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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 78

MARCH, 1949

No. 1

A. D. E. ELMER: LEAFLETS OF PHILIPPINE BOTANY.

Adolf Daniel Edward Elmer, son of Jacob Van Dyne and Alvina Elmer, was born at Vandyne, Wisconsin, June 14, 1870. He married Miss Emma Osterman, of Arlington, Nebraska, who survives him, in 1902.

He was graduated from the Washington State College in 1899, and finished his work for the degree of Master of Arts at Stanford University in 1903. Later in the same year, he went to the Philippines, as collector of plants for the Bureau of Government Laboratories. This connection lasted only until 1905, when he began his long career as a private collector and student of Philippine plants.

The life of the private collector is at best a hard one. Its only probable personal reward is in serving the collector's personal interest. With training, skill, judgment, unremitting industry, and with luck, he makes a living. Elmer had the other qualifications, but at first no luck except his wife. He returned from his first field trip, and began the description of his collection and the preparation for distribution; and a flood, such as Americans had not yet learned to expect in Manila, inundated the city, and practically destroyed the entire collection.

Twice in later years, he had to come in for medical treatment, to return half-cured to finish his field work. Such experience weakens a man permanently, and after his Borneo trips he was never able to undertake any hard grind of field work.

On the other hand,—and this will perhaps give an idea of what thorough collection in the tropics involves,—on his Apo trip he was seven months without seeing a white man, and came out in good condition. But the Apo region is unique. It is paradise. In those days, the Bagobos could and would

explore the forest canopy, and do it with skill. A devoted botanist did not so much miss the amenities of white society when he could talk botany, and with the Bagobos he could do this with mutual satisfaction. As Elmer said, "Those Bagobos are good botanists." And if the force of this statement is not easy to grasp, let me testify that I have never known a botanist who could distinguish more local plants than could one old Bagobo, Angat. Elmer gave him Latin immortality, with *Solanum Angatii*. Naturally, this Apo collection was the most successful ever made by anybody in one season in the Philippines.

Elmer was primarily a botanist. He was a collector because collection served his kind of botany. Most collectors arrange with a staff of specialists to determine and describe their plants. Elmer did this with some specialists, but mostly his collections were material for his own study. To serve this purpose, he made field notes, the most uniformly good and ample I have known any collector to prepare. These notes were too ample for inclusion on herbarium labels, but were full of information which ought to be published.

To provide for the prompt publication of descriptions of his novelties, in one place and under his own control, Elmer decided to undertake the publication himself. Thus began his Leaflets of Philippine Botany. Among many such personal publications, this has been the outstanding success. At first, the printing was done by a local printer. As the collecting business was still paying an invisible profit for living expenses, he cheapened his publication by buying a little second-hand press, and became printer as well as collector, author and publisher.

At this point, his luck unsuspectingly reversed. Having a press, he did a job of job printing for a friend, who could not pay for it. To cancel the bad account, Elmer took in payment some valueless mining stock, and chucked it into a drawer to be forgotten. In later years, this stock paid in annual dividends many times its original cost; gave the Elmers a part of the measure of comfort in which they spent their later years; and gave their son, "our little Anton" when *Ilex Antonii* was named,—a Stanford education. Years later, another plant was named *Antonii*, this time for Dr. Anton D. Elmer.

The Leaflets ran their course, ten volumes, but with continuous pagination. In them, Elmer published descriptions of 1512 new species, besides a few new genera and varieties.

The number of articles was 137, mostly by Elmer, and mostly devoted wholly to the description of novelties. In a few papers, he treated families or genera, including all known Philippine representatives.

A number of articles were by specialists, reporting on Elmer's collections. Among the authors of such papers are Radlkofer, on Sapindaceae; Foxworthy, on dipterocarps; Ridley, on Zinziberaceae; Beccari, on palms; Martelli, on pandans; A. de Candolle, on Elaeocarpus; C. de Candolle, on Piperaceae; Kükenthal, on Carex; Ames, on orchids; Prain and Burkill, on yams; Christensen, on ferns; Stephani, on Hepaticae; Broth-erus, on mosses; Hieronymus, on Selaginella; Zahlbrückner, on lichens; and H. and P. Sydow, Rehm, Murrill and Patouillard, on fungi.

Several papers are introduced by descriptions of the country where he collected, of the people, their life and industry, as well as, of course, the vegetation. These are entertaining and instructive reading, like Jagor's records of an earlier day, and ought not to be lost by the wider public because they are sifted into a very technical publication. Literary sparks occur elsewhere too; as where, in the desperate search for valid specific names in large genera with which we are all familiar. Elmer named a *Ficus* for his own ancestor, as *F. Adamsii* (corrected later to *F. Adami*, "named after the man who first recognized the utility of this genus.")

Elmer worked under his own rules. His descriptions are all in English,—technically, not valid publication. As to type specimens, "holotypes," which the botanic world has come to respect during the years of Elmer's activity, he used to maintain that all specimens of one of his collection numbers were co-ordinate, that one specimen of a new species was as much a type as any other specimen. At the end, he fell into line, with the statement, p. 3831: "The type specimens of my new Philippine species of plants discovered and published in the *Leaflets of Philippine Botany* are preserved in my private type collection."

This type collection was kept, for safety, in the Philippine National Herbarium, in a "fire-proof" wing of the Bureau of Science. What may have endured bombardment was burned by the Japanese with the help of gasoline. The distributed isotypes are the nearest thing to types that now exist.

Immortality is conferred on collectors by giving their names to the novelties they collect. In such biographies as this, it

is common to conclude with a list of plants bearing the name of the subject. Of course, Elmer curtailed the list of plants bearing his name, by almost every paper he himself wrote. Of his fifteen hundred new species, at least a tenth would have been likely to bear his name if others had described them. Almost one-sixth of his novelties described by others do bear his name, but this proportion has to decrease with increase of numbers, because there can be only one *Ficus Elmeri*, one *Eugenia Elmeri*, one *Quercus Elmeri*. In spite of his describing the most of his new species, more than 120 have been given his name, a number so great that their listing ceases to magnify his honor. Genera are *Elmeria*, changed to *Adelmeria*; *Elmerina*; *Elmerinula*; and *Elmeriobryum*.

Elmer died of natural causes, in Manila, April 17, 1942, soon after the Japanese occupation, in time to escape the evil era of the concentration camps.

In spite of discouragement and difficulty, he had lived as he would. We may quote from him a fitting epitaph:

IT WAS ALL SO INTERESTING TO ME.

EDWIN B. COPELAND

PTERIDACEAE OF NEW GUINEA *

By EDWIN BINGHAM COPELAND
Of the University of California, Berkeley

SIX PLATES

Genus DICKSONIA L'Heritier

Key to the New Guinea species of Dicksonia

- Major rachises black.
Primary pinnules up to 16 by 4 cm..... 1. *D. grandis*
Primary pinnules up to 10 by 2 cm..... 1a. *D. Ledermanni*
- Major rachises dark brown.
Hairs on rachises few or deciduous..... 2. *D. Schlechteri*
Hairs comparatively persistent.
Ultimate sterile teeth broadly triangular.
Stout dark bristles mixed with fine reddish
ones 3. *D. Hieronymi*
Hairs uniform 3a. *D. sciurus*
Sterile teeth narrow and sharp..... 4. *D. Archboldii*

1. DICKSONIA GRANDIS Ros.

D. grandis Ros., Fedde's Repert. 5 (1908) 34.

Mount Gelu, alt. 1,000 m, *Werner* 79, isotype in Herb. Univ. Calif.; *Brass* 11897, see comment under *D. Ledermanni*. Endemic.

1a. DICKSONIA LEDERMANNI Brause.

D. Ledermanni Brause, Engler's Jahrb. 56 (1920) 46.

Ledermann 8440, Hunstein Peak, alt. 1,050 m, type, not seen. *Carr* 14769 is received as this species, and I accept the identification, because Mr. Alston visited Berlin while working on this collection. It is a tree fern, instead of an epiphyte as stated on the field label of the type; the pinnules are up to 10 cm instead of 7 cm long; and the rachises are black rather than dark-brown. Mr. Alston is in general likely to see resemblances where I am more impressed by differences, but I still accept this identification. However, I cannot dis-

* This paper includes the report on the ferns collected by the Third Archbold Expedition to New Guinea. Previous reports were published in the Philippine Journal of Science 73 (1940) 345-357; 457-469; 75 (1941) 347-361; 76 (1941) 23-25.

tinguish Carr 14769 from the type collection of *D. grandis* by any probably specific difference. Brass 11897 has the black axes of *D. grandis*; its frond, including the stipe, is 105 cm long, even smaller than *D. Ledermanni*. Except for having blacker axes and being more naked, it should be the latter species; except for stature, it is *D. grandis*. I believe it to be a depauperate form of *D. grandis*, and must then mistrust the distinctness of *D. Ledermanni*. As Brause mistrusted the field label of *Ledermann 8440*, so did I assume a misplaced label of Brass 11897,—“Rare low epiphyte in mossy forest;” but it is most extraordinary if this is a mistake made twice by good collectors or with well handled collections.

2. DICKSONIA SCHLECHTERI Brause

D. Schlechteri Brause, Engler's Jahrb. 49 (1912) 11.

Schlechter 17150, Kani Mountains, alt. 1,000 m, isotype in Herb. Univ. Calif; *Carr 15133*, Papua, alt. 8,500 feet. *Keysser II 8* (1912), Mount Bolan, alt. 2,400 to 3,000 m, is var. *glabrescens* Ros., Fedde's Report. 12 (1913) 165, isotype in Herb. Univ. Calif.; it may be a distinct species. Endemic.

3. DICKSONIA HIERONYMI Brause

D. Hieronymi Brause, Engler's Jahrb 56 (1920) 48; C. Chr., Brittonia 2 (1937) 282.

Ledermann 12851, Sepik region, alt. 1,400 to 1,500 m, not seen; *Brass 4550*, Murray Pass, Papua, alt. 2,840 m, det. C. Chr.; *Brass 9485, 10711*, Lake Habbema, alt. 3,225 and 2,800 m. Endemic.

3a. DICKSONIA SCIURUS C. Chr.

D. sciurus C. Chr., Brittonia 2 (1937) 283.

Brass 4991, Mount Tafa, alt. 2,400 m. I find on the isotype in Herb. N. Y. Bot. Garden a few stouter, longer and darker bristles among the otherwise smaller and brighter reddish ones. Endemic.

4. DICKSONIA ARCHBOLDII Copel.

Plate 1.

D. Archboldii Copel., Univ. Calif. Publ. Bot. 18 (1942) 217.

Trunco teste Brassio 4 m alto sursum 13 mm crasso deorsum crassiore; foliis circa 10, 3.5 m longis, stipitibus 30–40 cm longis inclusis, lano basale fulvo-cinnamomeo denso crinito, stipite sursum rhachique setis fusco-cinnamomeis brevioribus (5–10 mm) obsitis, maximis sparsis delapsis tuber-

cula relinquentibus; pinna mediale 65 cm longa, 22 cm lata, subsessile, acuminata, subtripinnata, rhachi densissime setifera setis apicem versus pinnae parvis pallescentibus; pinna primaria recte patente, brevi (1–2 mm)–pedicellata, acuminata, deorsum imbricante, basi 3 cm lata; pinnulis secundariis contiguis, brevipedicellatis, apice aciculati-mucronatis, circa 6 mm latis, aut omnino glabris aut costa inferne sparsissime setulosis; segmentis utroque latere usque ad 6, oblique positis, anguste decurrenti-connexis, inferioribus furcatis vel bis furcatis lobo acroscopico fertile, aliis acute dentiformibus; soris 1.5–2 mm latis, valvis stramineis integris vel irregulariter crenulatis.

Dutch New Guinea, 9 kilometers northeast of Lake Habbema, alt. 2,700 m, *Brass 10970*, "abundant in forest of lower slopes."

Characterized most clearly by the acute, dentiform, sterile ultimate segments. *D. sciurus* has some resemblance in this respect.

Genus CYSTODIUM J. Smith

CYSTODIUM SORBIFOLIUM (J. E. Smith) J. Smith

C. sorbifolium (J. E. Smith) J. Smith, in Hooker, *Genera* (1841) *Pl.* 96.

Dicksonia papuana F. v. M., *Descr. Pap. Pl. IV* (1876) 76.

King 230, 350, Brass 1084, 1470; Carr 12542, 12714, all from Papua at minor and moderate altitudes; *Schlechter 16519, 18463*, Kaiser-Wilhelmsland.

Moluccas; Celebes; Borneo.

Genus CULCITA Presl

CULCITA VILLOSA C. Chr.

Culcita villosa C. Chr., *Brittonia* 2 (1937) 283.

Brass 11589, Bele River, alt. probably 2,200 m. The type is *Brass 4791*, Vanapa Valley, Papua, alt. 1,900 m; isotype in Herb. N. Y. Bot. Garden.

Endemic. Related species from Australia and Polynesia to Malaya and the Philippines.

Genus ORTHIOPTERIS Copeland

Ithycaulon Copel., *Univ. Calif. Publ. Bot.* 16 (1929) 79.

The type species of *Orthiopteris* is *O. ferulacea* (Moore) Copel., *Bishop Mus. Bull.* 59 (1929) 14. That of *Ithycaulon* is

I. moluccanum Copel., since called *I. minus* (Hooker) C. Chr. The supposed essential difference was that *Orthiopteris* bore hairs, and in *Ithycaulon* the paleae, on the erect caudex. The near affinity, shown by the spores and otherwise, was noted in the publication of each genus. It has since appeared that *O. ferulacea* is really paleate. This is most obvious on *St. John 18311*, collected in 1937. The black-brown, thick, rigid paleae are rather more than 2 mm long, acute, lanceolate, forming a small apical tuft. This tuft is more or less concealed by the stipe bases of most collections, and the paleae are usually narrower. I find them narrower still, when present, on the bases of the stipes, where they suggest the bristles of *Dipteris*. With this correction as to *Orthiopteris*, *Ithycaulon*, described a few months later, became a synonym.

Key to New Guinea species of Orthiopteris.

Pinnules toothed, with undissected middle area.

Undissected area over 3 mm wide.

Indusia narrowly cuneate at base..... 4. *O. minor*

Indusia broadly cuneate at base..... 5. *O. acuminata*

Undissected area about 2 mm wide..... 3. *O. caudata*

Dissection complete, leaving no middle area.

Segments and winged axes over 0.5 mm wide..... 2. *O. cicutarioides*

Segments and winged axes under 0.4 mm wide..... 1. *O. trichophylla*

1. *O. TRICHOPHYLLA* Copel.

Plate 2.

O. trichophylla Copel., Univ. Calif. Publ. Bot. 18 (1942) 218.

O. rhizomate suberecto, 1 cm crasso, paleis castaneis glabris integris ovatis 1–2.5 mm longis vestito; stipitibus fasciculatis usque ad 30 cm altis, fuscis, basi paléatis et squamulatis, sursum laminaque glabris; lamina usque ad 65 cm longa et 35 cm lata, acuminata, basi rotundata, herbacea, quinquepinnatifide dissecta, rhachillis tertiae ordinis et ultimis angustissime alatis, segmentis 1.5–3 mm longis, 0.2–0.3 mm latis, fertilibus ad gerendum soros tantum dilatatis; soris vix 1 mm longis, 0.5 mm latis, vix basi alatis.

Brass 12027, 15 kilometers southwest of Bernhard Camp, Idenburg River, alt. 1,800 m; "very abundant, tufted, terrestrial in rain forest."

More finely dissected than *O. ferulacea* and *O. cicutarioides*; the sori hardly winged; probably the most finely dissected fern of its size.

2. *O. CICUTARIOIDES* (Baker) Copel., comb. nov.

Davallia cicutarioides Baker, Journal of Bot. 28 (1890) 106.

Ithycaulon cicutarioides Alston, Journal of Bot. 77 (1939) 289.

I. tenuisectum C. Chr., Brittonia 2 (1937) 285.

Brass 12239, alt. 1,800 m; *Carr* 13257, Boridi, Papua, alt. 1,500 m; *Brass* 3919, Papua, alt. 700 m, isotype of *I. tenuisectum* in Herb. N. Y. Bot. Garden. I depend upon Alston for the interpretation of Baker's species. In describing *I. tenuisectum*, Christensen remarked on the resemblance to *O. ferulacea*. The latter is appreciably more finely divided, and thinner; and the sorus is in larger part unwinged, although this feature is not usually as conspicuous as it was figured by Hooker, Second Century of Ferns (1861) Pl. 64. Endemic.

3. *O. CAUDATA* Copel., comb. nov.

Saccoloma caudatum Copel., Philip. Jour. Sci. 30 (1926) 327.

Ithycaulon caudatum Copel., Univ. Calif. Publ. Bot. 16 (1929) 80.

Known only by the type, *King* 462, Hydrographers Range, alt. 900 m. Alston, [Journal of Bot. 77 (1939) 289] would reduce this to his *I. cicutarioides*. *Carr* 13257, by which I construe that species, has the tertiary pinnules more deeply and narrowly cut, although several times smaller.

4. *O. MINOR* (Hooker) Copel.

O. minor (Hooker) Copel., Genera (1947) 50.

Brass 12941, alt. 1,200 m; 12269, alt. 1,700 m. approaching the next species; *Bamler*, *Rosenstock Fil. Novog. Exsicc. n. 116*, Wareo, alt. 600 m. To Malacca and Fiji.

5. *O. ACUMINATA* (Ros.) Copel., comb. nov.

