evolve broader leaves than Manisuris, must have come from maize, while other vegetative features are better ascribed to Manisuris. The profuse tillering and perennial habit of growth in Tripsacum would probably have come from Manisuris. There is no evidence that the mere doubling of the number of chromosomes would convert an annual such as maize into a perennial such as Tripsacum. Certainly the perennial character would have been initially useful in the 2n hybrid by allowing it to persist despite sterility until a fertile 4n amphidiploid could arise through somatic doubling. Assuming, then, that the perennial habit did originate with Manisuris (because the oldest archaeological remains of maize from Tehuacán, Mexico, indicate that wild maize, like modern maize, was an annual (Mangelsdorf *et al*, 1964)) it must have been strongly dominant in its expression. All known New World species of Manisuris are perennial, and the rhizomatous habit is especially strong in *M. rugosa*, in which underground shoots may extend horizontally for several feet.

Even more significant than the general intermediate position of Tripsacum is the fact that when we use the technique of Anderson (1949) in asking the question of what source among grasses now known could make the necessary modifications in an assumed parent (Manisuris) to produce a given offspring (Tripsacum), then we find that the other parent could only have been either wild maize or teosinte. Of the two, wild maize is more promising than teosinte as the putative parent.

The chief evidence that indicates wild maize rather than teosinte (*Zea mexicana* (Schrad.) Reeves and Mangelsdorf) as the non-Manisuris parent of Tripsacum is the nature of the phenotypic effects described below of two genetic types of Tripsacum chromosomes which we have experimentally superimposed as "addition monosomics" upon maize. Also the cytogenetic and morphological evidence presented by Mangelsdorf and Reeves (1939), Reeves and Mangelsdorf (1959), that teosinte is a derivative of maize-Tripsacum hybridization suggests that it is of more recent origin than Tripsacum, and, if so, could not be the parent of Tripsacum.

Although a detailed study of their phenotypes is still in the early stage, the morphological effects which we have been able to observe so far support our hypothesis as to the parents of Tripsacum. That is, there is one type of Tripsacum chromosome which is both genetically similar to maize and has "maizoid" effects which tend in the direction of wild maize. The other type seems to be genetically foreign to maize and has "manisuroid" effects tending in the direction of both teosinte and Manisuris.

The effects suggestive of the characteristics of wild maize of only two addition monosomics of the maizoid type can be included in this preliminary report. First, the Tripsacum chromosome which is known to bear at least one locus, Lg_1 (maize marker liguleless$_1$), and probably many more, including Gl_2 (maize marker glossy seedling$_2$) and Ws_3 (maize marker white sheath$_3$) as found by Maguire (1962) has effects on the ear which we consider tend toward wild maize. Although the reduction in plant height and possibly the increase in tillering (Table III), as also observed by Maguire (1956), may be effects only from a chromosomal unbalance, the combination of longer internodes in the rachis (measured as thicker kernels) with shorter ears bearing a lower number of kernel rows would not result from just a general reduction of vigor. In the background of modern maize, long internodes in the rachis are associated with longer ears, even under conditions of stunting, but in primitive maize such as Confite Morocho of Peru (Grobman *et al*, 1961) and in the archaeological wild maize of Tehuacán, Mexico (Mangelsdorf *et al*, 1946), relatively long internodes in the rachis are associated with tiny eight-rowed ears. The data (Table III) show that there was no overlapping in the range of variation for ear length and almost none for kernel rows and kernel thickness. The one 10-rowed ear which occurred in the 21-chromosome plants was actually eight-rowed at the tip of the ear and, thereby, showing a tendency to be eight-rowed like the other ears bearing the extra chromosome. None of the 20-chromosome plants were eight-rowed. Thus, the Trip-

TABLE III. Phenotypic effects of the *T. dactyloides* counterpart for chromosome 2 when added to maize.[1]

Character	20-chrom			21-chrom.		
	$\bar{X}$	Min.	Max.	$\bar{X}$	Min.	Max.
Plant height cm.	96.0	75.0	120.0	90.5	73.0	110.0
No. of tillers	2.8	2.0	3.0	4.3	4.0	5.0
Ear length cm.	14.2	13.5	17.0	10.5	7.7	12.0
Kernel rows	11.5	10.0	12.0	8.1	8.0	10.0
Kernel thickness mm.[2]	3.6	3.3	3.8	4.2	3.7	4.7

[1] Since the population is small (16 plants), maximum and minimum are given rather than standard deviations.

[2] Averaged from 10 consecutive kernels in the central region of each ear.

sacum homeolog[1] or counterpart for chromosome 2 has several wild-maize-like effects on the ear.

The Tripsacum homeolog for maize chromosome 9 produces a staminate tipped ear, a characteristic of wild maize as reconstructed in Plate XLVI. These changes suggestive of wild maize are not associated with increases in glume or rachis induration, as they might be had they been caused by either teosinte or Manisuris germplasm. Also both of these maizoid isolates from Tripsacum as well as others bearing several genetically marked chromosomes from Tripsacum are usually completely female fertile and at least partially if not completely male fertile.

In sharp contrast are the effects of the "manisuroid" isolates which have extra chromosomes not markable by any of the seven marker genes of WMT maize (described later) which, if Manisuris is one parent of Tripsacum, may represent the chromosomes originally from Manisuris. The manisuroid isolates tiller more profusely, have narrower leaves, smaller spikelets, smaller kernels, increased induration of rachis and glumes, less specialization between the staminate and pistillate glumes and are partially female sterile and usually completely male sterile. The tendency for the staminate and pistillate glumes to be more alike through a reduction in the usual development of wings on the pistillate glumes and a reduction of the usual increased elongation of the staminate glumes, is of significance because with the perfect flowered condition of Manisuris, there is no pressure for glumes which are specialized into two shapes, one for protecting kernels, the other for protecting anthers.

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[1] A term sometimes spelled *homoeologue*, used first by Huskins (Am. Nat. **75:** 329–344, 1941) to designate the genetically similar chromosomes in the hexaploid wheat genom.

CYTOGENETIC EVIDENCE

The conception of Tripsacum as an amphidiploid of wild maize and Manisuris originated from the rather surprising results of a segregation of Tripsacum chromosomes from a hybrid of *T. dactyloides* with a unique multiple tester stock of maize which has recessive marker genes on seven chromosomes (1, 2, 3, 4, 7, 8, 9). This "WMT" stock of maize was developed by Mangelsdorf some years ago expressly for the purpose of crossing with Tripsacum. Its development started in Texas on a background of the variety "Mexican June." Later, after being moved to Massachusetts where earlier maturity proved to be necessary, germplasm from two northern inbreds, P39 and A158, was added. The original hybrid of *T. dactyloides* with this multiple tester was actually produced on a vigorous line cross between two inbred strains of the WMT stock. The principal purposes in making this hybrid with Tripsacum were: (1) to determine whether Tripsacum carries dominant alleles of the maize recessives; (2) to determine whether Tripsacum, having almost twice as many chromosomes as maize, carries the dominant alleles in duplicate in some cases; (3) to identify cytologically the Tripsacum chromosomes which carry the dominant alleles.

A hybrid plant, obtained by the embryo culture work of Dr. Hager, exhibited none of the seven recessive characters introduced from maize but proved to be completely sterile. Consequently, colchicine treatment to double the chromosome number was required in order to produce a tetraploid hybrid. This proved to have only about 50 per cent female fertility (Galinat, 1961), although virtually full female fertility of the F_1 on the 2n level occurs in maize-Tripsacum hybrids involving another species, *T. floridanum* (Galinat, 1962). Backcrosses of the F_1 hybrid to the WMT maize stock produced triploid plants having 20 maize and usually 18 Tripsacum chromosomes. The second backcross to WMT yielded a population of 92 plants segregating for varying numbers of extra Tripsacum chromosomes, ranging from one to thirteen, of which seven were marked by dominant genes.

Our genetic analysis (Galinat, Mangelsdorf and Chaganti, 1963) of the transmission frequencies of the seven dominantly marked Tripsacum chromosomes indicated a negative answer to the second question: *i.e.*, does Tripsacum carry the dominant alleles in duplicate? The frequencies of these dominants were similar, averaging 32.2 per cent with the exception of J_1 which was present in almost twice this frequency (Table IV). We now know that at least part of the high frequency of J_1 was the result of a poor expression of j_1 which is characteristic of this gene. The progeny of another generation of backcrossing to WMT of one plant classified as J_1 proved to be all j_1, while another similar backcross progeny proved to be all green, perhaps because of the presence of one of the *R* alleles which is known to be associated with a factor inhibiting the expression of j_1 (Emerson, Beadle and Fraser, 1935).

The average transmission frequency of 32.2 per cent for each dominantly marked chromosome (except J_1) was interpreted as a deviation from the expected 50 per cent on random segregation of a single chromosome. This was

TABLE IV. Genetic data for transmission rate to 92 WMT maize plants of seven dominantly marked *T. dactyloides* chromosomes derived from a maize-Tripsacum BC_1 hybrid.