Dennstaedtia acuminata Ros., Hedwigia 56 (1915) 350.

Ithycaulon acuminatum Copel., Univ. Calif. Publ. Bot. 12 (1931) 395.

Known by the type collection, *Bamler* 139, Sattelberg, alt. 800 m, isotype in Herb. Univ. Calif. As just noted, *Brass* 12269 is very similar.

This fern is reduced by Alston, [Journal of Bot. 77 (1939) 289], to *Ithycaulon Novae-Guineae* (Ros.) Alston, which is *Oenotrichia Novae-Guineae* Copel. Alston remarks "I have the types of both Rosenstock's species." I have only isotypes, but have some reason to regard these as more authentic than the types, where there is any difference. Ours are the specimens retained by Dr. Rosenstock for his own use when he reputedly

sold the types. They fit the descriptions perfectly, which cannot be the case with Alston's types if the latter are congeneric. As to this *D.* (or *I.* or *O.*) *Novae-Guineae*, Rosenstock states: "Eine dem *Saccoloma moluccanum* (Bl.) Mett. gleichende Art, jedoch noch mehr zerteilt, und durch das Indusium wesentlich von ihm unterschieden. Dies ist breiter als lang und nach unten nicht verjüngt." It is certainly no *Ithycaulon*, no *Orthopteris*. *O. acuminata* has the cuneate indusium base typical of the genus. Its distinctness from *O. minor* is questionable.

Genus DENNSTAEDTIA Bernhardt

Key to New Guinea species of *Dennstaedtia*

Pinnae and pinnules not articulate.

Axes not aculeate.

Veins setose on both surfaces.

Herbaceous 1. *D. penicillifera*

Subcoriaceous 2. *D. concinna*

Veins setose beneath, naked above..... 3. *D. magnifica*

Veins naked on both surfaces.

Rachises naked or glabrescent.

Axes light-brown 4. *D. cuneata*

Axes dark 5. *D. Shawii*

Rachises pubescent 6. *D. flaccida*

Major axes aculeate.

Fronnd tripinnatifid 7. *D. resinifera*

Fronnd at least quadripinnatifid.

Lowest pinnules not dwarfed.

Herbaceous 8. *D. novoguineensis*

Subcoriaceous.

Ultimate segments acute 9. *D. moluccana*

Ultimate segments rounded 10. *H. papuana*

Lowest pinnules dwarfed 11. *D. scandens*

Pinnae and pinnules articulate 12. *D. glabrata*

1. *D. PENICILLIFERA* v. A. v. R.

D. penicillifera v.A.v.R., Bull. Jard. Buit. II No. 28 (1918) 17.

Hypolepis grandifrons Gepp, in Gibbs, Dutch N. W. New Guinea (1917) 195.

Described from Humboldt Bay, alt. 500 feet. With this plant, with limited confidence, I identify *King 244*, from Papua.

Mindanao, *Copeland 1755*. Both of these specimens have been confused with *D. samoensis* (Brack.) Moore, which has also been reported from New Guinea.

2. D. CONCINNA Ros.

D. concinna Ros., *Hedwigia* 56 (1915) 349.

Known by the original collection, *Bamler 1*, Sattelberg, isotype, in Herb. Univ. Calif. Its sori are those of *Microlepia* rather than of *Dennstaedtia*, and Rosenstock himself changed the generic name on our label. However, the affinity is with species recognized as *Dennstaedtia*.

3. D. MAGNIFICA Copel.

Plate 3.

D. magnifica Copel., Univ. Calif. Publ. Bot. 18 (1942) 218.

Stipite teste Brassio 3.1 m, lamina 3.9 m longis; rhachi cinnamonea setis minutis sparsa; pinna visa (non infima) patente, sessile, 110 cm longa, rhachi (nisi in sulca) glabra straminea; pinnulisⁱ circa 18 cm longis, sessilibus, acuminatis, recte patentibus, vix contiguus; pinnulisⁱⁱ circa 3 cm longis, basi 1 cm latis, deinde ad apicem subacuminatum angustatis; pinnulisⁱⁱⁱ circa 6 mm longis, supra basin cuneatam 3 mm latis, obtusis, oblique profunde incisus, firme papyraceis, costis inferne sparse setuliferis aliter glabris, superne atroviridibus inferne pallidioribus; soris in sinubus, deflexis, parvis (0.7 mm latis), indusii valva interiore paulo minore.

Dutch New Guinea, 6 kilometers southwest of Bernhard Camp, Idenburg River, alt. 1,050 m, *Brass 12982*, on bank of stream.

Distinguished from most of the related species by the acute to acuminate secondary pinnules.

4. D. CUNEATA (J. Smith: Hooker) Moore

D. cuneata (J. Smith: Hooker) Moore, Index (1857) XCVII.

Schlecter 16606, Kaiser-Wilhelmsland, alt. 200 m.
Philippines; Malaya.

5. D. SHAWII Copel.

D. Shawii Copel., Philip. Jour. Sci. 30 (1926) 326.

Known only by the type, *Rev. P. C. Shaw, King 491*; mountains behind Taupota.

6. D. FLACCIDA (Forster) Bernhard

D. flaccida (Forster) Bernhard, Schrader's Journal "1800" (1801) 124, Pl. 1, f. 3.

Reported from New Guinea; not known to me.

Pacific Islands. Although the type of the genus, this species is almost unknown.

7. **D. RESINIFERA** (Blume) Mett.

D. resinifera (Blume) Mett.: Kuhn, Ann. Lugd. Bat. 4 (1869) 290.

Listed by report; another mysterious species.

Java.

8. **D. NOVOGUINEENSIS** (Ros.) Copel., comb. nov.

Dennstaedtia Smithii var. *novoguineensis* Ros., Fedde's Repert. 10 (1912) 323.

Bamler S 49, Sattelberg, isotype in Herb. Univ. Calif.; *Clemens s. n.*, Morobe, alt. 4,200 feet. Differs from *D. Smithii* most essentially in having spiny axes. The two are probably not intimately related.

9. **D. MOLUCCANA** (Blume) Moore

D. moluccana (Blume) Moore, Index (1857) XCVII.

Brass 12267, alt. 1,800 m. *Keysser 18*, received with this name, is a distinct, probably undescribed, species.

Moluccas; farther range questionable.

10. **HYPOLEPIS PAPUANA** Bailey

Hypolepis papuana Bailey, Queensland Agric. Journal 23 (1909) 159.

King 440 is probably this species,—was so identified by Bailey,—but has a thing inner (extrorse) indusium, which I cannot detect on other sheets, apparently of the same species. The Bagobos long ago called my attention to the close affinity of *Hypolepis* and some species of *Dennstaedtia*. Endemic.

11. **D. SCANDENS** (Blume) Moore

D. scandens (Blume) Moore, Parker's Cat. (1858); Index (1861) 307.

Brass 11519 alt. 2,200 m; *Bamler s. n. Rosenstock Fil. Novog. Exsicc. n. 204*, Sattelberg, received as *D. moluccana*. *Schlechter 18945* probably belongs here, but our specimen is defective. Malaya to Tahiti.

12. **D. GLABRATA** (Cesati) C. Chr.

D. glabrata (Cesati) C. Chr., Index (1905) 217; Dansk Bot. Arkiv. 9 No. 3 (1937) 42.

Dicksonia glabrata Cesati, Rend. Ac. Napoli 16 (1877) 28.

Dicksonia rhombifolia Baker, Journal of Bot. 23 (1890) 105.

Dicksonia erythrorachis Christ, Ann. Jard. Buit. 15 (1897) 86, Pl. 13, f. 7.

Dennstaedtia articulata Ros., Fedde's Repert. 10 (1912) 322.

D. Rosenstockii v.A.v.R., Bull. Jard. Buit. II No. 7 (1912) 11.

These synonyms apply to New Guinea specimens, and are taken from Christensen, l. c. (1937). If the species be thus broadly construed, I believe that it must include *D. ampla* (Baker) Bedd, also reported from New Guinea. My own belief is that several closely related species are here combined; but it is certain that more species have been described in this group than are justified by the number of collections.

Brass 13462, alt. 850 m. Many previous collections.

To Fiji and the Malay Peninsula, as here construed.

Genus MICROLEPIA Presl

Because the assignment of various species to one or the other genus is problematical, it would be better if all *Microlepia* species were transferred to *Dennstaedtia*. The discrimination of the species is also unsatisfactory. Curiously, neither the collection under study, nor the greatest previous one, Ledermann's includes any *Microlepia*.

Key to New Guinea Species of *Microlepia*

- Bipinnate, most pinnules subentire..... 1. *M. strigosa*
 More compound.
 Rachis black 2. *M. melanorhachis*
 Rachis stramineous to brown.
 Densely setulose, hairs with bulbous bases..... 3. *M. trichosticha*
 Hairs without bulbous bases.
 Pinnules over 10 cm long, lanceolate..... *Denn. concinna*
 Pinnules relatively broad, mostly shorter.
 Pinnules 10 by 5 mm, hardly incised..... 4. *M. pseudohirta*
 Frond more finely dissected..... 5. *M. Speluncae*

1. *M. STRIGOSA* (Thunb.) Presl

M. strigosa (Thunb.) Presl, Epim. (1849) 95.

A specimen collected by Mrs. Clemens, from Boana, Morobe, alt. 1,000 m, seems to be a small form of this species, reported from New Guinea, distinguished by small subentire or incised pinnules and long, whitish hairs.

To Japan.

2. *M. MELANORHACHIS* Ros.

M. melanorhachis Ros., Fedde's Repert. 12 (1913) 526.

Keysser 179, Sattelberg Hinterland, alt. 1,400—1,500 m, in Herb. Univ. Calif. Subquadripinnate, with small, cuneiform segments. Endemic.

3. *M. TRICHOSTICHA* J. Smith

M. trichosticha J. Smith, Journal of Bot. 3 (1841) 416, *nomen*.
Davallia trichosticha Hooker, Sp. Fil. I (1846) 183.

Cited from New Guinea as var. *glabrata* Prantl. As a Philippine species, this plant is well characterized by dense, short hairs with bulbous bases. *King 458*, Hydrographers Range, alt. 600 m, is like it in aspect but not in pubescence.

Dennstaedtia concinna Ros. bears sori which mostly fall short of the margin, and would therefore be looked for in *Microlepia*.

4. *M. PSEUDOHIRTA* Ros.

M. pseudohirta Ros., Fedde's Repert. 9 (1911) 425.

The type is *King 308*. We do not have Rosenstock's specimen, but this plant seems to be *No. 174* of my set. *Brass 5295*, Mafulu, Papua, alt. 1,250 m, identified by Christensen, is the same as *King 174*. We do have *Bamler 29*, distributed as *Rosenstock Fil. Novog. Exsicc. n. 90* as *M. scaberula*, but the name changed by Rosenstock on our label to *M. pseudohirta*; it does not fit the description, and is very unlike *King 174*. It is not *M. scaberula*, but may be responsible for the listing of *M. scaberula* as a New Guinea species. Its indusium is drawn upward (toward the margin) at the sides, and would justify its description as a new species.

Schlechter 17575 is also misnamed *M. scaberula*; it may be a large *M. pseudohirta*.

5. *M. SPELUNCAE* (L.) Moore

M. Speluncae (L.) Moore, Index (1857) XCIII.

This species, regarded as very variable in dissection and pubescence, is the dumping ground for all *Microlepia* not named otherwise. Several such specimens are in hand from New Guinea. Among them may be the *M. pilosula* listed by Brause.

All warm lands; in most places a "collective species."

Genus *OENOTRICHIA* CopelandO. *NOVAE-GUINEAE* (Ros.) Copel.

O. novae-guineae (Ros.) Copel., Univ. Calif. Pub. Bot. 16 (1929) 82.

Davallia Novae-Guineae Ros., Fedde's Repert. 5 (1908) 36.

Known only by the type collection, *Warner 73*, Mount Gelu, alt. 1,700 m, isotype in Herb. Univ. Calif. See comment above, under *Orthiopteris acuminata*.

Genus *LINDSAEA* Dryander

Many *Lindsaea* species which are bipinnate in full development produce also fully fertile simply pinnate fronds. If the frond is bipinnate, the leaflets (pinnae) on the main axis, and on its branches (technically, pinnules) are alike. In the key below I call them all pinnae, and describe the technically bipinnate fronds as fronds with branched axes. The basisopic margin of the pinna is almost always entire; statements as to margin or dissection apply therefore to the acroscopic side. This is the only genus of considerable size in which I recognize fewer species than Brause did nearly thirty years ago.

Key to New Guinea species of *Lindsaea*

Pinnae dimidiate.

Veins free unless in the sorus.

Rachis of frond unbranched.

Rhizome elongate, fronds distant.

Stipe short, 5 to 20 mm long.

Pinnae not deeply incised.

Larger fronds fully 4 cm wide..... 1. *L. sessilis*

Fronds 2 cm wide..... 2. *L. Foersteri*

Pinnae dissected 3. *L. hymenophylloides*

Stipe normally at least 5 cm long.

Pinnae deeply incised..... 4. *L. roemeriana*

Pinnae crenate or lobed.

Pinnae cartilaginous-bordered 10. *L. marginata*

Pinnae not bordered.

Pinnae bifid, distal lobe broad..... 11. *L. blanda*

Lobes or crenations several.

Fronds over 2.5 cm wide..... 12. *L. rhombifoliolata*

Fronds not over 2 cm wide.

Pinnae about 5 mm wide..... 8. *L. adiantoides*

Pinnae about 3 mm wide..... 9. *L. gracilis*

Rhizome short.

Pinnae entire to shallowly incised.

Lowest pinnae crowded, much reduced. 13. *L. brevipes*

Lowest pinnae not crowded.

Stipes brown 14. *L. concinna*

Stipes black 15. *L. crassipes*

Pinnae dissected.

Sori widened across segment tips..... 5. *L. Bakeri*

Sori cup-shaped, narrow 5a. *L. Schlechteri*

Rachis branched.

Rhizome short.

Pinnae dissected 6. *L. tenuifolia*

Pinnae lobed or incised.

Sorus marginal 16. *L. tricrenata*

Sorus inframarginal 17. *L. Kingii*

- Rhizome elongate.
 Pinnae dissected 7. *L. Versteegii*
 Pinnae entire to shallowly incised.
 Coriaceous 18. *L. rigida*
 Herbaceous.
 Sori several, submarginal 19. *L. microstegia*
 Sori few, marginal 16. *L. tricrenata*
- Veins more or less anastomosing.
 Rachis unbranched.
 Pinnae about 2 mm wide..... 20. *L. sinuato-crenata*
 Pinnae over 4 mm wide.
 Entire plant dark 22. *L. obscura*
 Plant not remarkably dark.
 Pinnae cartilaginous-bordered..... 23. *L. Schultzei*
 Cartilaginous border not evident.
 Rhizome elongate.
 Margin inciso-crenate 24. *L. Wernerii*
 Margin lobed 30. *L. stolonifera*
 Rhizome short 31. *L. decomposita*
- Rachis branched.
 Pinnae entire or nearly so.
 Pinnae broadly rounded at apex..... 25. *L. azurea*
 Pinnae narrowed to obtuse apex..... 26. *L. papuana*
 Pinnae crenate or shallowly incised.
 Basal branches of frond forked..... 27. *L. furcata*
 Basal branches not forked.
 Sori near ends of pinnae..... 28. *L. sepikensis*
 Sori along upper and distal margins. 21. *L. decomposita*
 Pinnae lobed half-way to costa..... 29. *L. davallioides*
- Pinnae not dimidiate.
 Frond mostly pinnate, pinnae narrow..... 31. *L. ensifolia*
 Frond mostly bipinnate, pinnae broad..... 32. *L. heterophylla*

1. *L. SESSILIS* Copel.

L. sessilis Copel., Philip. Jour. Sci. 6 C (1911) 82.

Brass 8840, Hollandia, alt. 50 m; *King* 244 (type) and 271 (juvenile), *Brass* 1077, 5471, *Carr* 11992, Papua; *Werner* 70, *Keysser*, *Rosenstock Fil. Novog. Exsicc. n. 215*, Kaiser-Wilhelmsland. Some of these have been determined also as *L. repens*, *L. macraeana*, *L. pectinata* and *L. Merrillii*, any of which except the last may be a preferable name, according to the fineness with which one elects to discriminate between species. *L. sessilis* is the common local species or form of the group or species ranging from Mauritius to Hawaii, of which the oldest specific name is *L. repens* (Bory) *Thwaites*.

Solomon Islands.

2. *L. FOERSTERI* Ros.

L. Foersteri Ros., Fedde's Repert. 12 (1913) 527.

Keysser 193, Sattelberg Hinterland, isotype in Herb. Univ. Calif. Like *L. sessilis* but much smaller; it is approached by *Brass 5471*.

3. *L. HYMENOPHYLLOIDES* Blume

L. hymenophylloides Blume, Enum. (1828) 218.

Listed by Brause; I have no New Guinea specimen. Malaya; Philippines.

4. *L. ROEMERIANA* Ros.

L. roemeriana Ros., Nova Guinea 8 (1912) 719.

Von Roemer s. n., 731, 1137, 1088, Dutch New Guinea; Brause cites three collections by Ledermann. Not seen. We have construed *L. hymneophylloides* rather loosely in the Philippines, and some specimens could be referred to *L. roemeriana*. *L. Wollastonii* v.A.v.R. (*Odontosoria tenera* Ridley) must be something of this kind, but its description does not make sense.

5. *L. BAKERI* C. Chr.

L. Bakeri C. Chr., Suppl. III (1934) 121; Brittonia 2 (1937) 287.

Asplenium Bakeri C. Chr., Index (1905) 102.

Davallia lanceolata Baker, Kew Bull. (1899) 119.

Lindsaea trichophylla Copel., Philip. Jour. Sci. 6C (1911) 83.

L. Ledermanni Brause, Engler's Jahrb. 56 (1920) 130.

This synonymy is by Christensen (1937).

Brass 13651, alt. 750 m; *Lam 825, 944*, alt. 80 to 150 m; *King 262* (type of *L. trichophylla*), *Brass 3819*, Papua. Endemic.

5a. *L. SCHLECHTERI* Brause

L. Schlechteri Brause, Engler's Jahrb. 49 (1912) 28, f. 1 J.

Schlechter 19395, Kaiser-Welhelmsland, alt. 250 m. Not seen; but, by description and figure, it seems to be a small *L. Bakeri*.

6. *L. TENUIFOLIA* Blume

L. tenuifolia Blume, Enum. (1828) 219.

Lindsaea blumeana (Hooker) Kuhn, Ann. Lugd. Bat. 4 (1869) 277.

Brass 13737 A, 13754, alt. 50 and 570 m; common.

Malaya and Philippines to Fiji.

After trying to distinguish *L. blumeana* from *L. tenuifolia*, and finally deciding that it is impossible, I awaken to the fact that *Davallia blumeana* Hooker could not be the name of a

distinct species, because it was originally published as a synonym.

7. **L. VERSTEEGII** (Christ) v.A.v.R.

L. Versteegii (Christ) v.A.v.R., Malayan Ferns Suppl. (1917) 206.

Odontosoria Versteegii Christ, Nova Guinea 8 (1909) 157.

L. Rosenstockii Brause, Engler's Jahrb. 56 (1920) 128.

L. Versteegii is typified by *Versteeg 1222*. Under *L. Rosenstockii*, Brause lists five collections by Ledermann. I have seen none of these, and cannot distinguish the two species by the descriptions.

8. **L. ADIANTOIDES** (Blume) Kuhn

L. adiantoides (Blume) Kuhn, Ann. Lugd. Bat. 4 (1869) 278.

Brass 13494, alt. 850 m, typical; *11869*, alt. 1,800 m, very small, possibly *L. gracilis*; *10761*, alt. 2,750 m, with a discernible marginal strand; *King 479*; *Brass 5079, 5122, 8699*, alt. 2,400 m, Papua.

Described from the Moluccas, and of questionable occurrence farther West; Fiji.

9. **L. GRACILIS** Blume

L. gracilis Blume, Enum. (1828) 217.

Two collections by Ledermann reported. I have not seen this species here unless *Brass 11869* be so identified; it fits the description approximately, but comparison with Java specimens makes me regard it as a small *L. adiantoides*. The two are nearly related, not identical.

Malaya; Mindanao.

10. **L. MARGINATA** Brause

L. marginata Brause, Engler's Jahrb. 56 (1920) 126.

Brass 12021, 12213, 13051, 14131, alt. 850 to 1,500 m; described from *Ledermann 12660 and 11384*; also var. *falcata*, Brause No. *12864*; none of these seen. Near *L. adiantoides*, but usually distinct.

Endemic.

11. **L. BLANDA** Mett.

L. blanda Mett.: Kuhn, Linnaea 36 (1869) 80.

Brass 11256, Bele River, alt. 2,200 m; *Schlechter 18699*, Bismarck Mountains, alt. 1,800 m.

Described from Java.

12. *L. RHOMBIFOLIOLATA* v. A. v. R.

L. rhombifoliolata v.A.v.R., Nova Guinea 14 (1924) 4.

Known only by the type collection, *Lam 1892 partim*, Doorman Mountain, alt. 1,450 m; not seen. It might be an unusually ample *L. adiantoides*.

13. *L. BREVIPES* Copel.

L. brevipes Copel., Philip. Jour. Sci. 6C (1911) 83.

Brass 13652, alt. 750 m; *King 237* (type), 266, *Brass 3817*, Papua.

Reported from Amboyna.

14. *L. CONCINNA* J. Smith

L. concinna J. Smith: Hooker, Sp. Fil. I (1846) 205, *Pl. 61 B*.

Schlechter 1990, *Bamler*, *Rosenstock Fil. Novog. Exsicc. n. 109*, Sattelberg., alt. 500 to 900 m.

Philippines; Borneo; Palau.

15. *L. CRASSIPES* Ros.

L. crassipes Ros., Fedde's Repert. 5 (1908) 36.

Brass 13203, alt. 860 m; *Werner 74*, isotype in Herb. Univ. Calif. *L. crassipes* is not very near to *L. concinna*, but may be a form of *L. cultrata*. *Clemens 6020* in Herb. Arnold Arb. is a mixture, the major part being intermediate between *L. cultrata* and *L. crassipes*. The former is as yet unknown in New Guinea, and may not safely be reported on this evidence.

Endemic if distinct.

16. *L. TRICRENATA* Baker

L. tricrenata Baker, Journal of Bot. 28 (1890) 106.

Known only by the original collection, by MacGregor, Mount Musgrave.

17. *L. KINGII* Copel.

L. Kingii Copel., Philip. Jour. Sci. 6C (1911) 83.

Brass 8338, alt. 50 m; *8929*, Cyclops Mountains, alt. 575 m; *King 241* (type), 280, Papua.

Endemic.

18. *L. RIGIDA* J. Smith

L. rigida J. Smith: Hooker, Sp. Fil. I (1846) 217, *Pl. 63 A*.

L. monosora Ros., Nova Guinea 8 (1912) 720, non Copel.

L. monocarpa Ros., in C. Chr., Suppl. I (1913) 49.

Brass 11761, 12473. *L. rigida* was previously reported from New Guinea,—four collections by Ledermann. *L. monosora*

was based on *v. Roemer* 785, 1163, not seen. With the material now in hand the supposed distinctions disappear, except that I have never seen anastomosing veins in *L. rigida*.

Malacca, Ponape.

19. **L. MICROSTEGIA** Copel.

L. microstegia Copel., Philip. Jour. Sci. 6C (1911) 83.

Brass 12214, alt. 1,750 m; *King* 272, type, Papua; *Schlechter* 17133, Kani Mountain Range, alt. 1,000 m, received as *L. repens*; *Bamler* 126, Sattelberg, received as *L. pectinata* var. *brevipinnula* Ros; *Lam* 1327, Doorman River, alt. 300 m, received as *L. pectinata*. The *Brass* and *Bamler* collections have the margin shallowly lobed, one sorus on each lobe. If any New Guinea species may be *L. repens* or *L. pectinata*, it is not this one, but *L. sessilis*.

Endemic.

20. **L. SINUATO-CRENATA** v.A.v.R.

L. sinuato-crenata v.A.v.R., Nova Guinea 14 (1924) 30.

Known only by the type, *Lam* 1888, Doorman Mountain, alt. 1,450 m; not seen.

21. **L. DECOMPOSITA** Willd.

L. decomposita Willd., Sp. Plant. V (1810) 425.

Brass 13204, 13415, 13416; very common. *King* 381, 416 have smaller and crowded pinnae; they may represent the ill known *L. ambigua* Cesati.

India to the Marquesas.

22. **L. OBSCURA** Brause

L. obscura Brause, Engler's Jahrb. 56 (1920) 132.

Known only by the original collection, *Ledermann* 8969, Etappenberg, alt. 850 m; not seen.

23. **L. SCHULTZEI** Brause

L. Schultzei Brause, Engler's Jahrb. 49 (1912) 29.

Brass 11868, alt. 1,800 m, identification not positive. The type is *Schultze* 304 g, Sepik region; not seen.

Endemic.

A cartilaginous strand reinforces the basiscopic margin in many or most species of *Lindsaea*. It is not rare on the rachiscopic margin. Extended around all margins, it character-

izes *L. rigida*, *L. marginata* and *L. Schultzei*; but a faint border of this kind can sometimes be detected on other species.

24. *L. WERNERI* Ros.

L. Werneri Ros., Fedde's Repert. 5 (1908) 37.

Brass 13387, alt. 850 m; *Werner* 5, Mount Gelu, alt. 1,000 m, isotype in Herb. Univ. Calif., *Schlechter* 18144, Finisterre Mountains, alt. 950 m.

A Sumatra specimen, *Winkler* 194, may belong here.

25. *L. AZUREA* Christ.

L. azurea Christ, Verh. Nat. Ges. Basel 11 (1896) 429; Ann. Jard. Buit. 15 (1897) 101, Pl 14, f. 12.

Brass 13654, alt. 750 m, typical except for being larger; *Brass* 3989, Papua, alt. 50 m. The New Guinea plants should be var. *Mambae* v.A.v.R., Bull. Jard. Buit. 7 (1912) 21, the type of which is *King* 48 p. p.

Celebes.

26. *L. PAPUANA* Copel.

L. papuana Copel., Philip. Jour. Sci. 7C (1912) 68.

Known only by the type, *King* 358, Lakekamu, Papua. As King sent this plant to me not long before he sent to Buitenzorg the plant named *L. azurea* var. *Mambae*, it may be suspected that they are the same. The brief varietal description of the latter might apply to *L. papuana*. The specimens cited above as *L. azurea* are not *L. papuana*, even though they approach it in size of pinnae.

Endemic.

27. *L. FURCATA* Copel.

Plate 4.

L. furcata Copel., Univ. Calif. Publ. Bot. 18 (1942) 218.

Synaphlebium, rhizomate 2–3 mm crasso, brevi-repente, paleis minutis lanceolatis vestito; stipite 25–30 cm alto, brunneo, basi paleis paucis angustis 2 mm longis sparso, alibi nudo; lamina 30–35 cm longa, 25 cm lata, bipinnata, pinnis sessilibus, infimis typice angulo angusto furcatis, ramo basiscopico 15 cm, acrosopico 25 cm longis, pinnis sequentibus uni-jugis 20 cm longis, foliolo terminale fere 30 cm longo, pinnis omnibus valde acuminatis; pinnulis infimis flabelliformibus circa 7 mm longis, medialibus dimidiatis, 13 mm longis, basi cuneata 5 mm latis, brevissime stipitulatis, patentibus vel erecto-patentibus, apice

rotundatis, herbaceis, superne obscure viridibus margine acropico leviter crenatis lobis 4 ad 6 truncatis; venis laxe anastomosantibus; soris dilatatis, indusio cum margine conterminantibus.

Dutch New Guinea, 4 kilometers southwest of Bernhard Camp, Idenburg River, alt. 900 m, *Brass 13229*, "frequent low epiphyte in rain forest;" also no. 13731, *ibidem*, alt. 850 m, slightly smaller and with the basal pinnae not forked.

The frond form of the type is like that of *Pteris quadriaurita*, with single long basal prongs on the basal pinnae. I regard this as the normal frond of the fully mature plant, but it may possibly be only an abnormality. Without this peculiarity, the species seems to be distinguished by its few long, long-acuminate, ascending pinnae, many ascending pinnules, sparsely anastomosing veins, and marginal sori. In describing this species, I conform to usage and call the branches of the frond pinnae.

28. *L. SEPIKENSIS* Brause

L. sepikensis Brause, Engler's Jahrb. 56 (1920) 131.

Known only by the type, *Ledermann 9423*, Etappenberg, alt. 850 m; not seen.

29. *L. DAVALLIOIDES* Blume

L. davallioides Blume, Enum. (1828) 218.

Reported, and probably not uncommon, but we have no specimen from "continental" New Guinea. *Bamboer R 13* is from Rook Island, alt. 150 m.

Malaya; Philippines; Caroline Islands.

30. *L. STOLONIFERA* Mett.

L. stolonifera Mett.: Kuhn, *Linnaea* 36 (1869) 81.

Described from New Ireland, cited from the New Hebrides, and reported from New Guinea. Not seen.

31. *L. ENSIFOLIA* Swartz

L. ensifolia Swartz, Schrader's Journal "1800" (1801) 77.

King S 17, *Brass 6027*, Papua; *Bamler 143*, Sattelberg, alt. 100 to 200 m.

To Madagascar and Fiji.

32. *L. HETEROPHYLLA* Dry.

L. heterophylla Dry., Trans. Linn. Soc. 3 (1797) 41, *Pl. 8, f. 1*.

Reported here, but not seen.

To Madagascar and New Caledonia.

Genus **TAPEINIDIUM** (Presl) Christensen*Key to the species of Tapeinidium*

- Simply pinnate 1. *T. longipinnulum*
 At least bipinnate.
 Indusium mostly wider than long..... 3. *T. obtusatum*
 Indusium as long as wide..... 2. *T. moluccanum*
 Indusium much longer than wide..... 4. *T. stenocarpum*

1. T. LONGIPINNULUM (Cesati) C. Chr.

T. longipinnulum (Cesati) C. Chr., Suppl. III (1934) 176.

Davallia longipinnula Cesati, Rend. Ac. Napoli 16 (1877) 29.

D. intramarginalis Cesati, *ibidem*, teste Christensen.

T. marginale Copel., Philip. Jour. Sci. 6C (1911) 82.

Brass 8837, 13845, near sea-level; *King* 283 (type of *T. marginale*), 349.

Fiji.

2 T. MOLUCCANUM (Blume) C. Chr.

T. moluccanum (Blume) C. Chr., Gardens' Bull. 4 (1929) 399.

Davallia moluccana Blume, Enum. (1828) 237.

Davallia amboynensis Hooker, Sp. Fil. I (1846) 178, Pl. 56 C.

Brass 12102, 12958, 13363, alt. 850 to 2,100 m; *King* 261; *Schlechter*, 18185.

Moluccas.

3. T. OBTUSATUM v.A.v.R.

T. obtusatum v.A.v.R., Nova Guinea 14 (1924) 52.

Known only by the type, *Lam* 1857, Doorman Top, alt. 2,500 m; not seen. By description, this does not seem very distinct from *T. moluccanum*.

4. T. STENOCARPUM v.A.v.R.

T. stenocarpum v.A.v.R., Nova Guinea 14 (1924) 52.

Lam 1442, ridge near Idenburg River, alt. 1,420 m, isotype in Herb. Univ. Calif. Christensen, Suppl. III (1934) 176, reduces this to a variety of *T. moluccanum*. It seems to me to be sufficiently distinguished by its narrow, acute segments, as well as by its narrow indusia. As to its identity with *Davallia stenoloba* Baker, I have no opinion.

Brause lists also *T. Denhami*, which is *T. tenue* (Brack.) Copel., a Fiji species, and *T. pinnatum* (Cav.) C. Chr. As the latter is now construed more strictly than when he wrote, I do not know what his specimens would now be named.

Genus SPHENOMERIS Maxon

Key to New Guinea species of *Sphenomeris*

- Larger segments and sori at least 4 mm wide..... 1. *S. retusa*
 Segments about 2 mm wide..... 2. *Odontosoria decipiens*
 Segments up to 1.5 mm wide..... 3. *S. chusana*

1. *S. RETUSA* (Cav.) Maxon

S. retusa (Cav.) Maxon, Journal Wash. Acad. Sci. 3 (1913) 144.

Brass 13279, alt. 850 m; *Bamler, Rosenstock Fil. Novog. Exsicc. n. 147*. Typical.

Philippines. Reported elsewhere.

2. *ODONTOSORIA DECIPIENS* (Cesati) Christ (?)

Odontosoria decipiens (Cesati) Christ (?)

King 170, *Brass* 1434, Papua; *Schlechter* 16315. *Lam* 1352, identified as this species, has much more narrowly cuneiform pinnules, like an enormously overgrown *S. chusana*. Christensen, Dansk Bot. Arkiv. 9 No. 3 (1937) 44, maintains, in agreement with Baker, that this is "a large and more compound form," of *S. retusa*. As he had seen the type, I may not dispute him; but the specimens cited here are not in my opinion *S. retusa*.

3. *S. CHUSANA* (L.) Copel.

S. chusana (L.) Copel., Bishop Mus. Bull. 59 (1929) 69.

Brass 10797, 11470, alt. 2,200 and 2,750 m; *King* 184, *Carr.* 13957, Papua.

Madagascar; India; Japan across Polynesia.

Genus ISOLOMA J. Smith

ISOLOMA FULIGINEUM Copel., comb. nov.

Schizoloma fuligineum Copel., Philip. Jour. Sci. 1 Suppl. (1906) 252, Pl. 1 A.

Nephrolepis Schizolomae v.A.v.R., Bull. Jard. Buit. 7 (1912) 22.

Schizoloma Schizolomae v.A.v.R., Malayan Ferns Suppl. (1917) 214.

Brass 8804, Hollandia, alt. 20 m.

Philippines; Borneo.

Christensen, Suppl. III (1934) 170, 171, reduces *S. fuligineum* to *S. ovatum*, to which I cannot assent; and makes *S. Schizolomae* a variety of *S. guirinianum*, which may be reasonable if one knows how to distinguish a variety from a species. The essential difference between them as species is that *I. fuligineum* has all or practically all veins free; I myself distrust this as a distinction.

Genus TAENITIS Willdenow

Key to New Guinea species of *Taenitis*

- Hardly or not at all dimorphic..... 1. *T. blechnoides*
 Conspicuously dimorphic 2. *T. requiniana*

1. *T. BLECHNOIDES* (Willd.) Swartz

T. blechnoides (Willd.) Swartz, Syn. Fil. (1906) 24, 220.

Brass 13293, 13617, alt. 750 to 900 m; *Bamler W 3*, Wareo, alt. 600 m; *King* 153, *Carr* 12665, Papua.