	Maize Chromosome						
	1	2	3	4	7	8	9
Dominant from Tripsacum	Bm_2	Lg_1	A_1	Su_1	Gl_1	J_1	Wx
Frequency of Dominants, %	34.5	23.9	31.6	28.2	38.0	60.5	37.0

the first clue that there was only one homeolog in Tripsacum for each of the maize chromosomes.

Confirmation of this indication followed the chromosome counts made by Chaganti for individual plants in about a third of this segregating population. First, one of the genetic addition monosomics for Wx^T (62–586–20) which bore an ear segregating Wx^T kernels at the frequency (32 per cent) that had been attributed to single homeolog transmission, was in fact found cytologically to have only one extra Tripsacum chromosome. Secondly, chromosome counts in many of the other plants revealed the presence of various numbers of unmarked Tripsacum chromosomes in addition to those which represented homeologs of the seven recessively marked chromosomes in WMT maize (Table V). Since three of the 10 maize chromosomes were unmarked by recessive genes, the counts of extra Tripsacum chromosomes have to be considered accordingly. For example, plant 62–582–27 carried 13 extra Tripsacum chromosomes and seven dominant markers leaving not less than three nor more than six unmarked addition chromosomes; Plant 62–588–65 carried 12 addition chromosomes with only three dominant markers leaving six to nine unmarkable chromosomes; Plant 62–586–43 carried five addition chromosomes with no dominant markers, leaving two to five of the unmarkable type.

If we assume that there is in Tripsacum a genom of nine unmarkable chromosomes and a genom of nine markable chromosomes for which two markers are lacking in the WMT stock, then we can calculate the number of unmarked chromosomes to be expected in the population of 163 extra Tripsacum chromosomes listed in Table V. This turns out to be 100; the actual number found was 85. The value of Chi-square for the ratio is 5.82 which represents a P value of less than .02.

TABLE V. Segregation of genes and chromosomes in the testcross progeny of the triploid hybrid [(bm_1, lg_1, a_1, su_1, gl_1, j_1, *wx* × *T. dactyloides*) × bm_1, lg_1, a_1, su_1, gl_1, j_1, *wx*)].

Plant Number	Number of Chromosomes	Number of extra Tripsacum chromosomes	Dominants from Tripsacum	Number of unmarked Tripsacum chromosomes excluding J
62-580- 8	24	4	Su, Lg, (J)[1]	2
- 9	23	3	Su, Lg	1
-10	27	7	Su, Lg	5
62-582-16	21	1	Wx	0
-18	24	4	Wx	3
-20	21	1	Wx	0
-22	22	2	Wx, (J)	1
-23	20	0	None	0
-25	28	8	Su, Wx, A, Gl, Bm, (J)	3
-26	29	9	Su, Wx, A, Gl, Lg, Bm	3
-27	33	13	Su, Wx, A, Gl, Lg, Bm, (J)	7
-29	25	5	Su, Wx, Lg, (J)	2
-31	29	9	Su, Wx, Bm	6
-32	22	2	Su, Wx	0
62-586-41	22	2	(J)	2
-42	26	6	Bm	5
-43	25	5	None	5
-45	23	3	Lg, (J)	2
-47	23	3	(J)	3
-49	27	7	Wx, A, Gl	4
-51	28	8	Wx, Gl, (J)	5
-59	24	4	Wx, A, (J)	2
-60	24	4	Wx, A, (J)	2
-61	25	5	Wx, Lg	3
62-588-65	32	12	A, Gl, Bm	9
-68	27	7	A, Gl, (J)	5
-71	25	5	Gl, (J)	4
-72	24	4	Gl	3
-77	25	5	Gl, Bm	3
-81	22	2	A	1
-84	23	3	A	2
-86	23	3	A	2
-89	22	2	Lg, (J)	1
-92	25	5	Lg, (J)	4
Totals		163	63	100
Theoretical *			54	109

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[1] See text for unreliability of *J* phenotypic expression. The total at the bottom of the column excludes *J*.

* On the assumption that there is a genom of nine unmarkable chromosomes and a genom of nine markable chromosomes for which three markers are lacking.

Knowing from the progenies of some of the plants listed in Table V that the classification for *J* has been inaccurate in some cases, we have made another calculation excluding *J* as one of the markers. The observed ratio of marked and unmarked chromosomes is now 100: 63 and the theoretical ratio is 109:54. Chi-square for this ratio is 2.24 which represents a *P* value of 0.14.

The closeness of the fit between the theoretical and observed ratios of marked and unmarked Tripsacum chromosomes in this population is regarded as good, indeed almost conclusive, evidence that Tripsacum contains two distinct genoms. One of these is so remotely related to maize that it contains no dominant counterparts of the maize marker recessives tested so far and presumably its nine chromosomes are not homeologs of maize chromosomes. This is the genom which we assume to have been derived from a genus of the tribe Andropogoneae, probably Manisuris. We are, accordingly, designating this the "manisuroid" or X genom. The other genom is much more closely related to the maize genom, since it does carry dominant alleles of the maize recessive. Furthermore, some of these chromosomes have a similar gene content to their maize homeologs. For example, Maguire (1962) has found that the genes Ws_3, Lg_1, Gl_2 which in maize occur on the short arm of chromosome 2, are also linked together on the long arm of one of the Tripsacum chromosomes, although according to our recent unpublished data, the V_4 gene on the other arm of maize chromosome 2 is located elsewhere in our "Bussey clone" of *T. dactyloides* (2n of Kansas). Maguire (1961) found also that this Tripsacum chromosome segment competes successfully about 5 per cent of the time in synapsis with maize chromosome 2 to the exclusion of its partner. Furthermore, she found that pollen bearing this extra chromosome from Tripsacum functioned in direct competition with pure maize pollen about 42 per cent of the time. Thus, this particular Tripsacum chromosome is in several respects the counterpart of modern maize chromosome 2, although, it is shorter in length and may not have the counterpart of the V_4 locus on this particular chromosome in maize.

Our own data likewise show that the Tripsacum homeolog of maize chromosome 9 which carries a dominant allele of *wx* also carries dominant alleles of sh_1 and *bz*, two other recessives whose loci occur on chromosome 9.

Thus, even the cytogenetic data so far available suggest strongly that the second genom is much more closely related to maize than the *X* or "manisuroid" genom. Accordingly, we are designating this as the "maizoid" or *Z* genom. This genom may have been derived from a wild maize not too different in its characteristics from the prehistoric wild maize described by Mangelsdorf *et al* (1964) or it may have come from the remote ancestor of that maize.

Another means for the cytological corroboration for the presence of the postulated X and Z genoms within Tripsacum is by comparing the frequency of various types of synaptic relationships within haploid maize, Z, and haploid Tripsacum, XZ, to that of the F_1 maize-Tripsacum hybrid, Z (XZ). A model for their expected behavior on the basis of this hypothesis can be set up and tested against the observed behavior. Such a model would stipulate low intragenomic pairing of the Tripsacum chromosomes and considerable intergenomic pairing between maize and Tripsacum chromosomes when the chromosomes of the two species are brought together in the same cell.

The behavior of chromosome synapsis was studied in haploid maize and in hybrids of maize and *Tripsacum floridanum* (a close relative of *T. dactyloides*) (Chaganti and Galinat, 1964) and their backcross progenies (Chaganti, 1964). The objective of this study was to score the frequency of associations which are a consequence of effective synapsis (synapsis followed by exchange, reflected as chiasmatic associations at metaphase) and homologous or homeologous synapsis in haploid maize (reflected as side-by-side associations at metaphase, Person, 1955; Riley and Chapman, 1957), in the haploid genom of Tripsacum and in the F_1 maize-Tripsacum hybrid. If the pairing frequency in one or both the species or their sum is equal to or greater than that of the hybrid, then most of the pairing in the hybrid would be autosyndetic and not reflective of intragenomic affinities. If, on the other hand, the pairing in the hybrid is higher than that of the parents individually or even that of their sum, then such an increase in pairing could only result from some intragenomic or allosynditic associations (Riley and Chapman, 1957).

The haploid maize used for this type of comparison was found in the backcross progeny of a triploid hybrid of maize and *Tripsacum floridanum.* Although no haploid Tripsacum plants as such were available or have ever been discovered, the essential information for our purposes was obtained from observations made on a haploid genom of Tripsacum isolated within a triploid hybrid which also contained two genoms of maize in each cell. Since the two genoms of maize pair with each other rather than compete with the Tripsacum chromosomes, any synaptic relationships within the Tripsacum genom are expressed, except when confused by rare but apparent maize-Tripsacum interchanges which occurred in the parental F_1 hybrid. Furthermore, any other exchanges between the non-homologous Tripsacum chromosomes occurring in the F_1 hybrid will be apparent (if the exchange chromatids are transmitted to the egg developing into the triploid hybrid) as extra bivalents in the triploid hybrid (Maguire, 1964). Thus, the behavior of Tripsacum chromosomes in the triploid hybrid may be taken to represent the intragenomic affinities within the Tripsacum genom. In Table VI, the mean per cell of chiasmatic and side-by-side association found at meta-anaphase in haploid maize, a haploid genom of Tripsacum (in the triploid hybrid) and the F_1 maize-Tripsacum hybrid are presented (also see Plate XLVIII).