To Assam.

2. *T. REQUINIANA* (Gaud.) Copel.

T. requiniana (Gaud.) Copel., Univ. Calif. Publ. Bot. 16 (1929) 85.

Bamler, *Rosenstock Fil. Novog. Exsicc. n. 252*, Rook Island. Admiralty Ids.; Melanesia.

Genus SYNGRAMMA J. Smith

Key to New Guinea species of *Syngamma*

- Fronde pinnate 1. *S. pinnata*
 Fronde simple 2. *S. Hookeri*

1. *S. PINNATA* J. Smith

S. pinnata J. Smith, London Journal of Bot. 4 (1845) 168, Pl. 7, 8, f. C.

Brass 8999, Hollandia, alt. 100 m; *King* 118, 298, *Brass* 5571, *Carr* 12663, Papua.

Queensland; Fiji.

2. *S. HOOKERI* C. Chr.

S. Hookeri C. Chr. Index (1905) 346; (1906) 629.

Brass 12211, 13364, 13369, 13661, alt. 750 to 1,750 m; *King* 355, 480, *Brass* 3804, 5231, Papua.

Borneo; Fiji.

Genus CRASPEDODICTYUM Copeland

In establishing species in this genus, I have treated size, form, number and texture of leaflets, their insertion (stipitate or decurrent), the number of rows of areolæ, and the color of the stipe,—all as specific characteristics; and by these have thought to distinguish five species, to which Christensen has added a sixth. This may be correct; or, a considerable part of the supposed differences may be matters of variation within the species. Our collections are too few to afford a basis for confident judgment. Following my own precedent, I would now

describe one or two more species. However, with only seven New Guinea collections in hand; looking like five species, it is safer to deal tentatively with them, and let the future show which differences fluctuate and which are characteristic.

Key to New Guinea species of Craspedodictyum

Lateral leaflets decurrent	1. <i>C. grande</i>
Lateral leaflets stalked	2. <i>C. Schlechteri</i>

1. C. GRANDE Copel.

C. grande Copel., Philip. Jour. Sci. 6C (1911) 84.

King 117, Ambasi, type of genus and species.
Solomon Islands.

This plant may be too near to *C. quinatum* (Hooker) Copel. I suppose that *Kajewski 508*, from Vanikoro, is topotypic and typical of that species. The lateral pinnae are decurrent, as described by Hooker; my key, Philip. Journal Sci. 38 (1929) 147, is incorrect; no New Guinea specimen matches *C. quinatum*.

2. C. SCHLECHTERI (Brause) Copel.

C. Schlechteri (Brause) Copel., Philip. Jour. Sci. 38 (1929) 147.

Syngamma Schechteri Brause, Engler's Jahrb. 49 (1912) 32.

Schlechter 18164, Finisterre Mountains, alt. 1,000 m, isotype in Herb. Univ. Calif. This plant is approximately matched by *Brass 8932*, Cyclops Mountains, alt. 450 m, and *13616*, Idenburg River, alt. 750 m; and by *Brass 1494*, Owen Stanley Range, Papua, alt. 1,200 m. To this species, if to either, must be referred *Brass 13662*, Idenburg River, alt. 750 m, and *King 268*,—these two probably identical; and two Bamler collections, *Rosenstock Fil. Novog. Exsicc. n. 114* and *114a*, presumably collected together and representing the local range of variation, but distributed with different names.

Genus LEPTOLEPIA Mettenius

L. NOVAE-ZELANDIAE (Col.) Kuhn

L. Novae-Zelandiae (Col.) Kuhn, Chaetopterides (1882) 348.

Zahn (1903) Yabim. With a single specimen, two fronds, I do not know whether or not the local plant is characterized by minor differences from those of Queensland (of which we have a single specimen) and New Zealand. However that is, if our data of origin are dependable, this is an interesting proof of geographic affinity.

Genus **HYPOLEPIS** BernhardtKey to New Guinea species of *Hypolepis*

Fronde three to four times pinnate.

Rachis smooth or rough, not muricate.

Axes reddish.

Axes hairy beneath 1. *H. punctata*

Axes more or less naked beneath..... 2. *H. bamleriana*

Axes stramineous or buff.

Sori abundant 4. *H. tenuifolia*

Sori few and one side of pinnules..... 4a. *H. grandifolia*

Rachis spinescent 5. *H. papuana*

Fronde bipinnate 3. *H. Archboldii*

1. **H. PUNCTATA** (Thunb.) Mett.

H. punctata (Thunb.) Mett.: Kuhn, Fil. Afric. (1868) 120.

Bamler, Rosenstock Fil. Novog. Exsicc. n. 173, quite like *Formosa* specimens; *Brass 10288, 10717*, near Lake Habbema, alt. 2,800 m, scrambling 3 m high, these representing var. *obscura* Brause, Engler's Jahrb. 56 (1920) 161, as does also *Brass 4970*, Mount Tafa, Papua. *Keysser II 7*, Bolan Mountains, alt. 2,400 to 3,800 m, received from Rosenstock as *H. bamleriana f. minor*, may be a small form of *H. punctata*. *Brass 4389*, Mount Albert Edward, is similar, but bears remarkably long reddish hairs beneath the costae.

New Zealand to Africa, Japan and Hawaii.

2. **H. BAMLERIANA** Ros.

H. bamleriana Ros., Fedde's Repert. 10 (1912) 325.

Bamler 39 (1908), Logaueng, alt. 300 m, isotype in Herb. Univ. Calif.

Endemic.

3. **H. ARCHBOLDII** Copel.

Plate 5.

H. Archboldii Copel., Univ. Calif. Publ. Bot. 18 (1942) 218.

H. distanti Hooker affinis pilosa, rhizomate late repente, gracile, pilis aurantiacis vestito; stipitibus remotis, 15–20 cm altis, gracilibus, purpurascens, sparse pilosis; fronde 20–30 cm longa, 5–10 cm lata, acuminata, basi tripinnatifida, rhachi pilis fusco-aurantiacis crassis basibus bulbosis vestita; pinnis suboppositis, sessilibus, inferioribus remotis brevioribus, medialibus usque ad 5 cm longis basi 15 mm latis, acutis, rhachibus deorsum angustissime sursum late alatis, pilis pallidioribus obsitis; pinnulis oblongis, obtusis, infimis pinnatifidis sequentibus lobatis, crenatis et integris, papyraceis, utraque facie sparse

setosis, decidue ciliatis; soris lobos et dentes fere complentibus, vix margine reflexo protectis vel omnino nudis.

Dutch New Guinea, 7 kilometers northeast of Wilhelmina Top, alt. 3,560 m, *Brause & Myer-Drees 9852*, common in ground moss in subalpine forest.

Similar to *H. distans*, and thus presenting another close link with the flora of New Zealand; and a member of the widespread group of *H. punctata*. *Brass 4235*, from Mount Albert Edward, alt. 3,690 m, determined by Christensen as a variety of *H. punctata*, is possibly *H. Archboldii*, but bears longer hairs, is more harsh, and not evidently ciliate. *Brass 4389*, referred to under *H. punctata*, is more distinct. Mrs. Clemens sends from Mt. Sarawaket, alt. 11,000 to 12,000 feet, a minute *Hypolepis*, the fronds 5 to 6 cm long, hardly bipinnate, and fruiting freely. It is probably *H. Archboldii*, and shows how far reduction can go.

4. *H. TENUIFOLIA* (Forster) Bernhardt

H. tenuifolia (Forster) Bernhardt, Schrade's Neues Journal 1² (1806) 34.

King 168, Papua.

New Zealand to Japan.

4a. *H. GRANDIFOLIA* Gepp

H. grandifolia Gepp, in Gibbs, Dutch N. W. New Guinea (1917) 195.

Gibbs 6258, Humboldt Bay, alt. 150 m; not seen. "The huge fronds, the stipitate pinnules, and the few sori distinguish this species from the rest,"—but not very convincingly.

5. *H. PAPUANA* Bailey

H. papuana Bailey, Queensland Agric. Journal 23 (1909) 158.

Papua, the type collection, of which I have a fragment; also *King 465*, *Carr 12220*, *Brass 3956*. See comment under *Dennstaedtia*, species No. 10.

Endemic.

H. ACULEATA

H. aculeata Gepp, Journal of Bot. 61 (1923) Suppl. 59.

Forbes 555, Sogere, Papua, alt. 600 m. I have not seen this plant, and cannot by description distinguish it from *H. papuana*.

Genus *PAESIA* St. Hilaire

Key to New Guinea species of Paesia

Sterile segments over 1 mm wide, sori long..... 1. *P. radula*
Sterile segments under 1 mm wide, sori short..... 2. *P. lamiana*

1. *P. RADULA* (Baker) C. Chr.

P. radula (Baker) C. Chr., Index (1906) 476.

Brass 4603, 4709, Murray Pass, Papua, alt. 2,840 m, det. C. Chr.; *Keysser II* 59, Bolan, alt. 2,400 to 3,000 m. The latter is the collection responsible for the report of *P. scaberula*, Fedde's Repert. 12 (1913) 162.

Sumatra.

2. *P. LAMIANA* v.A.v.R.

P. lamiana v.A.v.R., Nova Guinea 14 (1924) 35.

Brass 12342, 12472, alt. 1,650 and 2,150 m. The type, not seen, is *Lam* 1934, Doorman Mountain, alt. 2,480 m. The *Brass* specimens are smaller than the type, and are accordingly at most quadripinnatifid, instead of quadripinnate or quinquepinnatifid. They seem well distinguished from *P. radula* by finer dissection.

Species of *Paesia* have been described from scanty material on the apparent assumption that they vary within narrow limits. I suspect that they are both variable and plastic, and that Rosenstock's identification of *Keysser II* 59 is correct. In that case, *P. scaberula* ranges from New Zealand to Sumatra, and *P. radula* is a synonym. *P. lamiana* looks distinct, locally, but some New Zealand specimens are similarly dissected.

Genus *PTERIDIUM* Gleditsch*P. AQUILINUM* (L.) Kuhn

P. aquilinum (L.) Kuhn, in v. Decken, Reisen 3³ Bot. (1879) 11.

Brass 11490, Bele River, alt. 2,200 m; *Carr* 13228, Boridi, Papua, alt. 1,300—1,400 m; these are substantially alike, and represent *Pteris lanigera* Blume.

Brass 8962, Hollandia, alt. 20 m, is less woolly than *No.* 11490, and may be *P. revolutum* (Blume) Nakai. We may have here two closely related species, altitudinally separate; or one species which responds with observable difference to the local environment; or the difference may be mere variation, appearing anywhere.

Genus *HISTIOPTERIS* (Agardh) J. Smith*Key to New Guinea species of Histiopteris*

- Stipule-like leaflets present 1. *H. incisa*
 Stipule-like leaflets wanting 2. *H. estipulata*

1. *H. INCISA* (Thunb.) J. Smith

H. incisa (Thunb.) J. Smith, Hist. Fil. (1875) 295.

Brass 10750, alt. 2,800 m; 12320, alt. 1,700 m; *Clemens* 10165, Mt. Sarawaket, alt. 3,300 m; *Carr* 14385, alt. 1,450 m, *King* 229, 396, Papua. Three species may be represented by these collections, but not even Brass' are sufficiently complete to provide a sure idea of the entire frond. His note on *No. 12320* shows a height of 3 m, and *No. 10750* looks like part of a still larger frond.

Pantropic, and to Japan and New Zealand.

2. *H. ESTIPULATA* v.A.v.R.

H. estipulata v.A.v.R., Nova Guinea 14 (1924) 25.

Brass 12040, 12438, alt. 1,750 and 1,800 m, epiphytic. The type is *Lam* 1923, Doorman Mountain, alt. 2,480 m, not seen. Endemic.

Genus *LEPIDOCAULON* Copeland*L. CAUDATUM* Copel.

L. caudatum Copel., Univ., Calif. Publ. Bot. 18 (1942) 218; Genera (1947) 60.

Rhizomate 3–5 mm crasso scandente, paleis castaneis lanceolato-ovatis 2 mm longis, decidue caudatis vestito; stipite 25 cm alto basi cum rhizomate continuo, paleis similibus basi aut cordatis aut sagittatis vestito, alibi nudo, atrocastaneo nitido; lamina 45 cm longa, 40 cm lata, deltoidea, basi tripinnata, pinisque caudatis; pinnis suboppositis, infimis 22 cm longis basi 8 cm latis, basiscopice auctis acrosopice paulo angustatis; pinula infima basiscopica 7 cm longa attenuato-caudata, pinulisⁱⁱ circa 6-paribus 1 cm longis 2 mm latis adnatis obtusis; pinnulis pinnarum superiorum remotis, anguste lanceolatis, acutis; costis inferne conspicuis pallidis, venis paucis inconspicuis, oblique marginem versus salientibus, deinde fertilibus margini parallelis.

Dutch New Guinea, 9 kilometers northeast of Lake Habbema, alt. 2,800 m, *Brass* 10714; "mossy forest of slopes; climbing on lower trunks of trees." Also, *No. 12051*, a single frond, Lake Habbema, alt. 3,225 m, an epiphyte in edge of forest; more ample than the type, and reflexed margin (false indusium) better developed. This reflexed margin is no more than suggested on the type.

The elongate rhizome with solenostele and the elongate submarginal sori or coenosori suggest affinity to such ferns as *Lind-*

saea ensifolia. The nearer affinity, shown best by the rhizome, is to *Histiopteris*, in spite of free veins and different pattern of frond. The paleae are true scales, not mixed nor intergrading with hairs. The stipe contains a single bundle, horse-shoe-shaped in section. A part of the long-caudate tips of the pinnae of the type are short-fastigiate at the very tip.

Genus **PTERIS** Linnaeus

Key to New Guinea species of Pteris

- Veins free (except in sori).
- Pinnate with simple pinnae.
 - Stipe and rachis stramineous 1. *P. vittata*
 - Stipe and rachis purplish..... 2. *P. moluccana*
 - Pinnate with lower pinnae forked.
 - Large fern with many pinnae..... 3. *P. papuana*
 - Small or medium-sized, pinnae few.
 - Stipe smooth, usually stramineous.
 - Lamina herbaceous 4. *P. cretica*
 - Lamina coriaceous 5. *P. pellucida*
 - Stipe rough, dark 6. *P. scabripes*
 - Sparingly bipinnate.
 - Fronds uniform 7. *P. deltoidea*
 - Fronds somewhat dimorphic 8. *P. ensiformis*
 - Pinnae pectinate or compound.
 - Pinnae pectinate on lower side only..... 9. *P. semipinnata*
 - Pinnae pectinate on both sides.
 - Lowest pinnae not exceedingly enlarged.
 - Huge ferns.
 - Segments 1 cm wide above base..... 10. *P. excelsa*
 - Segments much narrower 11. *P. Gardneri*
 - Ferns of small or moderate size.
 - Apices of pinnae long caudate..... 12. *P. ligulata*
 - Apices only moderately elongate.
 - Segments over 4 mm wide..... 13. *P. blumeana*
 - Segments under 4 mm wide..... 14. *P. pacifica*
 - Lowest pinnae greatly enlarged, fronds tripartite.
 - Ultimate divisions confluent segments.
 - Sori short, far from sinus..... 16. *P. Schlechteri*
 - Sori long.
 - Large ferns.
 - Segments serrate at apex..... 17. *P. Keysseri*
 - Segments entire 18. *P. macrophylla*
 - Small, lamina about 20 cm long.... 15. *P. Brassii*
 - Ultimate divisions free pinnules..... 19. *P. montis-wilhelminæ*
 - Areolae single along costae..... 20. *P. wallichiana*
 - Areolae in single rows along costules..... 21. *P. tripartita*
 - Areolae numerous.
 - Frond pinnatifid or pinnate..... 22. *P. comans*
 - Frond more compound 23. *P. Warburgii*

1. P. VITTATA Linn.

P. vittata L., Sp. Plant. (1753) 1074.

Brass 11665, Balim River, alt. 1,600 m; apparently common at minor and middle altitudes.

Warm parts of the Orient, and adventitious elsewhere.

2. P. MOLUCCANA Blume

P. moluccana Blume, Enum. (1828) 208.

Several New Guinea collections at middle altitudes.

Moluccas; Solomon Islands (?)

3. P. PAPUANA Cesati

P. papuana Cesati, Rend. Ac. Napoli 16 (1877) 25, 29.

Brass 11314, alt. 2,200 m; 10886, alt. 2,800 m; *Schlechter* 16591, alt. 1,500 m. No. 11314 is the larger specimen, and has no forked pinnae. About half of those of No. 10886 are forked or twice forked.

P. bambusoides Gepp, from the Arfak Mountains, described from a fragment, and *P. Brausei* Ros., *Taenitis Brausei*, Ros., Nova Guinea 8 (1912) 730, seem neither to be adequately distinguished from *P. papuana*.

Endemic; but not surely distinct from *P. opaca* of the Philippines.

4. P. CRETICA Linn.

P. cretica L., Mantissa (1767) 130.

A species or synonym of world-wide distribution, reported in New Guinea, whence I have no specimen. The three following species are members of its group.

5. P. PELLUCIDA Presl

P. pellucida Presl, Rel. Haenk. I (1825) 55.

Brass 11508, Bele River, is this or an undescribed relative, still larger and with extravagantly caudate pinnae.