TABLE VI. Mean per cell of chiasmatic and side-by-side associations and their range (in parenthesis) in haploid maize, a haploid genom of Tripsacum and the F_1 maize-Tripsacum hybrid. The rest of the chromosomes occurred as unpaired univalents or end-to-end associations of various kinds and frequencies. It is assumed (Person, 1955; Riley and Chapman, 1957) that the later type of associations do not imply homologies or homeologies.

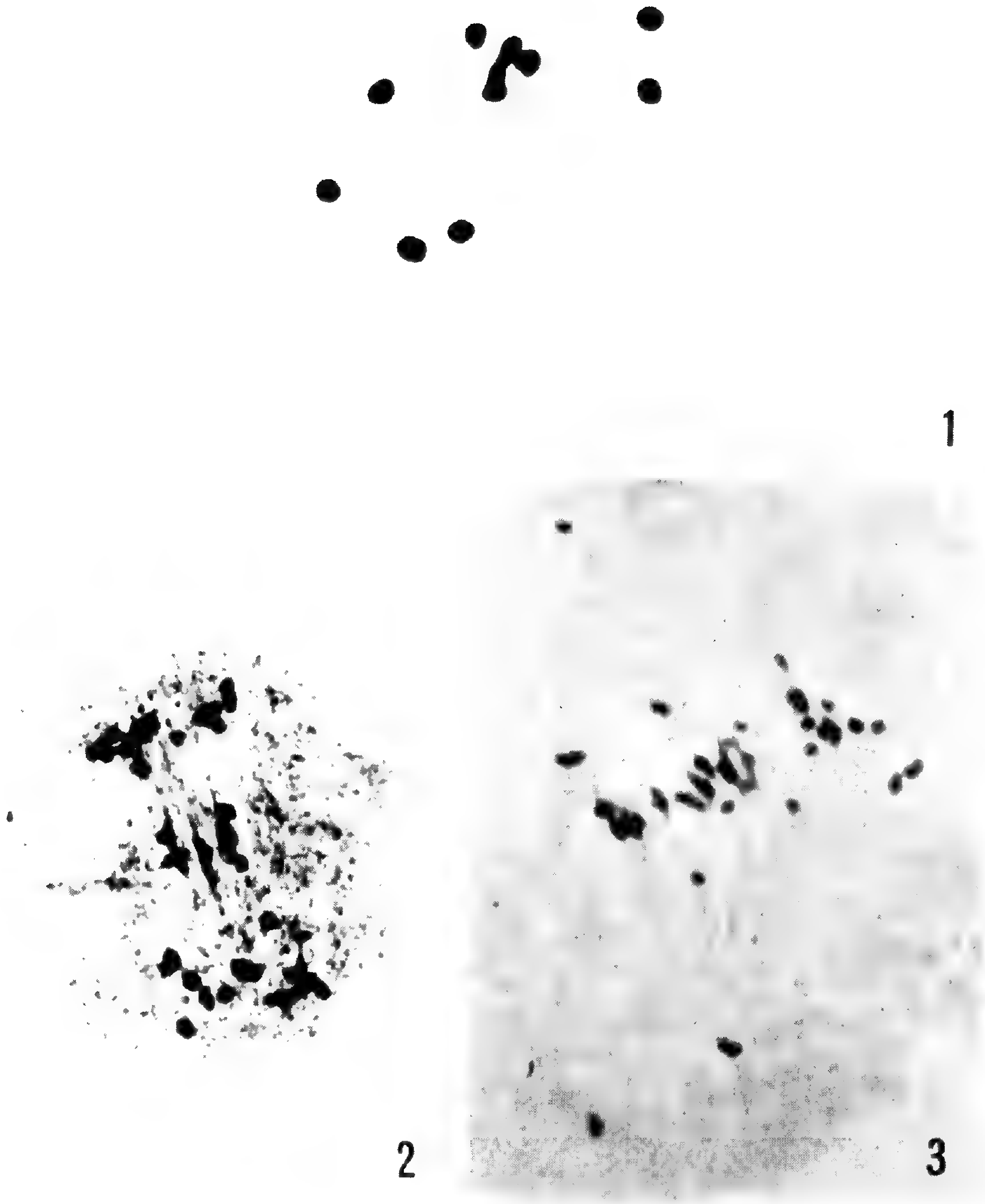
	Mean per cell of chiasmatic trivalents	Mean per cell of chiasmatic bivalents	Mean per cell of s–s assns.	Remainder of chromosomes
Haploid maize	0.00	0.06 (0 to 1)	0.28 (0 to 2)	9.32
Haploid genom of Tripsacum	0.06 (0 to 1)	0.20 (0 to 1)	0.20 (0 to 1)	17.07
Haploid maize plus haploid genom of Tripsacum	0.06	0.26	0.48	27.34
F_1 maize-Tripsacum hybrid	0.00 (0 to 4)	2.28 (0 to 4)	0.69 (0 to 2)	22.04

The above data clearly demonstrate that the mean synapsis is higher in the F_1 hybrid of maize and Tripsacum compared to the pairing in the parents individually or together and hence most of it must be allosyndetic. In this connection, it is of interest to refer to certain observations on chromosome exchanges in maize-Tripsacum hybrids made by Maguire (1964) in a study of chromosome pairing in the backcross progenies of maize-Tripsacum hybrids. Maguire studied two triploid hybrids, one of which showed 10 maize bivalents and 18 Tripsacum univalents consistently. In the other, out of 34 cells examined, at metaphase, 27 (or 79.4%) showed two trivalents each, nine (or 26.5%) showed one trivalent each, and 24 or 70.6%) showed an additional Tripsacum bivalent besides the 10 maize bivalents. She attributed the trivalents to maize-Tripsacum exchanges in the F_1 hybrid, while the extra Tripsacum bivalent was assumed to have arisen from interchanges within the Tripsacum genom. Thus, Maguire's data, like ours, show a rather low intragenomic exchange either in the F_1 or the triploid hybrid. In the one hybrid in which prior exchange is reflected it seems that maize-Tripsacum exchanges are more frequent than Tripsacum-Tripsacum exchanges.

The foregoing data and discussion clearly demonstrate three facts: (1) there is low intragenomic pairing within haploid maize, (2) there is also low intragenomic pairing within the haploid genom of Tripsacum, and (3) pairing in the maize-Tripsacum hybrid is allosyndetic.

If this allosyndetic synapsis involves all of the Tripsacum chromosomes such that the entire Tripsacum genom shows synaptic affinities to the maize genom, then one would assume that Tripsacum is a polyploid with two similar sets of chromosomes. In such a case, the chances for the members of a given Tripsacum genom to pair and exchange segments with their homologs or homeologs in the maize genom would be equal to their chances of pairing with the members of the second Tripsacum genom. This would be reflected as a higher (than observed) frequency of extra bivalents from Tripsacum in the triploid hybrid. Furthermore, in the F_1 hybrid there would be at least some proportion of trivalent pairing. Since no such trivalents were encountered in the F_1 hybrid of this test, the evidence indicates that the two genoms of Tripsacum are dissimilar.

PLATE XLVIII



Chromosome association in haploid maize, maize-Tripsacum hybrid and the triploid hybrid. 1, Meta-anaphase of haploid maize showing 8 univalents and one bivalent. 2, Meta-anaphase of maize-Tripsacum hybrid showing three bivalents and 22 univalents. 3, Metaphase I of the triploid hybrid showing a ring of four maize chromosomes (probably due to exchange between two non-homologous chromosomes in the F_1) 8 maize bivalents and 18 Tripsacum univalents. 1, 2 and 3, 800 ×.

DISCUSSION

The hypothesis presented here regarding the ancient origin of Tripsacum from an amphidiploid hybrid of wild maize and Manisuris is a testable one. We shall continue with experiments designed to test it in various ways, and we hope that others will also be interested in doing likewise by all means, including, for example, the use of techniques sometimes referred to as "chemical taxonomy." Virtually all of the morphological and cytological data which we have been able to evaluate so far is consistent with the hypothesis. An exception yet to be explained, however, is the fact that if the 10 pairs of chromosomes in modern maize are combined with the nine pairs of Manisuris, we might expect it to produce an amphidiploid with 19 pairs rather than the 18 pairs of Tripsacum. The most plausible explanation at the moment is that one maize chromosome has been lost, probably in the 2n hybrid.

The past and possible future contributions of Tripsacum germplasm to the evolution of maize should be more completely evaluated. Genes for the perennial habit, the immunity to some of the major fungal diseases affecting maize (Malm and Beckett, 1962), increased resistance to heat and drought, stiffer leaves and stalks (Mangelsdorf and Reeves, 1939), early flowering and longer internodes above the ear position (Galinat, 1963) and increased yielding capacity and improved chlorophyll characters (Reeves and Bockholdt, 1964) are probably but a few of those which we might wish to transfer from Tripsacum to maize.

Mangelsdorf (unpub.) has pointed out that because the apparent wild maize genom in Tripsacum has been subjected to some very rigorous environments for long periods of time, it may possess genes of great economic value, some of which can undoubtedly be transferred to maize (*cf.* Reeves and Bockholt, 1964). Thus, maize breeders might select Tripsacum for introgressive purposes from the region in which they are interested. In this connection, Beckett and Lambert have already conducted a state-wide survey of Tripsacum in Illinois for possible maize breeding purposes (Lambert, 1963).

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PLANTAE COLOMBIANAE XVIII

DE PLANTIS REGIONIS AMAZONICAE NOTAE

BY

RICHARD EVANS SCHULTES

1. *Henriquezia*

In 1859, Bentham read a paper to the Linnean Society of London entitled: "On the genus Henriquezia of Spruce" (in Trans. Linn. Soc. London 22 (1959) 295–298, tt. 52–54). He described four species, all collected by Spruce in 1851 and 1854 from the upper reaches of the Rio Negro and Casiquiare in Brazil and Venezuela: *H. verticillata; H. obovata; H. nitida;* and *H. oblonga.*

Very little material referable to *Henriquezia* had apparently, until very recently, been collected during the intervening century. Schumann described *Henriquezia Jenmanii* from British Guiana; and Standley described a concept that he called *H. aturensis* from the Savannah of Atures in southern Venezuela. Ducke described *Henriquezia macrophylla* and Bremekamp *H. longisepala,* both on the basis of material collected in the upper Rio Negro basin of Brazil. Most recently, Steyermark has described as new *Henriquezia verticillata* var. *apiculata* from Manaós and *H. nitida* var. *subcuneata* from the upper Rio Negro of Brazil.

Henriquezia was established by Bentham as a somewhat aberrant member of the *Bignoniaceae.* The genus has, however, usually been treated as belonging to the *Rubiaceae.* In a very critical study of the morphology of *Henriquezia* and *Platycarpum,* Bremekamp (in Acta.

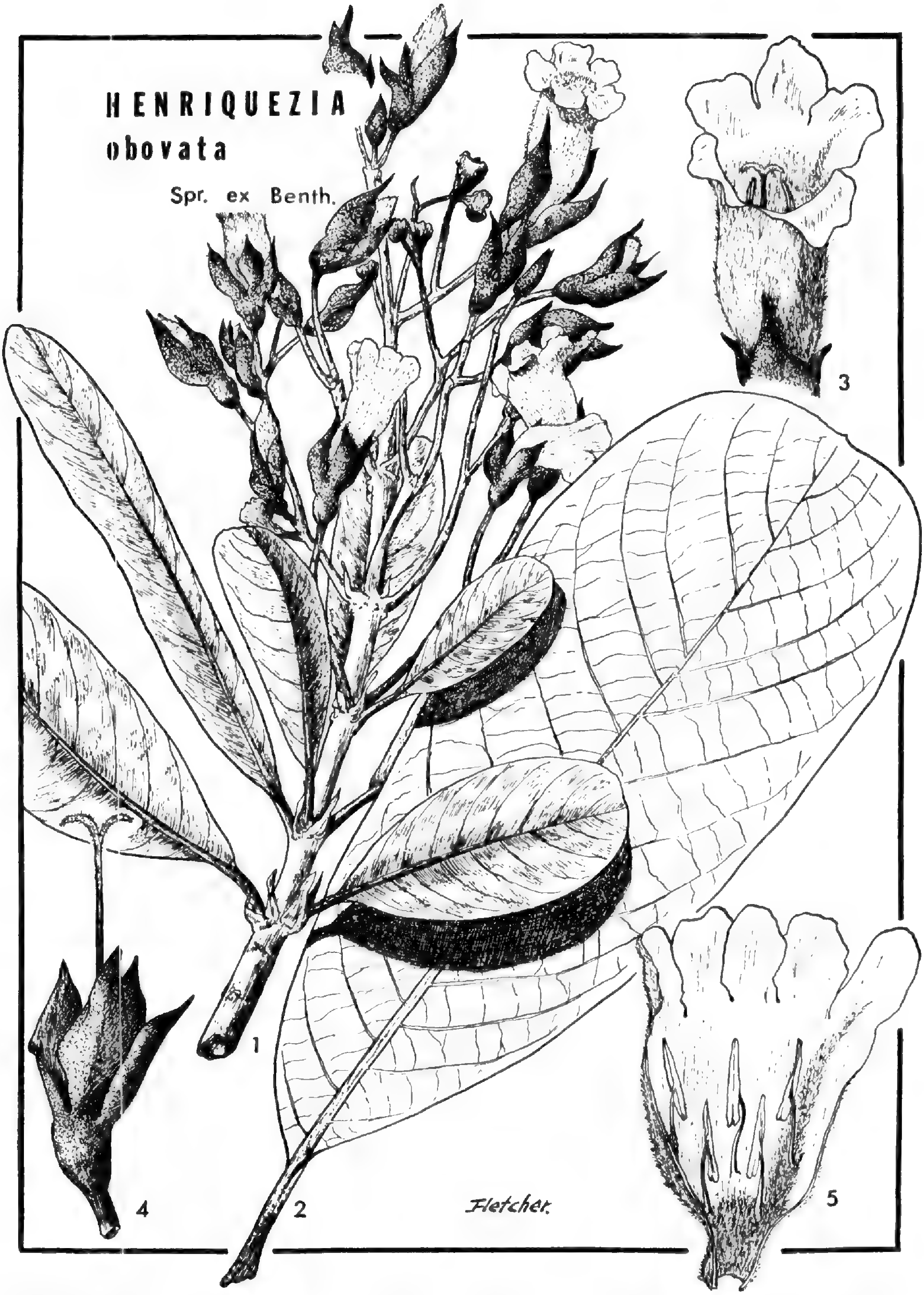
Bot. Neerland. 6 (1957) 351–377) has set these two generic concepts apart in a distinct family: the *Henriqueziaceae*. Steyermark's recent study (in Mem. N.Y. Bot. Gard. 10 (1964) 199), however, retains the genus in the *Rubiaceae*.

Of Spruce's original species from the upper Río Negro — Casiquiare area, *Henriquezia verticillata* (the type of the genus) and *H. nitida* were known in flower; *H. obovata* and *H. oblonga* (which Bentham suspected as representing possibly but a variety of *H. nitida*) were known only from fruiting material; and the type collection of *H. obovata* consisted of but a single specimen.

In 1952, ninety-eight years after the Spruce collection, I encountered *Henriquezia obovata* in flower in early November along the Río Guainía, the headwaters of the Río Negro. The tree, about 50 feet in height, prefers the river bank, especially near outcroppings of rock or above cataracts. The bark is unique in being greenish and very rough. The Kuripako Indians who inhabit the Río Guainía know the tree as *oo-wá-pa* and utilize the ashes of the bark and leaves for mixing with clay for making pots. The Kuripakos of the Colombian village of Sejal on the upper Guainía report that the water in which the bark has been boiled for an hour is an efficaceous wash in the treatment of a prevalent skin disease known as "pinto" or "carate"; the bark is intensely bitter.

The collection *Schultes, Baker et Cabrera 18222*, on which the following description of the inflorescence and flower is based, was made probably not far from the type locality which was "in woods along the Guainía or upper Río Negro, above the confluence of the Casiquiare."

Panicula terminalis, intra folia summa subsessilis, thyrsoidea, 15–20 cm. longa, usque ad 13 cm. in diametro, ramis crassis, subcompressis, sulcatis, verticillatis atque dichotome cymiferis, dense sed minutissime albido-tomentellis. Calyx incurvus, subcrassus, 25–30 mm. longus, extus dense sed minutissime tomentellus pilis



HENRIQUEZIA OBOVATA Spr. ex Benth. 1, flowering branch, × approximately ½ natural size. 2, large leaf, × approximately ½. 3, flower, × approximately 1. 4, calyx and style, after dropping of the corolla, × approximately 1. 5, interior of corolla tube, × approximately 1½. *Drawn by* JOHN STANWELL-FLETCHER sordide albidis, intus similiter tomentellus sed basin versus aliquid sericeus, $\frac{2}{3}$ pro parte in lacinias quattuor divisus; laciniis aestivatione valde imbricatis, ovatis, longe acuminatis, apice ipso acutissimis, margine integris sed frequenter aliquid reflexis, parte latiore usque ad 9–10 mm. latis. Corolla rosea, intus atrosanguineo-maculata, 35–55 mm. longa; extus maxime densissime albo-sericea appressa siccitate canescens, intus praecipue laciniarum apicem versus minutissime ferrugineo-tomentella sed maxima pro parte glabrescens, et serie pilorum ferrugineorum secus lineam mediam labii inferioris; ad basin faucis dense et grossiuscule albo-strigillosis, lobis adscendentibus, valde rotundatis, usualiter 15–20 mm. longis, usque ad 15 mm. latis. Stamina glabra, infra medium tubi inserta, usque ad 25 mm. longa; antherae 7–8 mm. longae, flavae, medifixae, biloculares, siccitate aliquid spiraliter contortae, longitudinaliter dehiscentes. Stylus basi glaber, apicem versus irregulariter hirto-stigmatosus, apice in lamellis oblongis divisus, usque ad 38–40 mm. longus. Discus epigynus brevis, crassus, pilosus.