Philippines; Malaya.

6. P. SCABRIPES Wall.

P. scabripes Wall., List (1828) n. 94, *nomen*; Agardh, Rec. Sp. Gen. Pteridis (1839) 11.

A relative or form of *P. cretica*, listed here by report. Range doubtful.

7. P. DELTOIDEA Copel.

P. deltoidea Copel., Philip. Jour. Sci. 6C (1911) 85.

Known only by the type, *King* 242; Papua.

8. P. ENSIFORMIS Burm.

P. ensiformis Burm., Fl. Ind. (1768) 230.

Common at minor altitudes.
Tropics of the Orient.

9. P. SEMIPINNATA Linn.

P. semipinnata L., Sp. Plant. (1753) 1076.

Listed here by report.
To Eastern India.

10. P. EXCELSA Gaud.

P. excelsa Gaud., in Freycinet, Voyage Bot. (1827) 388.

The New Guinea specimens I have seen with this name more probably represent *P. torricelliana* Christ, closely related but probably distinct.

A clear-cut Hawaiian species, apparently sporadic even into Asia.

11. P. GARDNERI (Fée) Hooker

P. Gardneri (Fée) Hooker, Sp. Fil. II (1858) 206.

Brass 11495, Bele River; *Bamler*, *Rosenstock Fil. Novog. Exsicc. n. 84*, alt. 300 m; *Carr* 14431, 15435, Papua. Large, like *P. torricelliana*, but with dark axes and much smaller and more numerous segments.

Philippines; Malaya to Tahiti.

12. P. LIGULATA Gaud.

P. ligulata Gaud., in Freycinet, Voyage Bot. (1827) 385.

P. beccariana C. Chr., Index (1906) 593.

Apparently common at minor altitudes, inconstant in form of frond.

Reported from the Solomon Islands to Borneo.

13. P. BLUMEANA Agardh

P. blumeana Agardh, Rec. Sp. Gen. Pteridis (1839) 22.

14. P. PACIFICA Hieron.

P. pacifica Hieron., Hedwigia 55 (1914) 355.

Both of these have been treated by most authors as forms of a pantropic species, *P. quadriaurita*, also reported from New Guinea,—*Bamler* 45. I have thought I could distinguish these two segregates elsewhere, but in New Guinea they seem to me indistinguishable.

15. *P. BRASSII* C. Chr.

P. Brassii C. Chr., Brittonia 2 (1937) 287.

Brass 5650, Mount Albert Edward, alt. 2,680 m. A small plant with deltoid fronds, related to the preceding species.

16. *P. SCHLECHTERI* Brause

P. Schlechteri Brause, Engler's Jahrb. 49 (1912) 33, f. 2 B.

Finisterre Mountains, alt. 1,200 m, *Schlechter* 18190, isotype in Herb. Univ. Calif.

Mindanao; Negros; Luzon (*P. quinquepartita* Copel.).

17. *P. KEYSSERI* Ros.

P. Keysseri Ros., Fedde's Repert. 12 (1913) 167.

Bolan Mountains, alt. 3,400 to 3,800 m, *Keysser II* 10, isotype in Herb. Univ. Calif.; Mt. Albert Edward, alt. 3,680 m, *Brass* 4291.

Endemic.

18. *P. MACROPHYLLA* Copel.

Plate 6.

P. macrophylla Copel., Univ. Calif. Publ. Bot. 18 (1942) 218.

Rhizomate invisio; stipite teste Brassio 1.5–1.7 m alto, valido, brunneo vel stramineo, paleis aciculari-linearibus brunneis sparsis et nisi in sulcis deciduis ornato, sparse spinulifero; lamina tripartita, segmento (ramo) mediale 80 cm longo 30 cm lato bipinnatifido, pinnis basalibus oppositis 65 cm longis erecto-patentibus, pinnula infima basiscopica maxima et similiter furcata, rhachibus majoribus flabis spinuliferis; pinnis medialibus segmenti medialis usque ad 18 cm longis, 2 cm latis, sessilibus, caudatis, superne atroviridibus inferne brunneis, firme subcoriaceis, costis superne dentibus lanceolatis segmentis oppositis praeditis; segmentis proximis, adnato-confluentibus sinibus acutis, circa 12 mm longis, basi 4 mm latis, acutis, rectis vel subfalcatis; soris a basi fere ad apicem elongatis, indusio integro.

Dutch New Guinea, 9 kilometers northeast of Lake Habbema, alt. 2,700 m. *Brass* 10298; "forest undergrowth; occasional in wet bottoms."

Related to *P. Keysseri*, but larger, with smaller, closer and entire segments, and with spinulose axes.

19. *P. MONTIS-WILHELMINAE* Alston

P. montis-wilhelminae Alston, Journal of Bot. 78 (1940) 229.

Brass 9045, Lake Habbema, alt. 3,225 m, "frequent in moist open places in forest. Two or three rather fleshy large spread-

ing fronds on erect stipes 80–120 cm long;” *Brass & Myer-Drees 10056*, north slope of Mt. Wilhelmina, alt. 3,950 m, frequent among the stones of lime-stone screes. The type is *Versteeg 2532*, Mt. Wilhelmina, alt. 4,000 m, not seen. The podlike pinnules suggest those of *Onychium*.

Local.

20. **P. WALLICHIANA** Agardh

P. wallichiana Agardh, Rec. Sp. Gen. Pteridis (1839) 69.

Listed here by report.

India; Malaya; reported from Samoa.

21. **P. TRIPARTITA** Swartz

P. tripartita Swartz, Schrader's Journal "1800" (1801) 67.

Zahn, King, Carr; common at minor altitudes.

Old-World Tropics.

22. **P. COMANS** Forster

P. comans Forster, Prod. (1786) 79.

Reported but unknown to me in New Guinea.

Polynesia, very common.

23. **P. WARBURGII** Christ

P. Warburgii Christ, Monsunia I (1900) 70.

Brass 13459, alt. 850 m; apparently common throughout New Guinea. An isolated species, with broad lobes or pinnae and freely anastomosing veins, suggesting *Acrostichum*.

Moluccas.

Genus **HEMIPTERIS** Rosenstock

H. WERNERI Ros.

H. Weneri Ros., Fedde's Repert. 5 (1908) 38.

Werner 2, Gelu Station, alt. 1,000 m, isotype in Herb. Univ. Calif.; *Schlechter 10944*, Kani Gebirge, alt. 1,000 m.

Solomon Islands, *Brass 3329*.

Genus **CONIOGRAMME** Fée

C. MACROPHYLLA (Blume) Hieron.

C. macrophylla (Blume) Hieron, Hedwigia 57 (1916) 291.

Brass 12940, alt. 1,200 m; *Clemens* s. n., Morobe, alt. 1,400 m; this specimen is exactly like the Mindanao plant called *C. fraxinea* var. *Copelandi* by Christ, and transferred to *C. macrophylla* with the same varietal name by Hieronymus. *Carr*

15743 matches better the typical *C. macrophylla* of Java. Var. *undulata* Hieron., Engler's Jahrb. 56 (1920) 160, was described from Schraderberg, alt. 2,070 m, *Ledermann 11813*.

Java; Mindanao.

Genus ACROSTICHUM Linnaeus

A. AUREUM L.

A. aureum L., Sp. Plant. (1753) 1069.

King 204, common along coast.

Pantropic in brackish swamps.

Genus CHEILANTHES Swartz

Key to New Guinea species of Cheilanthes

Herbaceous, stipe not scaly.

Margin reflexed 1. *C. tenuifolia*
 Margin flat 2. *C. javensis*

Coriaceous, stipe paleate.

Fronde 2.5-4 cm wide 3. *C. papuana*
 Fronde 5-10 cm wide 4. *C. belensis*

1. *C. TENUIFOLIA* (Burm.) Swartz

C. tenuifolia (Burm.) Swartz, Syn. Fil. (1806) 129, 332.

Brass 8960, Hollandia, alt. 20 m; *King 290*. I have also two collections purporting to be by Zahn, Sattelberg, alt. 900 m; one is this species; the other is more probably *C. Sieberi* Kunze, but I mistrust the data of collection.

New Zealand to India.

2. *C. JAVENSIS* (Willd.) Moore

C. javensis (Willd.) Moore, Index (1861) 244.

Notholaena hirsuta (Poir.) Desv., Journal de Bot. Appl. (1813) 93.

King 289, Papua.

Malaya; Philippines; Polynesia.

Notholaena distans R. Br., of New Zealand, Australia and New Caledonia, has been reported from New Guinea and from Celebes.

3. *C. PAPUANA* C. Chr.

C. papuana C. Chr., Dansk Bot. Arkiv 9 No. 3 (1937) 57.

Brass 9147, Lake Habbema, alt. 3,225 m; *Brass & Myer-Drees 9767*, 9965, 10057, 10339, Mt. Wilhelmina, alt. 3,500 to 3,960 m, det. C. A. Weatherby. The type is from Mt. Cars-

tenz, 1. *Boden Kloss*, not seen. Doctor Weatherby's comment follows:

"No. 10339 is rather strikingly different in appearance from the rest, with longer, more remote pinnae, but in all technical characters agrees with them.

"The excellent series obtained by Brass and Myer-Drees shows well the range of variation in the species and makes possible some additions to and emendations of Doctor Christensen's description. The rhizome is, as he inferred, ascending, short and about 5 mm in diameter, very densely covered with scales like those of the lower part of the stipe, and producing rather numerous, closely approximate fronds. The lower pinnae are not reduced; and the indusium, which is very narrow, scarcely 0.2 mm wide, is not intramarginal, as described. It may appear so when folded under the reflexed margin, but is actually a direct extension of the epidermis, apparently of the upper surface. The lower surface of the lamina in young fronds is densely beset with small, sessile, pale glands. The spores are densely short-echinate with conical, acute, rather thick processes.

"The collectors' notes describe the lower surface of the lamina in Nos. 9147, 9965 and 10057 as "glaucous-white;" no such coloration appears in the dried specimens."

4. C. BELENSIS Weatherby

C. belensis Weatherby, Univ. Calif. Publ. Bot. 18 (1942) 218. Pl. 7.

Rhizoma breve circa 3 cm longum diametro 3 mm in specimine unico viso adscendens, paleis fusco-castaneis subrigidis concoloribus nitidis lineari-lanceolatis acuminatis integris e cellulis elongatis utrinque truncatis luminis coloratis vix translucentibus compositis dense onustum, apicem versus frondes plures laxae caespitosas emittens. Frondes (juveniles) and 3.6 dm altae, vetustiores verisimiliter majores. Stipes crassus teres castaneus opacus leviter albo-ceraceus quam lamina multo brevior, paleis brunneis ovatis acuminatis subtenuibus integris e cellulis brevibus irregularibus compositis plus minusve dense tectus. Lamina elliptico-lanceolata pinnato-pinnatifida vel bipinnato-pinnatifida ad apicem pinnatifidum acutum et ad basem angustata. Rachis stipiti similis paleas minores sparsioresque gerens. Pinnae ad 16-jugae (in frondibus juvenilibus solum perfectis visis) sessiles oblongae vel oblongo-lanceolatae obtusae latere basis copico modice producto inaequilaterales profunde pinnatifidae vel pinnatae, pagina superiore glabrata venulis vix impressis, inferiore plus minusve albo-ceracea, costis costulisque prominentibus castaneis. Segmenta lineari-oblonga obtusa integra vel $\frac{1}{2}$ ad costam obtuse lobata, margine hyalino angustissimo continuo integro plus minusve glanduloso anguste revoluta instructa. Venae subremotae plerumque 2-furcatae, venulis sub angulo late acuto abeuntibus, apice cla-

vellato-incrassato juxta marginem soros gerentes. Sporangia in soris singulis pauca brevistipitata, annulo subangusto cellulis transverse angustis circa 20. Spori sphaeroidei brunnei diametro circa 35 μ rugis crassis subtortuosis processibusque late conicis acutis valde asperatis.

Dry, bare face of limestone cliff; one specimen only. 18 kilometers northeast of Lake Habbema, Bele River, alt. 2,200 m, November, 1938, *Brass 11210*, type in Herb. Arnold Arboretum, deposited at Gray Herbarium.

Cheilanthes belensis apparently has no near relatives except *C. papuana* C. Chr., with which it agrees in characters of scales and spores and its little developed "indusium." It differs in its oblong or oblong-lanceolate pinnae, the lower two or three pairs more or less reduced, in its ceraceous lower surface, the rachis and costae without capitate glands, and with far fewer and smaller scales, and in the non-impressed veins of the upper surface of the lamina. *C. farinacea*, which, at first sight, it resembles, has the scales of the rhizome and stipe with dark central band and pale margin, the lower pinnae not reduced, the hyaline margin strongly developed, and differently sculptured spores.

Genus PELLAEA Link

P. ZIPPELII (Miquel) Baker

P. Zippelii (Miquel) Baker, Synopsis (1874) 477.

Originally described from "Nova Guinea, in rupibus." Schlechter, Engler's Jahrb. 49 (1912) 5, lists this fern as a characteristic plant of bare slopes on the Finisterre Mountains.

Endemic, but closely related to *P. falcata*, and thus another witness of affinity to the flora of New Zealand.

Genus DORYOPTERIS J. Smith

Key to New Guinea species of *Doryopteris*

Fronde trifid to axis or nearly so..... 1. *D. concolor*
 Fronde cut to a broad wing..... 2. *D. papuana*

1. D. CONOCOLOR (Langsd. and Fischer) Kuhn

D. concolor (Langsd. & Fischer) Kuhn, in v. Decken, Reisen 3³ Bot. (1879) 19.

Reported and doubtless here, but I have no specimen.
 All warm lands.

2. **D. PAPUANA** Copel.

D. papuana Copel., Philip. Jour. Sci. 6C (1911) 86.

King 208, type, Goodenough Bay; 388.

Endemic. I cannot agree with Tryon in reducing this to *D. ludens*.

Genus **ONYCHIUM** KaulfussO. **SILICULOSUM** Desv.

O. siliculosum Desv. C. Chr., Index (1905) 20; (1906) 469.

King 209, 333, Papua.

Malaya; Philippines.

Genus **ADIANTUM** Linnaeus*Key to New Guinea species of Adiantum*

Frond simply pinnate.

Glabrous 1. *A. philippense*

Hairy 2. *A. caudatum*

Frond more compound.

Hairy 3. *A. hispidulum*

Glabrous (unless upper side of rachis).

Stipe at most 10 cm long..... 4. *A. Kingii*

Stipe at least 15 cm long.

Sori orbicular 5. *A. neo-guineense*

Sori wider than long.

Rachis hairy above 6. *A. Christii*

Rachis naked 7. *A. hollandiae*

1. **A. PHILIPPENSE** L.

A. philippense L., Sp. Plant. (1753) 1094.

Schlechter 16359, 16980, alt. 200 m; *Clemens* (host of a fungus), Morobe; *King 211*, Papua.

Africa to Polynesia; immigrant in tropical America.

2. **A. CAUDATUM** L.

A. caudatum L., Mantissa (1771) 308.

Carr 11747, Kanosia, Papua, sea-level.

West to India and Africa.

3. **A. HISPIDULUM** Swartz

A. hispidulum Swartz, Schrader's Journal "1800" (1801) 82.

Zahn, Yabim.

To New Zealand, India and Africa.

4. **A. KINGII** Copel.

A. Kingii Copel., Philip. Jour. Sci. 9C (1914) 5.

Known only by the type, *King 420*, Tamata, Papua.

5. A. NEO-GUINEENSE Moore

A. neo-guineense Moore, Gard. Chron. N. S. 7 (1877) 12.

Known only as from New Guinea, collected by Goldie.

6. A. CHRISTII Ros.

A. Christii Ros., Fedde's Repert. 12 (1913) 166.

Brass 10812, 12688. The type is *Keysser B 43*, Bolan alt. 2,400 to 3,000 m, isotype in Herb. Univ. Calif.

Endemic.

7. A. HOLLANDIAE v.A.v.R.

A. hollandiae v.A.v.R., Bull. Jard. Buit. 7 (1912) 1.

Known only by the type, *Giellerup 946*, Hollandia, not seen.

A. fulvum Raoul is also reported, on the cited evidence of *Ledermann 11761*. It is common farther East and South.

ILLUSTRATIONS

All are photographs of the types

- PLATE** 1. *Dicksonia Archboldii* Copel.
2. *Orthiopteris trichophylla* Copel.
3. *Dennstaedtia magnifica* Copel.
4. *Lindsaea furcata* Copel.
5. *Hypolepis Archboldii* Copel.
6. *Pteris macrophylla* Copel.

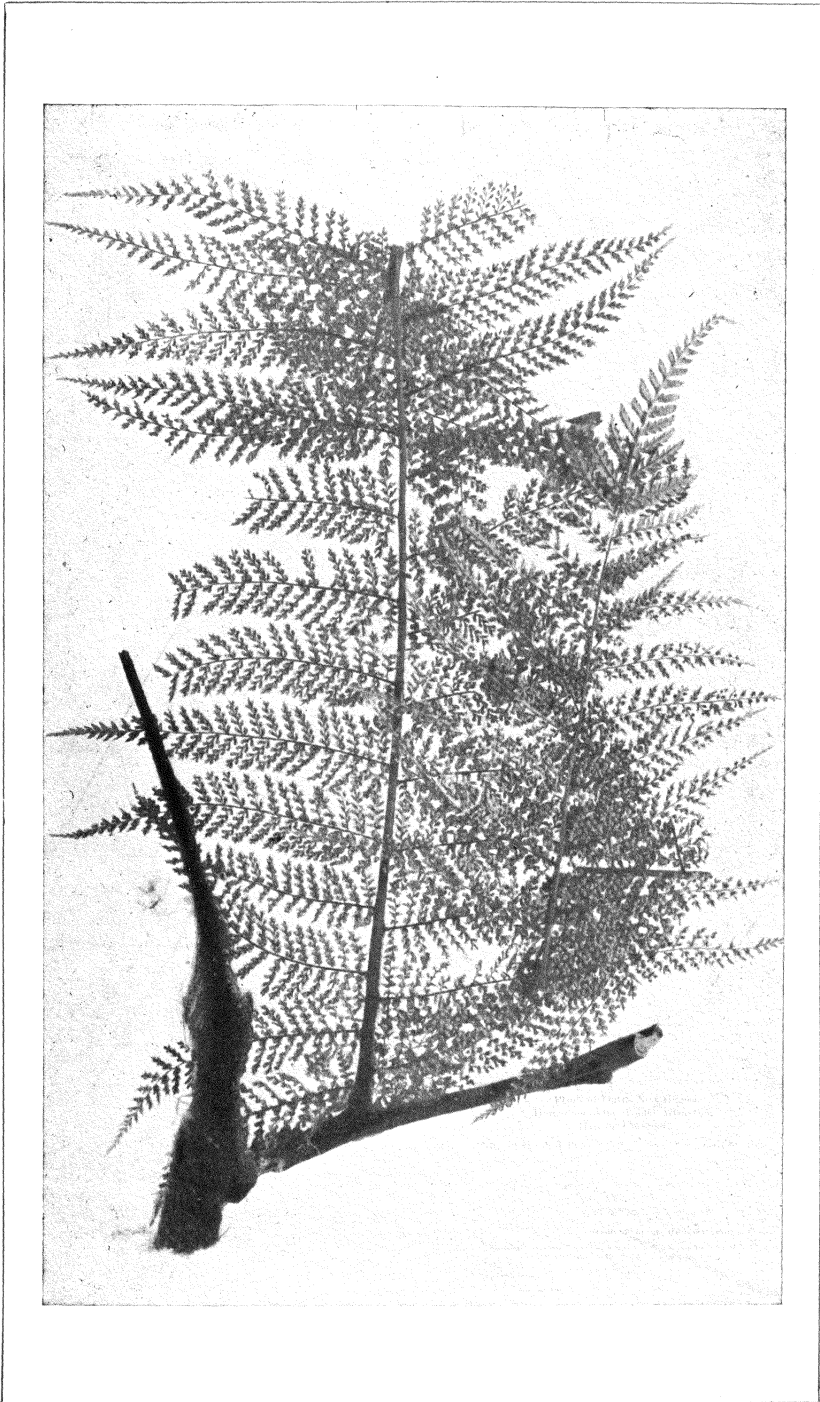


PLATE 1. DICKSONIA ARCHBOLDII COPEL.



PLATE 2. ORTHIOPTERIS TRICHOPHYLLA COPEL.

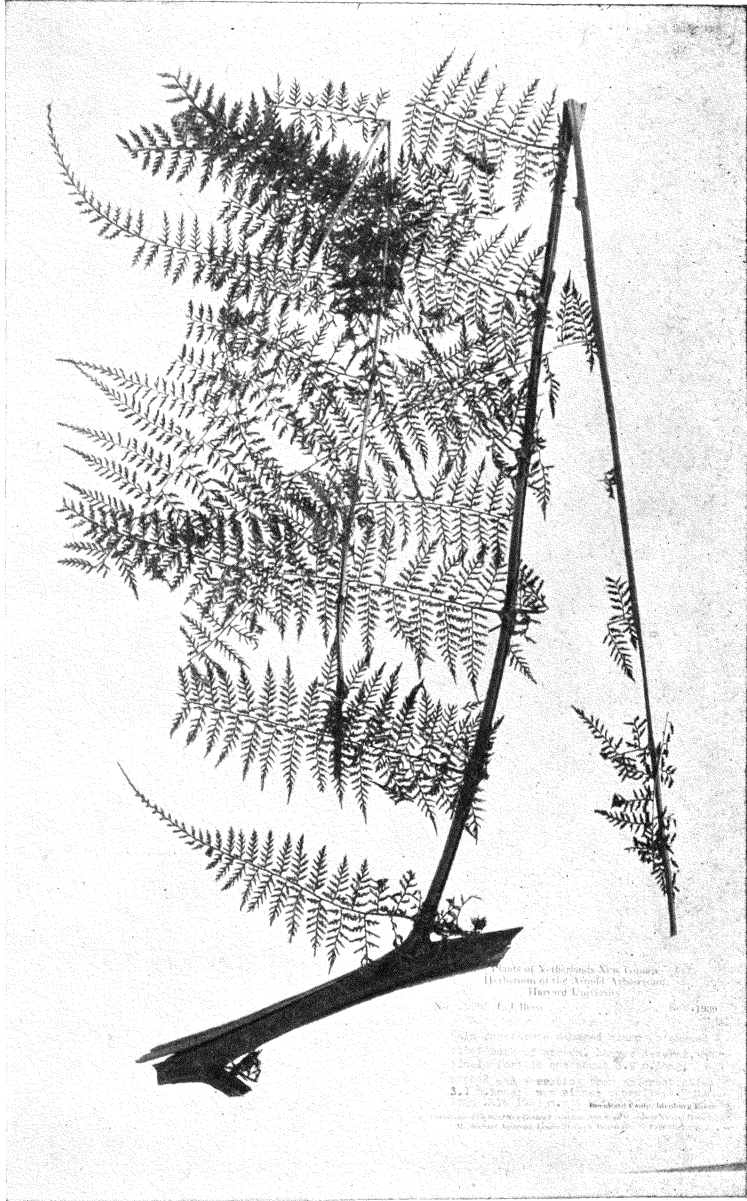


PLATE 3. DENNSTAEDTIA MAGNIFICA COPEL.



PLATE 4. LINDSAEA FURCATA COPEL.

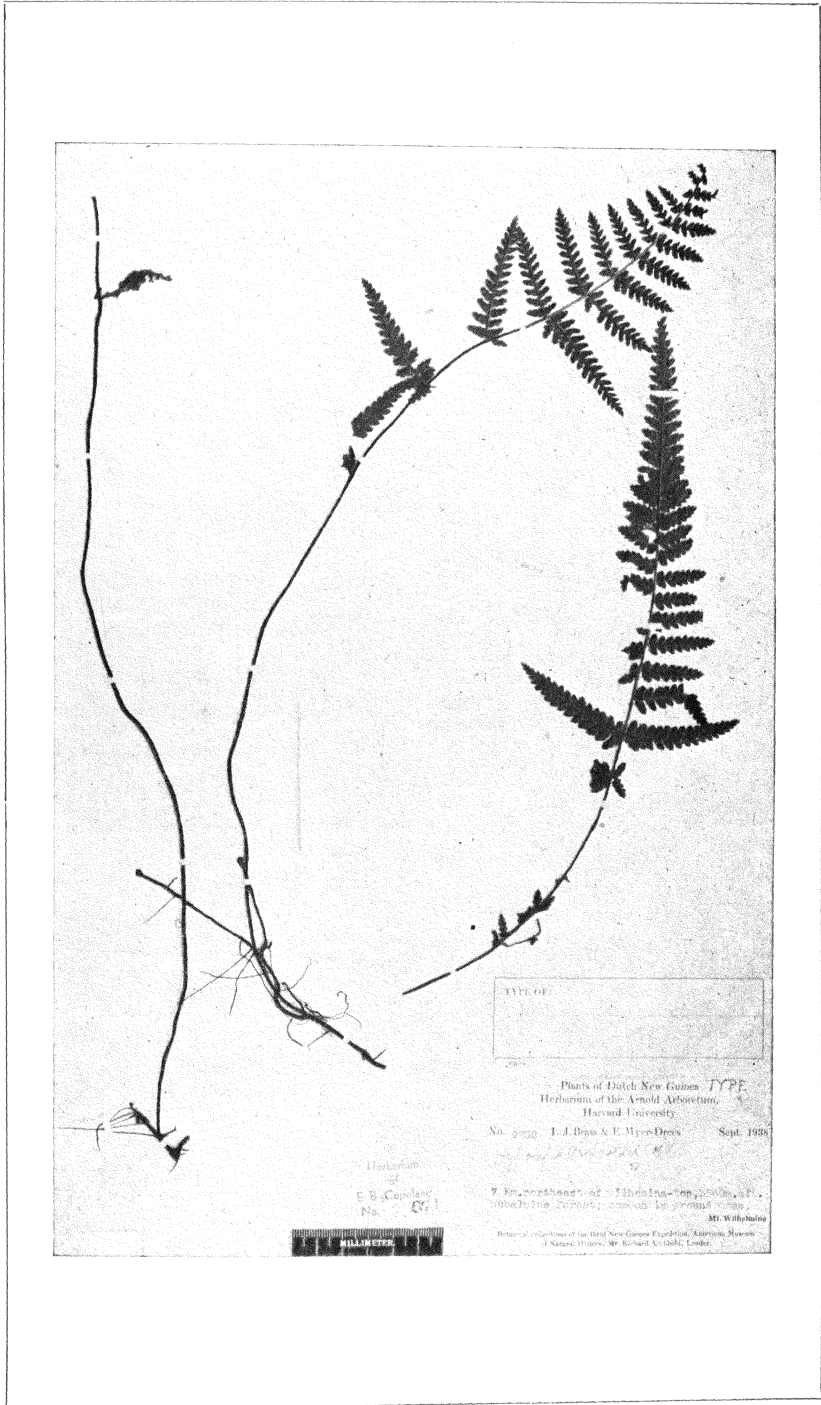


PLATE 5. HYPOLEPSIS ARCHBOLDII COPEL.

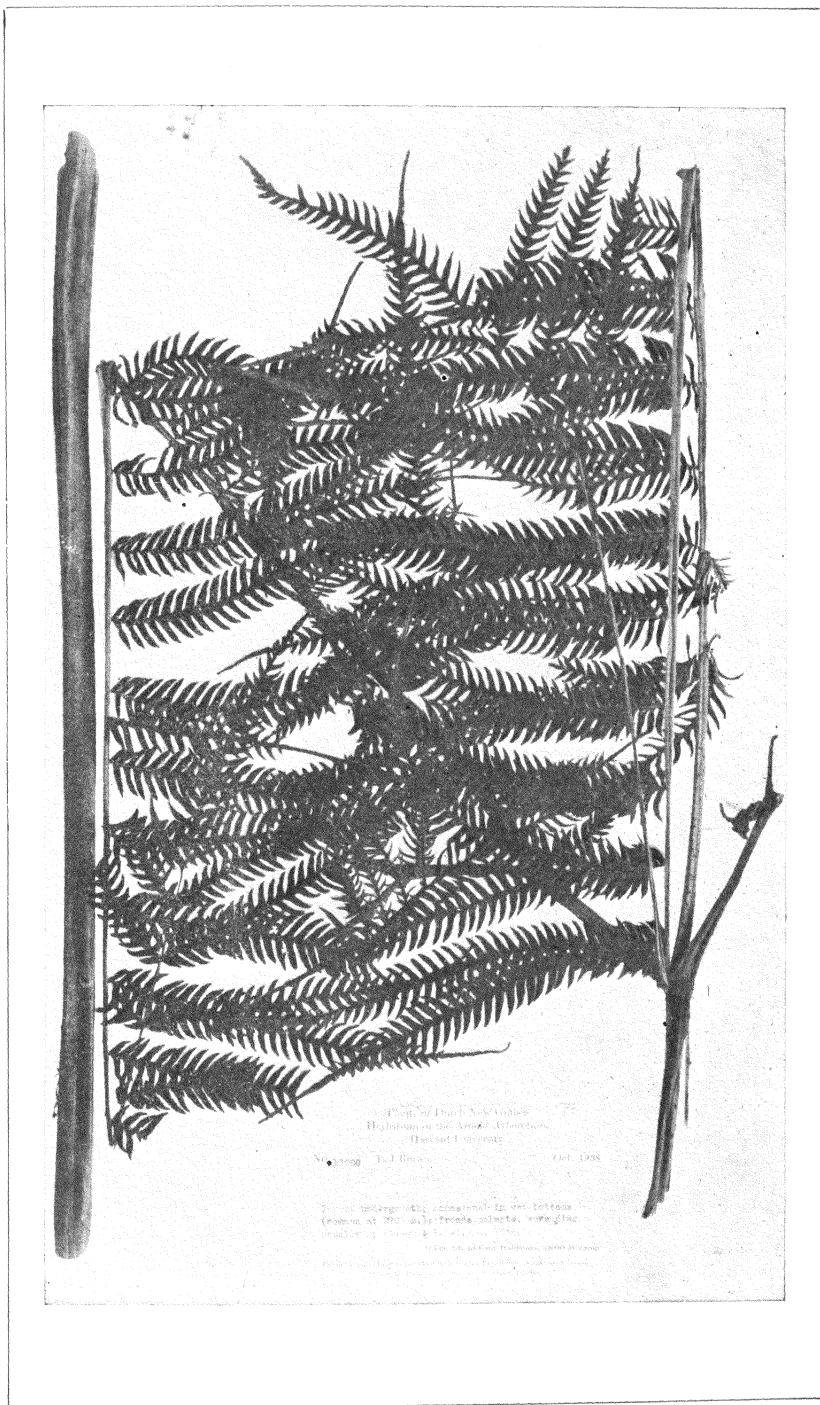


PLATE 6. PTERIS MACROPHYLLA COPEL.

NOTES ON PHILIPPINE MOSQUITOES. XV THE
CHÆTOTAXY OF THE PUPÆ AND LARVÆ
OF TRIPTEROIDES¹

By F. E. BAISAS and ADELA U. PAGAYON
Of the Malaria Control Section, Department of Health

FOUR PLATES

This is an attempt to unify the widely differing terminologies used by various authors for the pupal setæ of mosquitoes, and to harmonize these terms with the popular numeral hair notations for the larva. It does seem quite surprising that while the pupal hairs are evidently the representatives of larval setæ, all the schemes heretofore employed for the pupal chætotaxy were conceived in complete disregard of correlation or homology with the larval hairs.² Such a correlation would seem naturally indicated when the pupal hairs become sufficiently visible during development inside the larval skin. In available literature and in practice among our own laboratory workers, one of the main criteria to determine a fourth instar larva is the appearance of the float hairs. At a certain stage these are readily seen through the larval cuticle on abdominal segment I. Among anophelines, the float hairs are directly or nearly directly underneath the palmate hair. These are similarly situated in culicines where the palmate hairs are represented by what is more commonly known as hair No. 1. By a careful examination of suitable specimens, the other pupal setæ on the abdomen could be seen more or less in the same precise location beneath the larval hair to which each corre-

¹ Submitted for publication, September 10, 1948.

² On October 30, 1948, when this was already in press, we received a copy of the latest work on pupal chætotaxy by K. L. Knight and R. W. Chamberlain entitled: A new nomenclature for the chætotaxy of the mosquito pupa, based on a comparative study of the genera. *Proc. Helminth. Soc. Wash.* 15 (1948) 1-10. It was not possible for us to reproduce one of their illustrations for comparison with what we show here, or to include their scheme in our discussions, but there are fundamental differences between their interpretation and numbering of hairs and ours. Only No. 5 of abdominal segments IV to VIII, and No. 13 of VIII are similarly designated. Their scheme, like others before it, is not based on homology or correlation with larval hairs. Of their many illustrations, No. 6 represents a pupa of *Tripteroides (Mimeteomyia)*.

sponds. The profound changes in the form and contour of certain parts when the larva is transformed into pupa necessarily alter more or less decisively the positions and make-up of the hairs on these parts. The correlations of these particular hairs are, therefore, extremely difficult to determine. But in the main, the ones most valuable from the standpoint of classification are not so hard to correlate.

The most suitable specimens for the study of hair correlations are those where the pupal setæ are sufficiently visible through the larval skin. This is usually at the initial stage when the larva becomes pale and quiescent, indicating the changes that take place during pupation. Though advantageous for complete visibility of hairs, a pupa which has started to break through the larval skin or when about ready to do so is not suitable owing to alterations in position of its hairs. By a rapid examination of the living larva under a microscope, one can readily determine the suitable specimen. When found, it may be killed quickly but not too rapidly in warm water. Even in its death throes in warm water, a nearly mature pupa may wiggle out of its original position inside the larval skin. Suitable specimens may be mounted in balsam or any other medium containing no acetic acid. Acid clears the immature pupal hairs to complete invisibility.

The second half of this paper is likewise an attempt to homologize the hairs of a *Tripterooides* larva with those of an *Anopheles*. The schemes promulgated by different workers for the hairs on the head of culicines are different from those for anophelines, and are, moreover, not strictly based on homology. Some authors introduced hair notations for the thorax of culicines similar to the numeral hair designations for the thoracic hairs of anophelines, but none has been published to cover the abdominal chaetotaxy of culicines. The varying patterns of hair arrangement on the head, and the great difference in morphology from that of anophelines, of abdominal segments VIII and IX render the homology of the hairs borne by these parts no easy matter to determine. The siphon, particularly, obliterates all signs of hair correlations.