COLOMBIA: Comisaría del Vaupés, Río Guainía, Puerto Colombia (opposite Venezuelan town of Maroa) and vicinity, Raudal Sapo. Altitude about 800–850 feet. "Columnar tree 50 feet tall. Crown sparse. Flowers pink, without fragrance; dark red blotches inside throat of corolla. Bark green, rough. Kuripako name: *oo-wá-pa.* October 31–November 2, 1952, *Richard Evans Schultes, Richard E. D. Baker et Isidoro Cabrera 18222* (TYPE OF FLOWER in Herb. Gray).

The flowers of ***Henriquezia obovata*** indicate a closer relationship with ***H. verticillata*** and ***H. nitida*** than to other species, and the closest relationship seems to be with ***H. verticillata.*** The panicle of ***Henriquezia obovata*** is apparently smaller and with fewer flowers than that of ***H. verticillata***, and the rhachis is conspicuously white-tomentellous instead of rusty-tomentellous. The calyx of ***Henriquezia obovata*** is likewise white-tomentellous (not rusty-tomentellous as in ***H. verticillata***) and is divided for $\frac{2}{3}$ of its length (instead of only $\frac{1}{2}$ its length); the calyx lobes of the former species are rhombic-ovate and basally strongly constricted instead of ovate) and very long-acuminate (instead of abruptly acute). The corolla of ***H. obovata*** is much more densely pilose than that of ***H. verticillata*** and has even a pronounced beard at its base; it has dark red spots on its inner surface in the former species, whereas in the latter it is reported to be without spots. The style seems to be somewhat slenderer in ***Henriquezia obovata*** than in ***H. verticillata.*** These differences, together with the vegetative and fruit characters pointed out by Bentham and subsequent investigators, leave no doubt in my mind that the ***Henrequezia obovata*** is indeed worthy of specific distinction. Steyermark (loc. cit. 203) has reduced ***Henriquezia obovata*** to synonymy under ***H. verticillata,*** but I believe that, applying the same criteria to ***H. obovata*** that he applies to the several other concepts which he has treated, it should be worthy of specific, certainly of varietal, status. Steyermark recognizes four species and four varieties.

Since no illustrations of ***Henriquezia obovata*** in flower have apparently been published, the accompanying plate, drawn from *Schultes, Baker et Cabrera 18222* is offered.

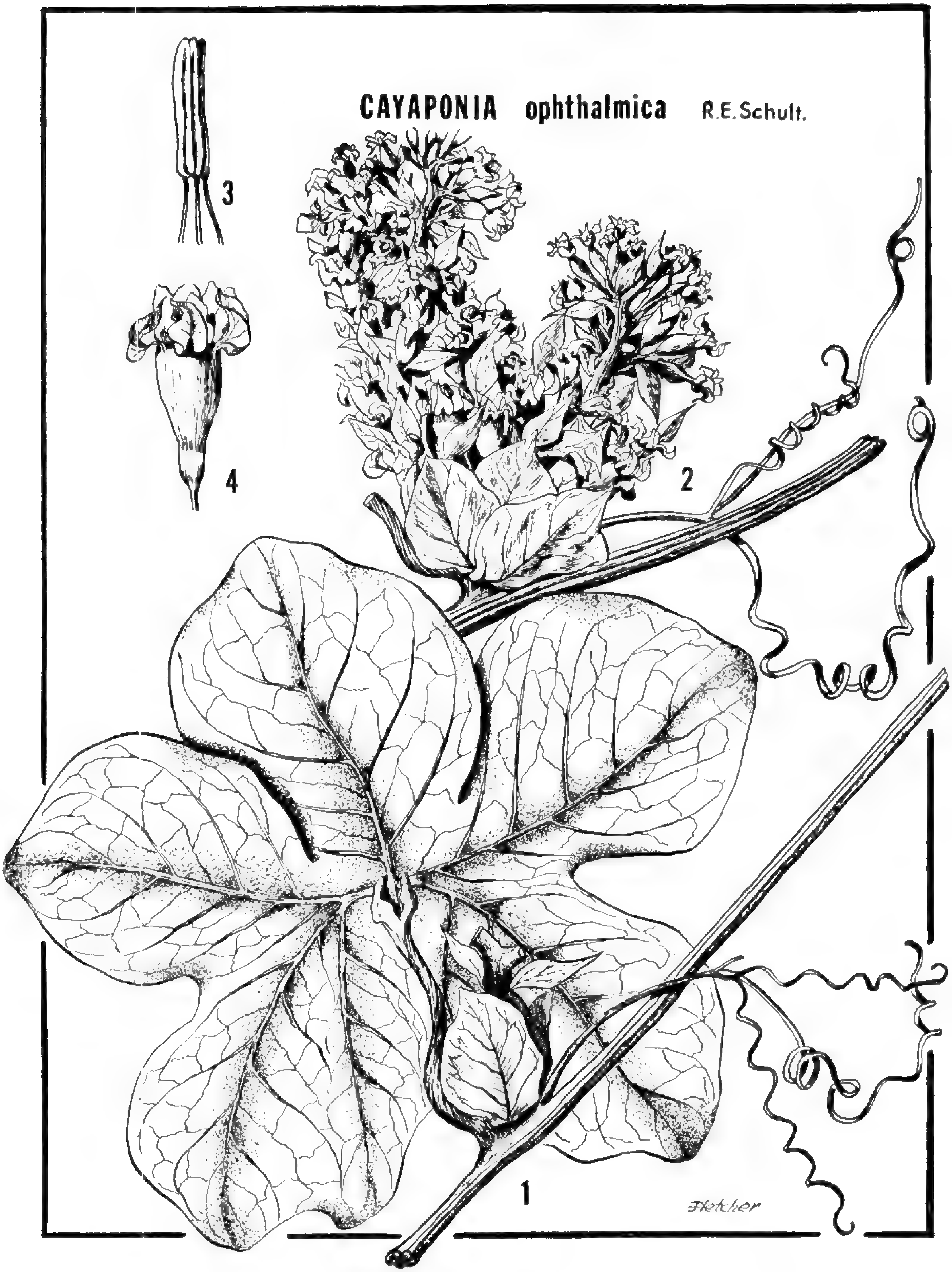
2. *Cayaponia*

Quite contrary to usual expectation, weeds and cultivated plants in areas botanically as poorly known as the northwestern part of the Amazon are of great interest and may often have escaped the attention of collectors. Not infrequently, species new to science turn up in or around native agricultural plots. This is apparently the case with the curious cucurbitaceous plant described herein as *Cayaponia ophthalmica.*

Cayaponia ophthalmica *R. E. Schultes sp. nov.*

Herba robusta, alte scandens, usque ad quattuor metr. longa. Caulis flexuosus, pseudolignosus, cortice molle, viride. Ramuli profunde striato-sulcati, omnino sed praecipue in canalibus leviter albo-hispiduli, cum in foliorum axillis 7–8 bracteis foliaceis conspicuis, violaceis, variabilibus (exterioribus majoribus, ovatis, acutis, usque ad 6.5 cm. × 4 cm., conspicue venosis; interioribus sensim minoribus, ovato-lanceolatis, usque ad 1 cm. × 0.6 cm.) instructi. Petiolus satis robustus, striatus, glabrus, apice carnoso-suberosus, conspicue alatus, usque ad 8 cm. longus. Folia coriacea, subpeltata, supra atroviridia, infra pallidiora, utrinque glaberrima, trilobata, usque ad $\frac{3}{4}$ pro parte divisa, subtus venis robustissimis et conspicue elevatis, nervis secundariis similibus sed inter nervis secundariis venulis tenuissime reticulatis; lobo centrale ovato, apice valde obtuso vel rotundato, margine integerrimo, usque ad 18 cm. longo, 11.5 cm. lato, lateralibus asymmetricis, minoribus, 15 cm. longis, apice rotundato, sino basilare rotundato, basi auriculatis, auriculo magno, normaliter asymmetrico, subovato sed saepe irregulare et frequenter cum auriculo secundario, saepe quam lobis lateralibus subaequale. Cirrhus satis robustus, elongatus, glabrus, 2-furcatus. Inflorescentiae fasciculatae, densissime multiflorae (60- ad 100-florae); rhachide robustiore, saepe 2- vel 3-ramificato. Pedicellus gracilis, glabrus, striatus, 60 mm. longus. Florium fasciculus 2-ad 8-floris, bracteolis conspicuis foliolaceis subviolaceis vel roseis, minutissime sed densiore hirsutis, lanceolatis vel rhombico-lanceolatis, integris, acutis, usque ad 3 cm. longis, 1.4 cm. latis (sed usualiter minoribus) subtentus. Pedicellus gracilis, glabrus, striatus, 60 mm. longus. Florium fasciculus 2- ad 8-floris, bracteolis conspicuis foliolaceis, subviolaceis vel roseis, minutissime sed densiore hirsutis, integris, acutis usque ad 2.5 cm. longis subtentus. Flores speciosi, albi, plus minusve 4 cm. longi. Flos staminiferis: calyx albido-viridis, coriaceus, glabrus, tubo 10-striato, 18–20 mm. longo, dentibus flavis conspicue geniculatis, subtriangularibus, acutis, 6–8 mm. longis, 4–5 mm. latis; corolla alba, plus minusve 10 mm. longa, segmentis triangularibus, acutis, usque ad 6 mm. latis; antherae cohaerentes, plus minusve 5 mm. longae. Flos pistilliferis 20–24 mm. longus. Fructus adhuc ignotus.