In another part of these notes, we intend to include complete acknowledgments of what we owe different people concerning this study. For the present suffice it to mention those of the Department of Health under whom we worked directly, namely, Dr. Walfrido de Leon, Chief, Division of Laboratories; Dr. Antonio Ejercito, Chief, Malaria Control Section; and those of

the 19th MGL, U. S. Army, from the Commanding Officer, Col. D. M. Kuhns, to the last enlisted and civilian personnel of the Entomology Department, who offered to us the use of their specimens and laboratory facilities.

The pupal setæ.—Considerable reduction not only in total number but also in sizes of individual hairs takes place when the larva is transformed into pupa. The relative positions of certain hairs are also changed. Fusion of the (larval) head and thorax into the so-called (pupal) cephalothorax is accompanied by the elimination of many hairs and the alterations in positions of those that are left on these parts. In comparison, the abdominal hairs on I to VII suffer very little elimination though their sizes are generally very much reduced.

A total of nineteen pairs of hairs arise directly and indirectly from the head capsule of a *Tripteroides* larva; forty two from the thorax. But only three pairs of those on the head and nine of those on the thorax are represented in the pupal stage.

In spite of the difference in number of hairs between the larvæ of Group A and Group B,³ subgenus *Tripteroides*, the number of pupal hairs is exactly the same for both groups. Normally each of the species with known pupæ of Philippine *Tripteroides* bears nine pairs of pupal hairs on abdominal segment I, eleven on II, while each of III to VII has twelve pairs. Quite often the only ventral hair on I and one of the two on II are absent; less frequently one of those on VII is also absent. Some species seem to have normally only one ventral pair even on II. If the socket which Baisas and others⁴ think represents pupal hair 3 (of authors) is included, each of segments III to V will have thirteen pairs. Segment VIII bears only four pairs of hairs in either group.

In the larval stage Group B has more hairs on abdominal segments I to VII than Group A. This is due to the absence of hair 14 in all species of Group A. The larva of the local *Rachisoura* does not possess abdominal hairs 2 and 14. A more detailed discussion on larval hairs is given below.

³ Edwards, F. W. *Genera Insectorum* (932) Fasc. 194. 77-78.

⁴ Baisas, F. E. Notes on Philippine mosquitoes, VII. Mon. Bull. Bureau of Health, 18 (1938) 182.

Stone A. and G. H. Penn. A new species of *Culex* from New Guinea Jour. Wash. Acad. Sci. 37 (1947) 90, Fig. 7.

A few hairs, in contrast, become more developed in the transformation to pupa. The most notable are the superior post-ocular hair (No. 3 of Rozeboom & Knight⁵), and the lateral tufts or the A's of abdominal segments VII and VIII. The equivalents of these hairs in the larval stage, as we interpret them, are tiny. But the float hair (dendritic tuft of authors) which is very well developed and markedly exceeds the larval hair it represents in all anophelines and most culicines, is rudimentary in all species except one in Group A, and though developed in all of Group B is, nevertheless, hardly larger than the larval hair to which it corresponds.

Edwards⁶ claims that rudimentary float hair is a general characteristic of treehole breeding mosquitoes. But this does not seem true for most of the Philippine treehole breeding species. Those of the local *Megarhinus*, *Orthopodomyia*, *Uranotænia*, and *Tripteroides* which breed in treeholes have very well developed float hairs. Even lesser amount of water in narrower spaces than ordinary treeholes does not seem detrimental to the development of the float hairs. The kind of *Aedes* which breeds exclusively in leaf axils of *Colocasia*; the *Topomyia* found only in very tiny holes of "climbing bamboo"; the *Zeugomyia* breeding in the leaf axils of *Livistona rotundifolia*, the *Tripteroides* known to breed only in pitcher plants; and that unusual *Tripteroides* which breeds in very little amount of water inside tiny forest shells—all of these have developed float hairs.

A few species, however, have rudimentary float hairs. The kind of Philippine *Ficalbia* found in treeholes in jungles, and all species, but one, of Group A, subgenus *Tripteroides*, which breed in pitcher plants have rudimentary float hairs.

Differences between the pupæ of Group A and Group B.—But for one partially annectant species, the pupæ of Group A can readily be separated from those of Group B by four well marked differences. The annectant form invalidates two of these. One is the character of the float hairs, and the other is the peculiarity of the respiratory trumpets. The float hairs are rudimentary, i. e., single or split into only two to about half a dozen branches, and the respiratory trumpets are relatively more stout with widely expanded but not deeply notched apices in Group A (except in the partially annectant species).

⁵ Rozeboom, L. E. and K. L. Knight. The *Punctulatus* complex of *Anopheles*. Jour. Parasit. 32 (1946) 123, Pl. IV.

⁶ Edwards, F. W. Mosquitoes of the Ethiopian Region, III (1941).

But in Group B the float hairs are dendritic and the respiratory trumpets are less stout and less expanded but deeply notched at the apices. The unusual species in Group A has well developed float hairs, and very much less stout respiratory trumpets the tips of which are, however, square cut and not notched. In common with all species of Group A, this partially annectant form has its superior postocular⁷ hair comparatively much shorter, moderately stout, frayed, single, seldom branched, and the paddles do not have any visible midrib. The superior postocular hair in Group B is very long and prominent, not frayed, single in one species, split into two or three equal branches in all the others; while the paddle has very well defined midrib.

The hairs of the head.—When inside the larval skin, the postocular hairs are better seen from the ventral side. These are very close to the sites of hairs 13, 14 and 15 on the head of the larva. The inferior and median, or what Rozeboom and Knight designate as Nos. 1 and 2, are short and slender. They are usually not visible because they arise directly beneath the anterior portion of the dark imaginal eye. The superior, or No. 3 of Rozeboom and Knight, is very much longer specially in Group B, and being the only one of the three which is truly postocular in position, can readily be seen from the dorsal surface. The larval hairs 13, 14 and 15 are weak in all known Philippine *Tripteroides* and usually No. 14 is the weakest. By relative positions, the inferior corresponds to No. 13, the median to No. 15 and the superior to No. 14. No appreciable change in size of Nos. 13 and 15 takes place in pupation, but No. 14 becomes more stout and very much longer.

The thoracic hairs.—Though very much reduced in number, and generally also in sizes, the hairs on the three thoracic segments of the larva are represented in the chaetotaxy of the pupa. The so-called antero-thoracic pupal hairs,⁸ or Nos. 4 to 7 of Rozeboom and Knight, are apparently all that remain of the prothoracic larval hairs; the dorsal and supra-alar,

⁷ The term "postocular" is by J. W. S. Macfie in:—The Chaetotaxy of the Pupa of *Stegomyia fasciata*. Bull. Ent. Res. 10 (1920) 161-169. R. Crawford uses "ocular" in:—Some Anopheline Pupae of Malaya. (1938) 1-110.

⁸ Knight, K. L. and R. W. Chamberlain consider the antero-thoracic pupal hairs part of the mesothoracic setae, but as shown in our Plate 1, fig. 5, this is evidently not the case:—*Vide*—A new nomenclature for the chaetotaxy of the mosquito pupa, based on a comparative study of the genera. Proc. Helminth. Soc. Wash. 15 (1948) 1-10.

Nos. 9 and 10 of Rozeboom and Knight, are the remnants of the mesothoracic larval hairs; while the metanotal (*O*, *P* and *R* or 10, 11 and 12 of Rozeboom and Knight) are the representatives of the hairs on the metathorax of the larva.

The arrangement of the four antero-thoracic hairs in their original state is shown in Plate 1, fig. 5. The more internal two of these hairs are close to each other and farther from the other two which are also close together. The innermost is either directly underneath or a little anterior or posterior or somewhat internal or external to hair 1 on the prothorax of the larva. The other is similarly placed in relation to larval pro-hair 3. Pro-hair 2 of the larva seems eliminated.

Though also somewhat variable in position, the most external of these pupal hairs does not arise (in the *Tripteroides* specimens on hand) outer to the site of larval pro-hair 4. It may, however, be a little anterior or antero-internal or postero-internal to that hair. If this is taken as the equivalent of larval hair 4, the other would have to be considered the representative of either the larval pro-*O* or 2. No. 2 seems out of the question, while *O* is weak and not correlated in position to this hair. Our choice is to consider the outermost pupal hair as No. 5 and the other as No. 4, even if there is apparently as much reason to consider them No. 7 and No. 5 respectively since in all species of *Tripteroides* the larval pro-hairs 5 and 7 are developed. But the distance from the outermost pupal hair to the site of larval hair 7 is too wide to be in harmony with that which intervenes between the innermost pupal hair and the pro-hair 1 of the larva. It would seem reasonable to expect the two antero-thoracic pupal hairs to be external to larval pro-hair 4 if they were the equivalents of the larval pro-hairs 5 and 7. Moreover, the tendency of the cephalothoracic hairs to be more internally located than the larval hairs they represent is least on the region of the antero-thoracic, somewhat more where the dorsal and supra-alar hairs are located, and greatest on the metanotal.

When inside the larval skin or on mounted whole pupæ, the identity of the four antero-thoracic hairs, according to the nomenclature of Crawford or the numbers given by Rozeboom and Knight, is not readily evident. Furthermore, the upper of these hairs, as seen in quite a good series of mounted pupal skins of different *Tripteroides* on hand, sometimes seem to become the lower. Plate 1, fig. 5 shows our interpretation of these and other cephalothoracic hairs according to what seem their re-

spective equivalents in the larval hairs. We consider the innermost of the antero-thoracic or the "upper anterior" of Crawford or No. 6 of Rozeboom and Knight, as No. 1; the next or the "lower anterior" (of C.) or No. 4 (of R. & K.) as No. 3; the third or the "upper posterior" (of Crawford) or No. 5 (of Rozeboom and Knight) as No. 4; and the fourth or outermost or the "lower posterior" (of C.) or No. 7 (of R. & K.) as No. 5.

The dorsal hair (No. 8) and the supra-alar (No. 9) apparently represent the mesothoracic larval hairs 1 and 5 respectively. In Group A, No. 8 arises at the same level (underneath) but a little internal to the mesothoracic hair 1 of the larva, and the two are nearly equal in rank in most species. In Group B this hair is either directly beneath the base of, or a little anterior or posterior to, the large stellate tuft (No. 1) on the mesothorax of the larva; No. 9 is less obvious in homology, it being seemingly equal, in different species, to either 2 or 3 or 4 of the mesothoracic larval hairs. But as No. 5 is one of the most developed mesothoracic setæ, we prefer to regard the supra-alar as the remains of this hair.

The metanotal hairs (*O*, *P* and *R* of authors, or Nos. 10, 11, and 12 of Rozeboom and Knight) seem to represent respectively 1, 2 and 5 of the metathoracic larval hairs. The metanotal hairs do not differ significantly between the two groups of *Tripteroides*, but in the larval stage at least No. 1 is a large stellate tuft in Group B; much smaller, often single, in Group A. No. 12 is the one directly or nearly directly beneath larval hair No. 1; Nos. 10 and 11 being internal to it and not immediately near the site of any larval hair. This appears to be due to the contraction of the metanotum (metathorax) when transformed into pupa.

The abdominal hairs.—Because there is a maximum of only twelve pairs of hairs (thirteen if the socket on III to V is included) on an abdominal segment of a *Tripteroides* pupa regardless of the difference in number of hairs between Group A and Group B in the larval stage, it seems reasonable to assume that the hairs carried over to the pupal stage are identical in all species. Likewise (and logically it seems) the hairs not found on the larva cannot presumably be expected to appear on the pupa specially because the tendency in pupation seems to be the reduction of hairs. But this does not seem to be always the case. Hair 2 which is absent from the larva of one species, is still represented on the pupa of even this species; and though tiny, is not less so than those in

which this hair is well developed in the larval stage. On the other hand, No. 14 which is developed in Group B, but absent in Group A, is not represented on any of the known pupæ of Philippine *Tripteroides*.

The remarkable similarities in number and general arrangement of the pupal setæ in different genera and subgenera of mosquitoes is contrasted more or less markedly by the differences in their respective larval chætotaxy. This would seem to indicate that development and retrogression of hairs are first manifested in the larval stage, such that "new" larval hairs may not be expected to appear in the pupal stage, just as "old" ones which have already been eliminated from the larva may still be represented in the pupal stage. Abdominal hair No. 2 may be taken as an "old" hair which has been eliminated from the larva of one species but still exists on the pupa of even this species. Apparently this hair is being discarded from the larva of Group A since it is very tiny when present, and often absent from some segments or from all segments of some individuals in any species. In contrast, this hair is well developed and stellate in the larva of Group B, but also very tiny like that in Group A in the pupal stage. For a "new" hair, No. 14 seems this kind. It is well developed and stellate in the larva of Group B, but absent in Group A, and not represented in the pupal setæ of any species.

The general likeness in arrangement of pupal hairs displayed by different mosquitoes does not strictly mean homology between similarly placed hairs. This is because some hairs vary in positions not only in different species, but also on different segments of an individual, and sometimes also on different individuals of the same species. Similarities between two or more hairs, and their close proximity to each other on any part or segment increase the difficulty of recognizing these hairs. Moreover, when the pupa emerges from the larval skin and stretches out to assume its normal form, the relative positions of some hairs (indicated when yet inside the larval skin) are altered. Abdominal hairs 3, 4, 6, and 8 are specially affected by this stretching. Only by comparing the setæ of a free pupa or pupal skin with those of an immature pupa inside the larval skin of the same species can these hairs be properly identified.

Hair B, or what we designate as No. 5, is one of the most variable in position in different species and on different segments. Normally, in most species this is posterior and in-

ternal to Nos. 3 and 4 (of our scheme) on abdominal segments and IV. But it is often external to 3 and posterior to 4 on V to VII; or Nos. 3, 4 and 5 may be evenly aligned one after another. In certain species, No. 5 is normally internal to 4.

The arrangement of hairs on VII among individuals of any species in Group A is very variable. No. 5 (or *B*) of this segment is often so close to No. 6 (or *A*) it may be mistaken as (our) No. 8; or it may be rather far away and well internal to 4. Sometimes it is weaker than either 3 or 4. In mounted flat preparations, Nos. 8 and 12 (of our scheme) on this segment may appear either dorsal or ventral; while No. 8 is sometimes unusually close to 6.

Two or three species in Group A have all the abdominal hairs weak. Even *B* and *C* or Nos. 5 and 1 of these species cannot be easily picked out unless correlated with the positions of the larval hairs.

Quite often in routine examination, one runs across larvæ which are ready to molt to the fourth instar. In this stadium, each of the fourth instar larval hairs is beautifully placed directly underneath the corresponding hair on the enveloping third instar larval skin. There can be no question about hair equivalents in this. But the picture is not as clearly carried over to the stage when the fourth instar larva is about to shed its skin and give rise to an entirely different form, the pupa. Every part of the larva undergoes changes in pupation, and the number and arrangement of hairs are as much affected as the degree of change that takes place in the part where such hairs are located. It seems the fourth abdominal segment suffers the least change in form, and the hairs it bears are the least altered in arrangement. From segment IV the changes increase progressively either anteriorly or posteriorly, the greatest being at segment I, thorax, and head, and at the terminal segments of the abdomen. We use segment IV, therefore, as the basis of interpreting hair relationships, but at the same time we give due value to relationships which are better indicated elsewhere. Correlations between the lateral hairs, for example, are better shown on VI and VII (see Plate 1, figs. 1 and 2).

In parts or segments where changes due to pupation are great, homology of pupal hairs cannot be strictly based on proximity to certain larval hairs. For instance, on segment VII as shown in Plate 1, fig. 6, the pupal hair that corresponds to

larval hair 5 is directly underneath larval hair 4, while that which represents larval hair 4 is directly under larval hair 3. The true relationships of these hairs can be correctly understood only from hair correlations indicated on the middle segments.

Among the few *Anopheles* and *Culex* pupæ we examined, the large pupal hairs *B* and *C* on the abdomen are readily recognized since they are, on most segments, directly beneath larval hairs 5 and 1 respectively. In *Tripterooides*, however, *B* is more or less ventral with respect to larval hair 5, and *C* directly or almost directly under larval hair 1.

On the ventral side the relationship between pupal and larval hairs is less apparent. If judged only by its position on IV, pupal hair 8 (of authors) would seem to correspond to larval hair No. 11. But hair 8 is evidently identical with the only ventral hair (often absent) on I, which in turn appears to represent hair 13 of the larva. This varies in position on different segments and is unrecognizable when all the ventral setæ are of about the same sizes or types. The other ventral hairs, *D*, 6 and 7 (of authors) seem to be the equivalents of larval hairs 9, 12 and 7 respectively. *D* or 9 is usually the longest; 7 ranks next and may equal or even exceed 9 on the more posterior segments; while 12 is about equal to 13. As No. 12 becomes dorsal in position on V-VII in Group A, only three pairs are on the ventral surface of each of these segments except on VII in cases or individuals where what we propose to be designated No. 8 becomes ventral, or where No. 8 is dorsal, but 12 is on the ventral side. Mounted flat preparations are often confusing since some of the dorsal and ventral hairs come to equally clear definition under the same focus either under high or low magnifications.

The pair of tiny ventral hairs (No. 9 of authors) found in all *Anopheles* and most culicines is absent in *Tripterooides*. The pair on VIII of *Tripterooides* being similar to 9 on VIII of other culicines may be mistaken for this hair. But what *Tripterooides* possesses, as such, seems more reasonably the equivalent of No. 8 (of authors) on the preceding segments, or what we consider No. 13. Hair 13 is present also on VIII of the larva among *Tripterooides*, although this is laterally located in Group B; ventral, as usual, in Group A.