PLATE L



CAYAPONIA OPHTHALMICA R. E. Schultes. 1, leaf and tendrils, × approximately $\frac{3}{8}$ natural size. 2, part of an inflorescence, × approximately $\frac{1}{4}$. 3, staminate flower, × approximately 2. 4, stamens, × approximately $\frac{3}{4}$.

Drawn by JOHN STANWELL-FLETCHER

COLOMBIA: Comisaría del Amazonas, Río Apaporis, Soratama (above mouth of Río Kananarí) and vicinity. Alt. about 900 feet. "Vine. Flowers white; green bark rasped and soaked in water to make eyewash for conjunctivitis. Puinave name = tsun-jo. Makuna = mun-teka." January 19, 1952. *Richard Evans Schultes et Isidoro Cabrera 14921* (TYPE in Herb. Gray).

The soft green bark of *Cayaponia ophthalmica* is employed in preparing a soothing wash for conjuntivitis, without any doubt the most widespread disease amongst the Indians of the northwestern part of the Amazon. The specific epithet alludes to this use. The vine, a strong heliophile, is frequently cultivated by the Indians living in the Apaporis River basin. Like so many of the cultivated plants of these natives, it grows almost without care along the margins of agricultural plots where *Manihot utilissima* and *Erythroxylon Coca* are set out, but it is definitely planted for use as a medicine.

Cayaponia ophthalmica appears to be most closely related to *C. capitata* Cogn., a species known from the Río Acre area of Amazonian Peru, a great distance from the Colombian Amazon. I have examined a duplicate type at Kew and find that the two concepts are distinct. Both have densely capitate inflorescences, not common in the genus; but in *Cayaponia ophthalmica* the inflorescence can attain a length of 15 cm. and may branch. The leaves of this new species are glabrous on both surfaces, whereas those of *Cayaponia capitata* are sparsely hirtellous above and densely villous beneath. The colored foliaceous bracts and bracteoles (which are not common in the genus) are much larger and more conspicuous in the former than in the latter. There are further differences in the flowers.

The fruit was not seen but is described as being yellowish and the size and shape of a small lime.

A spot test for alkaloids (cf. Raffauf, R. F. in Econ. Bot. 16 (1962) 171) applied to the leaves and the bark of the type specimen was negative.

The illustrations have been made possible by a grant from the National Science Foundation.

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PHILOGLOSSA — A CULTIVAR OF THE SIBUNDOY OF COLOMBIA

BY

MELVIN L. BRISTOL

ABSTRACT

A CULTIVATED potherb, *Philoglossa peruviana* DC. var. *sapida* is described, together with notes on its common names, utilization and cultivation in a primitive horticultural setting in Andean Colombia.

The Sibundoy inhabit a high montane basin in the south of Colombia. This basin — the Valley of Sibundoy — lies at an elevation of 7200 feet about 20 miles east of the city of Pasto, near the eastern edge of the great north-south ranges of the Andes. Dairying, timber exploitation and subsistence agriculture today support a population of about 9000 Europeans ("blancos"), 3700 Inga-speaking Santiagueño, and 2100 Kamsá-speaking Sibundoy. My investigations, covering the twelve-month period beginning in October 1962, involved only the geographically distinct Sibundoy, although the subsistence patterns of both native groups are nearly identical.

Collapsing agricultural terraces indicating prehispanic occupation of the area are obvious at many places on the valley sides. While no direct evidence relates these abandoned terraces to the Sibundoy (who are even unaware of their existence) or to any other people, the Sibundoy believe that their ancestors have lived in the valley from earliest times.

The present pattern of subsistence, the sole occupation of the great majority of the Sibundoy, may best be termed horticulture. Their gardens consist of highly mixed plantings in partly cleared areas which retain many elements of the native flora. Maize (*Zea Mays* L.) is the chief crop and is the most abundant food plant in the gardens. Beans (*Phaseolus vulgaris* L., *P. flavescens* Piper), taros (*Colocasia esculenta* Schott, *Xanthosoma Jacquinii* Schott), arracachas (*Arracacia xanthorrhiza* Bancr.) and tree kale (*Brassica oleracea* var. *acephala* DC.) are also much planted; together with maize, these constitute the basis of the food supply. Many other food and medicinal domesticates are grown, but most of them are encountered infrequently (Bristol, MS).

TAXONOMY

Philoglossa peruviana *De Candolle* var. **sapida** *Bristol var. nov.*

Jaumeopsis mimuloides Hieronymus var. *subintegrifolia* Hieronymus *in* Engler Bot. Jahrb. 28: 619. (1901) *nom. nud.*

A *Philoglossa peruviana* caulibus viridis, vivo apparenter carnosis sed siccitate ut videtur carnosioribus, glabris vel hirsutis; internodiis 45 cm. longis vel brevioribus; foliis ab integris usque ad subincisis, apice sive rotundatis vel acutis sed semper mucronulatis, basi acutis vel cuneatis, margine similiter mucronulato-denticulatis principaliter differt.

TYPE: *Bristol 1253.* 3 km. sw. Sibundoy, Valle de Sibundoy, Putumayo, Colombia. Alt. 2200 m. (Herb. Gray).

This member of the Compositae has weak, herbaceous, repent stems that send out at every node roots and that sometimes extend several meters in every direction. The ends of the stems are erect to a height of 20–30 cm. and bear one or two axillary, long-peduncled, conspicuous, yellow floral heads.

The following differences are observed between *Philoglossa peruviana* and its var. *sapida:*

	P. peruviana	var. *sapida*
Stems and leaves	pubescent	nearly or entirely glabrous
Stems	reddish	never reddish
Internodes	25–130 mm.	15–45 mm.
Leaves	shallowly lobed to entire	subincised to entire
	base acute to rounded	base acute to cuneate
	apex acute	apex acute to rounded
	thin, medium green	thick, light green

A further difference is that var. *sapida* grows slowly as compared to *P. peruviana.* In addition, in herbarium specimens (though not in live material), the stems of var. *sapida* are much thicker.

As noted by Sandwith (1956), Hieronymus' proposal of *Jaumeopsis* was not accompanied by any description and is consequently a *nomen nudum;* his var. *subintegrifolia* is, therefore, untenable. An isotype of that variety, *Bang 896*, from Bolivia, has been examined and is included within the concept *Philoglossa peruviana* DC. var. *sapida* Bristol.

Philoglossa peruviana is distributed along the Andes between the Comisaría del Putumayo in southern Colombia and the region of La Paz in Bolivia at elevations from 350 to at least 3000 meters (Sandwith, *op. cit.*). At the present time, var. *sapida* appears to be known only from the northern and southern extremes of this range, an anomalous situation that may be resolved as more collections become available from Peru and Ecuador.

SPECIMENS EXAMINED:

Philoglossa peruviana DC.

COLOMBIA: Comisaría del Putumayo, Valle de Sibundoy.—3 kms. south Sibundoy. " 'Tsbajosha'. Decumbent herb to 80 cm., flrs. yellow." 13-XI-1962, *Bristol 348* (COL, GH, LP, PASTO, US).—5 kms. south Sibundoy. " 'Tsbajosha'. Trailing herb, 2 m.; exposed sts. red; heads yellow. Potherb." 31-XII-1962, *Bristol 433* (GH). —1.5 kms. west Sibundoy. " 'Huacamuyu de monte'. Cooked for pigs. Herb 1 m., decumbent, sts. reddish; heads yellow. Indian garden, common." 22-VIII-1963, *Bristol 1329* (COL, ECON, GH, PASTO, US).—1.5 kms. south Sibundoy. " 'Tsbajosha'. Herb, sts. fleshy, decumbent, reddish, 1 m.; heads deep yellow. Indian garden (weed), frequent. Cooked for pigs." 21-IX-1963, *Bristol 1404* (COL, ECON, GH). —5 kms. south Sibundoy. " 'Tsabajosha' 50 cm., tallo morado; flrs. amarillas." 10-II-1963, *Chindoy 94* (COL, ECON, GH, PASTO, US).

Philoglossa peruviana DC. var. *sapida* Bristol.

COLOMBIA: Comisaría del Putumayo, Valle de Sibundoy. —3 kms. southwest Sibundoy. " 'Tsbajosha'. Herb, succulent, declining; heads yellow. Sts. unpigmented. Planted, edible form. Very infrequent." 25-V-1963, *Bristol 1039* (COL, US). —3 kms. southwest Sibundoy. " 'Tsbajosha'. Potherb. Herb, decumbent; sts. fleshy, green, rising 30 cm.; heads deep yellow. Indian garden, very infreq." 19-VII-1963, *Bristol 1253* (TYPE, GH). —Sibundoy. " 'Tsbajosha, huacamuyu, yuyu'. Potherb. Herb, sts. decumbent, 70 cm., upright 30 cm., green, fleshy; heads deep yellow. Garden, very infreq., planted." 3-X-1963, *Bristol 1444* (ECON).

BOLIVIA: Songo. —XI-1890, *Bang 896* (GH).

COMMON NAMES

Philoglossa peruviana and its var. *sapida* are known by a number of common names, but no native names have been encountered which apply exclusively to the weedy species itself or to the cultivar, var. *sapida*. The common names now current, together with some of their literal meanings, are listed below.

PLATE LI

Upper left: PHILOGLOSSA PERUVIANA. Scale divisions equal 10 cm. *Upper right:* Type specimen of P. PERUVIANA var. SAPIDA (*Bristol 1253*). *Lower:* Colony from which the type specimen (*Bristol 1253*) of PHILOGLOSSA PERUVIANA var. SAPIDA was taken. Note the short internodes and the often nearly entire leaves.

Photographs by M. L. BRISTOL

Kamsá:

Tsbájo. Perhaps an animal? (Cf. *conejo* below).

Tsbajushá. *-sha* is a common suffix, especially for plant names.

Tsbajtéma. *tema*: 'small'.

Tsbajoyúyu. Cf. *yuyu* below.

Beshána. Refers both to the plant and to the very common prepared food (cf. below) containing either *P. peruviana* var. *sapida* or *Brassica oleracea* var. *acephala.* The latter plant is known as *beshá* and *beshatemá* (diminutive).

Inga:

Huacamúyu. *Huaca*: 'grave, temple'; *muyu:* 'to surround', cf. also *yuyu.*

Camayúyu. Perhaps a variant of *canayuyu,* listed by Pupiales (1953) as "aquatic vegetable." *Cama* may be Spanish 'bed'.

Yúyu. Perhaps applied to any edible greens. Las Corts (1946) gives 'tender' for the variant spelling *llullu,* an apt term for edible leaves.

Macamóy. (?)

Spanish:

Conejo. 'Rabbit', in reference to a small mammal which is said to hide in the thick growth of *P. peruviana.*

Tsbajushá and *huacamúyu* are the two most commonly heard terms for either *Philoglossa peruviana* or var. *sapida.* The derivation of *tsbajushá* remains uncertain. *Huacamúyu* carries the literal implication of an edible plant growing in graveyards. This accords well with the observation that, in the Valley of Sibundoy, both plants grow only on disturbed sites. *Besh-* refers apparently to whatever greens are added to the prepared dish *beshán*, and is now almost completely transferred from *Philoglossa* to the much more important *Brassica oleracea* var. *acephala* of European origin.

The weed and cultivated *tsbąjushás* are distinguished in Spanish by the respective adjectives *morado* ('purple, reddish') and *blanco* ('white, uncolored') which refer to the stems. *Huacamúyu de monte* is often used for the weedy *Philoglossa peruviana* because of its growth in cleared (weeded) places. (*Monte:* Spanish for 'brush, secondary growth, weeds').

CULTIVATION

The cultivated *tsbąjushá*, *Philoglossa peruviana* var. *sapida*, grows relatively slowly. It is reproduced only as the natives occasionally break off stems and push them into loosened soil. In the Valley of Sibundoy, it grows only where it has been purposely propagated in this way.

The weedy *tsbajushá*, *Philoglossa peruviana*, grows vigorously and much more rapidly than the cultivated variety, often dominating many square meters of garden. The gardens are weeded with machetes four times a year, the weeding at the time of maize planting being the most thorough. At this time, all weeds and old cornstalks are gathered into heaps one to two meters apart throughout the garden. In spots where the weedy *tsbąjushá* is dominant, much of the ground is cleared by cutting up these weeds and gathering them into heaps, but many of its quickly rooting stems remain alive and spread rapidly from the heaps. Its chief and possibly sole mode of reproduction in the valley is by this fragmentation of the stems, accidental propagation by the natives.

The weed is frequently boiled in large pots and fed to pigs, the fattening of which is a common remunerative occupation of the Sibundoy.

Human consumption, except in times of scarcity, is confined to the cultivar, var. *sapida.* It is eaten in three ways. First, as an ingredient of a ''relleno'': the young stems and leaves are boiled and then fried along with blood, rice, potato, onion and sometimes other vegetables to be stuffed into a section of pig's intestine. These delicacies may be eaten by the Sibundoy on special occasions or sold for a good price to either natives or Europeans at the Sunday morning market. Second, tender *tsbqjushá* tips may be boiled very briefly and served with boiled potatoes or rice. Third, it may be an ingredient of *beshán.*

Beshán is eaten nearly every day by most of the Sibundoy, once at noon and usually again in the evening in lesser amounts. Normally it is a boiled mixture of ground maize (*Zea Mays*), green or dried beans (*Phaseolus flavescens, P. vulgaris*), and the fragmented leaves of tree kale (*Brassica oleracea* var. *acephala*) to which salt and sometimes chili peppers (*Capsicum frutescens* L.) and squash (*Cucurbita ficifolia* Bouché) are added. Together with the ever present, lightly fermented, maize beer (*bocóy*), *beshán* is the basis of nutrition.

Tsbqjushá, usually *Philoglossa peruviana* var. *sapida*, becomes an ingredient of *beshán* when tree kale is scarce. Many Sibundoy state that their ancestors planted and ate large quantities of this *tsbqjushá* but that nowadays everyone eats the tree kale. Tree kale was brought to the New World from Europe, probably during the 16th Century.

All agree on the fine flavor of this *Philoglossa* cultivar and often point out that various ''well situated'' people, both native and European, eat it at times. I prepared it simply, by boiling briefly with salt, and found it neither "stringy" nor bitter, but with an interesting and pleasant taste.

ACKNOWLEDGMENTS

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The field work upon which this report is based was supported by a Public Health Service Research Grant (MH 06941-01) from the National Institute of Mental Health, by the American Anthropological Association (AAA-SKF Agreement) and by the Gray Herbarium of Harvard University (Fernald Fund). Aid given by officers of these institutions was essential and is sincerely appreciated.

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LOUIS C. BIERWEILER — AN APPRECIATION

THE death of Louis C. Bierweiler on December 12, 1964 ended a unique career of 63 years of dedicated service to the Botanical Museum and to Harvard University.

The career began in 1901 when "Louie," as he was affectionately known to a host of friends, became personal assistant, at the age of fifteen, to Professor George Lincoln Goodale, founder and first Director of the Museum. He soon made himself an indispensable part of the Museum. There was almost nothing which he could not do.

After Professor Goodale's death, Louis became assistant to Professor Ames, who was responsible for recommending him for a corporation appointment as Curator. When I came to the Museum in 1940, first as Assistant Director and then later Director, I found Louis ready and willing to serve as my right hand, and I soon realized that, though Directors might come and go, the Museum would always be looked after and cared for so long as Louis was on the job.

Known to the public as "Mr. Glass Flowers," Louis, next to the Blaschkas, father and son, who created them, was responsible for making them Harvard's most popular scientitic exhibit. He made the plaques on which they were mounted, the supports which reduced vibration and breakage. After he took charge, no other person ever touched his beloved "Flowers." His skill in handling them was remarkable, and his hands remained steady until the illness which preceded his death.

Although officially "retired" in 1957, Louis continued to come to the Museum daily until a few weeks before his death. Indeed, he would have been quite unhappy had he not been able to continue to serve the institution to which he was so completely dedicated.

His service to the Botanical Museum and to Harvard University is epitomized in an excerpt from an engrossed citation presented to him in May 1951 on the occasion of the completion of fifty years of service:

> Steadfast in the performance of his many duties, constantly vigilant in guarding the interests of the University, always ready to lend effective help to others, he has endeared himself to successive generations of her faculty and students. . . .

—PAUL C. MANGELSDORF

PLATE LII

LOUIS C. BIERWEILER
1887–1964

PLANTAE COLOMBIANAE XVIII

PLANTARUM UTILIUM SPECIEI DUAE NOVAE

BY

RICHARD EVANS SCHULTES

DURING the course of ethnobotanical investigations in the northwestern part of the Amazon, two new species which are used in the primitive economy of the region have been discovered. The diagnoses of these two concepts are herewith published.

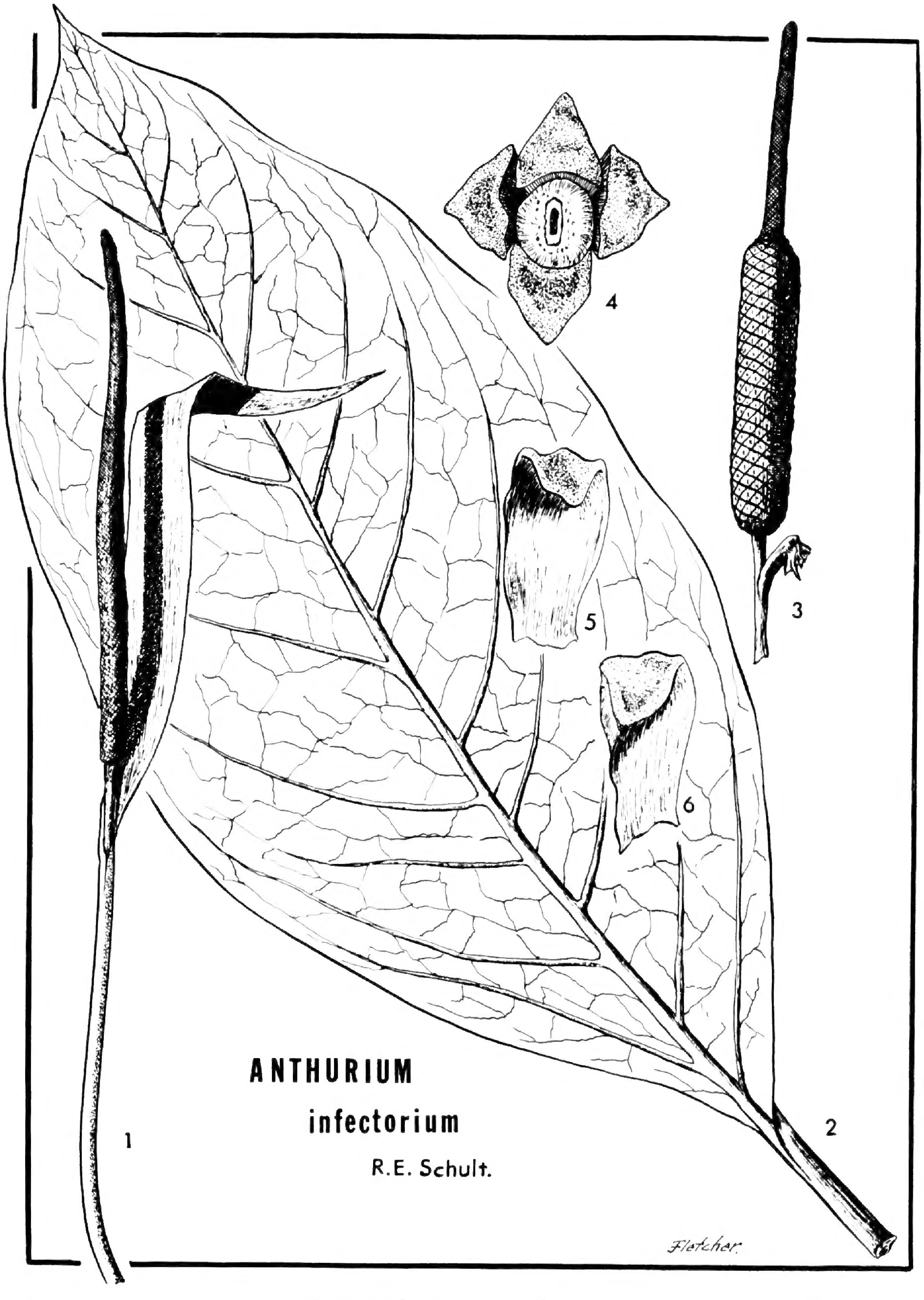
The illustrations that accompany the descriptions were made possible through a grant from the National Science Foundation for studies of the phytogeography of the northwest Amazon.

ARACEAE

Anthurium infectorium *R. E. Schultes sp. nov.*

Planta terrestris, non scandens, in arenis crescens. Caudiculus magnopere abbreviatus, robustus, internodiis brevissimis. Folia rigidissime erecta, valde coriacea, glabra supra atroviridia, subtus pallide viridia, petiolis strictis robustis, basi haud dilatatis; lamina elliptica vel elliptico-lanceolata, leviter marginata, basi sensim attenuata, apice breviter apiculata, usque ad 55 cm. longa, 26 cm. lata, nervo centrali robusto, recto, siccitate substramineo, usque ad apicem penetrante, supra leviter sed subtus valde elevato, nervis secundariis vel lateralibus arcuatis, non confluentibus. Inflorescentia erecta sed leviter arcuata, pedunculo usque ad 75 cm. longo, plus

PLATE LIII



ANTHURIUM INFECTORIUM *R. E. Schultes.* 1, inflorescence, × 1; 2, leaf, × 1; 3, mature fruiting spike, approximately × 1; 4, flower, approximately × 20; 5 and 6, stamens, approximately × 20.

Drawn by JOHN STANWELL-FLETCHER

CAYAPONIA KATHEMATOPHORA *R. E. Schultes.* Photograph from the plant from which the type collection was made. Rio Apaporis, Colombia.

Photograph by R. E. SCHULTES

minusve 6 mm. in diametro. Spatha intus rosea, extus purpurea, glabra, lanceolata, apice longe acuminata, 10 cm. longa, 1.3 cm. lata, valde contorta. Spadix fusco-brunneus vel purpureus, stipitatus (stipite 1.4 cm. longa) caudiformis, apice subacutus, usque ad 18 cm. longus, apicem versus 6 mm. sed basi 1.5 cm. diametriens; tepala membranacea, quadrata, 4 mm. longa, 2.5 mm. lata, apice valde cucullata, cucullo-triangulare 1.8 mm. lato; staminum filamenta membranacea, late linearia, 1.8 mm. longa, 1 mm. lata, anthera 0.7 mm. longa, 0.3 mm. lata; ovarium ovoideum, albo-crystallinum, circiter 4 mm. diametriens, stylo sessile ovale, nigro, 0.8 mm. longo coronata.

COLOMBIA: Comisaría del Vaupés, Río Vaupés, Circasia. Sandy savannah. Quartzite base. Altitude about 800 feet. November 1951, *Richard Evans Schultes et Isidoro Cabrera 19674* (TYPE in Herb. Gray).

Anthurium infectorium, a common species of the sandy savannahs in the Vaupés, does not appear to be closely allied to other species known from the western Amazon.

The ripened fruits of *Anthurium infectorium* are employed by the Kubeo Indians along the Río Vaupés to paint the teeth purplish or black for dances and ceremonies. The specific name *infectorium* refers to this use of the plant as a dye.

CUCURBITACEAE

Cayaponia kathematophora *R. E. Schultes sp. nov.* Herba robusta, alte scandens, usque ad tres metr. longa. Caulis flexuosus, pseudolignosus, cortice molle, viride. Ramuli profunde striato-sulcati, omnino dense hispidulosi. Petiolus crassiore robustus, densissime albido-lanatus, apice non alatus, usque ad 11 cm. longus. Folia membranacea, supra albo-hispidulo-scabra sed maturitate glabrescens, infra densissime molliterque in venis praecipue lanato-hispidula, trilobata, usque ad 4/5 pro parte divisa; lobo centrale oblanceolato, apice acuminata, margine integro, usque ad 23 cm. longo, 7.5 cm. lato; lateralibus asymmetricis, minoribus, usque ad 20 cm. longis, apice acuminatis, basi valde auriculatis; auriculo magno, normaliter asymmetrico, ovato sed saepe irregulare, frequenter quam lobis lateralibus paullo minore. Cirrhus elongatus, dense hispidulus, 3-furcatus. Inflorescentiae fasciculatae, comparate pauciflorae (usque ad 20-florae). Pedicellus gracilis, striatus, hispidulus, plus minusve 17 cm. longus. Flores speciosi, albi, plus minusve 3 cm. longi. Fructus pedunculo gracile instructus, ipse elongato-ovoideus, apice acutus, basi rotundatus, usque ad 14 cm. longus, 5.5 cm. crassus, testa dura, laeve, subnitida, flavo-viride, 6-spermus. Semina magna, ovata, valde compressa, marginata, fusca vel brunnea, nitidissima, 5 cm. longa, 3 cm. lata, 1.8 cm. crassa.

COLOMBIA: Comisaría del Amazonas, Río Apaporis, Jinogojé (at mouth of Río Piraparaná) and vicinity. Alt. about 700 feet. "Vine. Cultivated. Kabuyarí = wá-cha. Makuna = ká-moo-ka. Matapie = wá-yaw. Taiwano = pá-moo-pa. Puinave = way-yot." February 27, 1952, *Richard Evans Schultes et Isidoro Cabrera 15678* (TYPE in Herb. Gray).

Cayaponia kathematophora is remarkable in its very large fruit and seed. Indeed, it is cultivated for the large, shining, brownish seed which, hollowed out, is employed in the manufacture of anklets and necklaces. The specific epithet (meaning "necklace bearing") refers to this use.

This new species further differs from others known from the Amazon basin in its very densely and softly lanate-hispidulous leaves which are lobed, not trifoliolate. Even though the flowers in the type material are not well enough preserved for description, the vegetative and fruit characters alone are sufficiently distinct to allow the recognition of a new concept.