The chætotaxy of segments I and II differs somewhat from that of III-VII. *H* and the float hairs, just like *C'* and *C* of II-VII arise directly underneath or closely underneath

larval hairs 0 and 1 respectively, and so the float hair should be designated No. 1, and *H*, No. 0. *K*, *L*, *M*, *S*, *T*, and *U* are not immediately near the location of larval hairs. *K* in most species in Group B is the most prominent seta outside of the float hair, but it is comparatively much weaker in species of Group A. It seems the equivalent of what we regard as hair 2 (or 5 of authors) on the following segments. This may appear questionable, first, because hair 2 is not present on segment I of the larvæ among *Tripteroides*, and, second, it greatly outranks 2 of the other segments. Perhaps this is a vestige of an ancestral form which had hair 2 on I as in anophelines, while its size is understandable in the light of unusual variations in sizes of hairs. The *lh* on I and II in all kinds of mosquito larvæ are a good deal larger than those of other segments, yet in the pupal stage these are very much reduced on I and II and well-developed on VII and VIII. *L*, *M*, *S*, *T*, and *U* seem to represent larval hairs 3, 4, 5, 7 and 6, respectively.

In the nomenclature of authors for anophelines, segment II of the pupa is credited with two pairs of No. 1 and two pairs of No. 2 hairs. Even when in its original position inside the larval skin, the homology of the two No. 1 pupal hairs with the larval setæ is not evident because they are situated and pressed close to pupal hair *A* (of authors) on the lateral side of the segment. When released from the larval covering, they become farther apart. It seems that the first or the more external corresponds to the long secondary lateral hair or No. 7 of the larva, while the other corresponds to another lateral larval hair, No. 8. The more posterior, but often the more internal of the two No. 2 pupal hairs arises closely beneath larval hair No. 4, and the other closely beneath larval hair No. 3. *B* on this segment is rather far from larval hair No. 5, so its homology is based on evidences manifested on other segments. *C* and *C'* of segment II, like those of the succeeding segments, arise directly under or closely beneath larval hairs 1 and 0, respectively.

There is usually one pair of ventral hair on I and two on II. However, that on I and one of the two on II are absent from some individuals of species in which these hairs are normally present. Some species evidently have normally only one pair even on II. The ventral hairs are variable in position according to species and somewhat variable also among individuals within a species. That on I appears to be the equivalent of

larval hair 13. When only one pair is on the ventral side of II it seems to be also No. 13; and when there are two ventral pairs, the more external and anterior in position appears to be the equivalent of larval hair 12; No. 13, the inner and more posterior.

As a summary, and to harmonize the pupal hair notations with those of the larva, the following changes are proposed:

The post-ocular hairs.

The inferior (of Macfie), or No. 1 (of Rozeboom and Knight), should be No. 13 to correspond to sub-basal or post-mandibular hair or No. 13 of the larva.

The median, or No. 2 should be No. 15 to correspond to the infra-orbital hair, or No. 15, of the larva.

The superior, or No. 3, should be No. 14 to correspond to the orbital hair, or No. 14, of the larva.

The antero-thoracic hairs.

The upper-anterior, or No. 6, should be pro-1 to correspond to prothoracic larval hair No. 1.

The lower-anterior (of authors), or No. 4 (of Rozeboom and Knight), should be pro-3 to correspond to prothoracic hair 3 of the larva.

The upper-posterior, or 5, (sometimes this is the lower) should be pro-4 to correspond to prothoracic larval hair No. 4.

The lower-posterior, or 7 (sometimes this is the upper) should be pro-5 to correspond to larval hair No. 5 of the prothorax.

The dorsal hair, or No. 8, should be meso-1 to correspond to hair No. 1 on the mesothorax of the larva.

The supra-alar hair, or No. 9, should be meso-5 to correspond to hair No. 5 on the mesothorax of the larva.

The metanotal hairs.

O, *P*, and *R*, or Nos. 10, 11, and 12, should respectively be meta-1, meta-2, and meta-5 to represent the larval hairs on the metathorax of the same designations.

The abdominal hairs.

Proposed designations according to homology or apparent homology with larval hairs of the same notations.	Designations by authors.	Designations by Rozeboom and Knight.
0.....	<i>H</i> and <i>C'</i>	9 and 5
1.....	Float hair and <i>C</i>	10
2.....	<i>K</i> and 5.....	4 on I, 7 on other segments
3.....	<i>L</i> , anterior 2 of II, and 4 of other segments.....	5 on I, 6 on other segments
4.....	<i>M</i> , posterior 2 of II, and 2 of other segments.....	4
5.....	<i>S</i> , <i>B</i> and <i>A'</i>	8
6.....	<i>A</i> and <i>U</i>	1
7.....	<i>T</i> , first No. 1 of II, and 7 of other segments.....	15
8.....	Second 1 of II and 1 of other segments.....	2
9.....	<i>D</i>	16
10.....	3 (socket on III-V).....	3
12.....	6.....	14
13.....	8.....	17

To regard pupal hairs *A* and *U* as the equivalents of larval hair 6 or the *lh* (as we propose here) may seem questionable because, while *lh* of I and II are well developed, those on the following segments decrease progressively in length such that No. 6 on VII (of most species) and on VIII (of all species) are very tiny. By contrast, *U* and *A*'s of the pupa become increasingly developed from I to VIII, *U* on I being tiny, but *A*'s of VII and VIII are nearly always large subplumose tufts. Perhaps this may be explained by the fact that changes in hairs in the process of pupation do not follow the same direction, and that in part at least, it seems development or retrogression of hairs depends upon the usefulness of such hairs. Hair *lh* is evidently most useful to the larva on I and II, just as the *A*'s are apparently of greatest utility to the pupa on VII and VIII; hence, the development of *lh* in reverse direction to that of *U* and *A*. Perhaps the marked increase in size of larval hair 14 when it becomes the so-called superior post-ocular hair of the pupa is similar to the change of *lh* on VII and on VIII.

The illustrations in this paper were drawn by Mr. Eliseo Enriquez, artist of the Malaria Section. These are all original except the one copied from Rozeboom and Knight (for comparative purposes), and that which is reproduced from Baisas (1938) which was also originally drawn by Mr. Enriquez.

CHÆTOTAXY OF THE LARVÆ

The numerical notation for larval hairs of *Anopheles* employed by Puri,⁹ Christophers¹⁰ and Rozeboom and Knight (*loc. cit.*) is here adapted for the hairs of *Tripteroides larvæ*. Correlating the hairs of *Tripteroides* with those of *Anopheles* is difficult only on the head and abdominal segments VIII-X. The setal arrangement on the thorax and abdominal segments I to VII is closely similar to that of anophelines. Barraud¹¹ illustrates and numbers the thoracic chætotaxy of *Tripteroides*. From his interpretation, however, we differ in the case of metathoracic hairs 3, 4 and 5. As shown in Plate 1, fig. 5 of the present

⁹ PURI, I. M. Larvæ of anopheline mosquitoes with full description of those of Indian species. Ind. Med. Res. Mem. No. 21 (1931), *Plates VII and IX*.

¹⁰ CHRISTOPHERS, S. R. Fauna of British India. Diptera. Family Culicidæ. Tribe Anophelini. 4 (1933) p. 39, *Fig. 10*; and p. 43, *Fig. 11*.

¹¹ BARRAUD, P. J. Fauna of British India. Diptera. Family Culicidæ. Tribes Megarhinini and Culicini 5 (1934) 36, *Fig. 9g*.

paper, we follow the sequence of numbers according to the arrangement of hairs displayed on the pro- and mesothoraces; i. e., outwardly and somewhat upwardly from 1 to 4, and downwardly to 5.

Contrast in hairs between Groups A and B of subgenus *Trip-teroides* is very marked. The majority or at least some of the main hairs in Group A are spines or spinelike, or else very long and stout but single; whereas the dominant hairs in group B are the large stellate tufts. Stellate tufts, when present in Group A, are not predominant, and are of different types from those of Group B. But apart from the major differences between the two groups, there are secondary dissimilarities between species in each group which indicate deviations from the main direction of hair development. For instance, in Group A the shortness of all the hairs, including the *lh* of the abdomen in two species, is about as remarkable as the absence of spines from the thoracic pleural hair groups in another two species, or the very thick abdominal hair 13 in still two other species; or the distinct differences in abdominal hair 1 which can be used to divide the group into three smaller units.

Division between Groups A and B, though recognizable by the general types of hairs composing the thoracic pleural groups, is not clear cut as regards the pleural spines. Such spines are present in all but two species of Group A, and absent in all but two species and three subspecies of Group B. The spines when present are very much thicker in Group A than in Group B.

Four kinds of deviations from the main direction of hair development may be recognized in Group B. Most notable is the presence of one or two spines on the prothoracic pleural plate. New species *m*¹² is unique in having its prothoracic hairs 9 and 10 modified into spines, and this is the only known species which has some of its hairs on the head, less so on the thorax and abdomen, conspicuously flattened. The *powelli* complex is also distinct. While in this the prothoracic hair No. 9 is long and branched as usual for Group B, No. 10 is transformed into a slender spine—similar to a branch of a large stellate tuft though somewhat longer and thicker. A very wide range in number of branches of the stellate tufts is shown by the

¹² The new species and subspecies, of which there are twenty one will be named and described in subsequent papers. Here these are referred to merely by letters.

powelli complex. The higher number of branches seems associated with dark larvæ, while the low counts occur among pale individuals. The third type of deviation is represented in new species *j*. It has its prothoracic hair 1 on its own plate separate and some distance away from that which bears 2 and 3. Its Nos. 5 and 6 are branched into two or more; the meso- and the meta-hair 1 are not stellate but tiny with two or more branches, sometimes single; while its meso-13 differs from those of all the others in being long and single. Its abdominal hair 12 is also unusually long and prominent. The fourth type which embraces the majority of Group B (perhaps best represented by *dyari*), does not have any spine on the thoracic pleural plates, no hairs are distinctly flattened, and the variation in number of branches in the stellate tufts does not seem as wide as in the *powelli* complex.

The larva of the only known species of *Rachisoura* in the Philippines has its own pattern of hair development; is quite easily separable from those of subgenus *Tripteroides*, and differs markedly from known larvæ of Australasian *Rachisoura*. Its adult is different from all known *Rachisoura* in being ornate.

The head.—Assuming, as commonly accepted, that the arrangement of hairs in *Anopheles* is the most primitive and therefore the most “fixed,” the changes in position of hairs among culicines may be better understood from a comparison with anophelines. Thus compared, it becomes evident that the differences between the hairs on the head of an anopheline and a *Tripteroides* larva are more in types and arrangement rather than in actual number. For while an *Anopheles* has twenty one pairs on the head, a *Tripteroides* has nineteen. Only the post-clypeal or No. 4, and that which arises near the apex of the maxillary palp or No. 16 are not represented in *Tripteroides*.

On the pre-clypeal plate of an anopheline larva are located only two pairs of hairs—the inner pre-clypeal or No. 1, and the outer pre-clypeal which is not given any numeral designation by authors probably because it is not used in classification. There are constantly four pairs on the pre-clypeal plate in Group A *Tripteroides*, but there may be four, three and a half, or three pairs in Group B. This is because in Group B the innermost pair is variable in position, one or both members of the pair being on the fronto-clypeal plate in some species. Regardless, however, of the instability in

position of certain hairs, the pre- and fronto-clypeal plates together bear a total of eight pairs of hairs in all known Philippine *Tripteroides*; nine in *Anopheles*. Hence, actually only one pair is missing from *Tripteroides*. Because of the evidence of movement or tendency to move indicated by the innermost pair, it seems probable that other hairs have also moved, but have become fixed in their new positions. Fronto-clypeal hairs *A*, *B* and *C* of culicines, which authorities regard as the equivalents of the frontal hairs in anophelines, are good examples of those which have assumed different fixed positions. From this, it seems reasonable to consider two of the pairs on the pre-clypeus of *Tripteroides* represent two of the clypeal hairs in *Anopheles*.

The thick preclypeal spines apparently correspond to No. 1 hair in *Anopheles*. The long, slender pair directly inner to the preclypeal spines in Group A, but variably located above or posterior, though also internal, to the spines in Group B, appears to be the equivalent of the inner clypeal hairs or No. 2. Some distance posterior to the preclypeal spines, very close to the dividing line between the pre- and fronto-clypeal plates are two tiny pairs. Very often they are not visible because of the dark background specially when the feeding brushes are infolded, and because they are tiny and closely appressed (bent downwardly) to the preclypeal plate. The outer of these two seems to be the equivalent of the outer preclypeal in *Anopheles*, more so because of its similar position, and in two species it is flattened like those in many anophelines. The inner pair seems to be the representative of the outer clypeal hair (or No. 3) of *Anopheles*. If considered independently of anopheline notations, the innermost pair should be designated No. 1; the preclypeal spines, No. 2; the inner of the tiny pairs, No. 3; and the outer (outermost of the four pairs), No. 4. But if homology or apparent homology is given primary consideration as it should be, the preclypeal spines should be No. 1, the innermost pair No. 2; No. 3 should be as it is; and No. 4 may be left as such, for the sake of convenience, since it does not seem to represent the post-clypeal or No. 4 of anophelines.

While hair *A* of the fronto-clypeus is fairly fixed in position in all culicines we have examined, *B* and *C* are not. Among those species which have these three hairs in straight line, or where the line is not very badly broken, it is not difficult

to determine their correlation with the frontal hairs of *Anopheles*. But where one pair is very much forward or far behind in position, the usual method followed by authors is to regard the most anterior pair as *B*, regardless of whether this is internal or external to *C*. This seems erroneous when the most anterior pair is also the most internal, because (in *Tripterooides* at least) the movement of (clypeal) hairs seems forward (or backward) instead of inward or outward, although certain hairs (the sutural) manifest both types of movements. The great majority among known species of Philippine *Tripterooides* have the most anterior frontal pair also the most internal; in one or two this is directly anterior to what in the usual method will be considered *C*. We propose, therefore, to regard the most external pair as *A*; the most internal (in the majority of species) as *C*, and the remaining pair, wherever it may be, as *B*; or No. 5 for *C* (most internal), No. 6 for the next or *B*, and No. 7 for the most external or *A*. No. 5 arises at the very (anterior) border of the fronto-clypeal plate in some species of Group A; a little behind that point in others. It is single in some, branched in others. Group B differs in having hair 5 much more posteriorly located. No. 6, is more or less at the same level with 7 in Group A, usually more posterior in Group B. This is fairly long, slender, single in all species except in n. sp. *j*. Hair 8 or the sutural or *e* of authors is much more anterior and internal in position in Group A than in Group B; it is even internal though posterior to 6 in n. sp. *b*. It is shorter than the other fronto-clypeal hairs, and branched except in two species.

Hairs on the epicranial plate.—The trans-sutural, or No. 9, is similarly located as in anophelines. This is rather weak and usually branched, non-diagnostic. No. 12, or the sub-antennal, hair is more posteriorly located, branched in all species, but very short in Group A; fairly large tuft in Group B. The sub-basal or post-mandibular hair (No. 13) is more ventral, often at the same level with 12. It is usually single, distinctly flattened in new species, *m*. The orbital (No. 14) is laterally placed as in anophelines, weak, non-diagnostic. No. 15, or the infra-orbital, is farther forward, sometimes a little away from the anterior margin of the imaginal eye. These two hairs are seldom useful in classification. The post-maxillary hair (No. 18) is very weak, single or split into two or more branches in Group A, but fairly long in *microcala* and

nepenthicola, these two having 13 and 15 stronger than in other species of the group. On most species of Group B hair 18 is closer to the mentum in position. This is weak or moderately large, but very large in two of the undescribed species, *m* and *n*, where it constitutes the most developed hair on the head. The submental or hair No. 20 in Group A is at approximately the same location as that of anophelines but it is very much posterior, close to the rim of the epicranial plate in Group B. It is branched in all species, weak in Group A, slightly more developed in Group B.

Other hairs on the head.—No. 10, or that at the tip of the antenna, is moderately long and stout, single. No. 11, or the shaft hair, arises not far from the apex of the antenna, fairly long or moderately short, single. The hair which springs from the basal piece of the maxilla, or No. 17, is weak, single or branched in Group A; a fairly stout though small tuft in most species of Group B. This hair frequently appears as if it arises from the base of the maxillary palp because the suture dividing the basal piece from the palp is often not well defined. Hair 19 is fairly long, stout, usually single in both groups; it is the strongest ventral hair in some species of Group A. The hair which arises near the apex of the maxillary palp, or No. 16, is not present in *Tripteroides*.

The thorax.—There are fifteen pairs of hairs on the prothorax of *Tripteroides* larva, which conform closely in arrangement to those of *Anopheles* and may similarly be numbered from 0 to 14. Only fourteen pairs are on the mesothorax and thirteen on the metathorax. No. 13 is very weak or absent on the mesothorax of two species in Group A, but No. 14 is present as usual.

Between Groups A and B, the contrast in hairs of the thorax is about equal to that of the abdomen, and certainly more marked than that of the head. While the tendency of the main thoracic hairs of Group A is to become thick spines, or spine-like with a few branches, or else very long and stout, but single, those of Group B tend to become large stellate tufts with many branches. The branches usually vary from about ten to over thirty, of fairly uniform lengths. When large stellate hairs are present in Group A, the branches are usually markedly different in lengths, more stout, taper distinctly from about the middle to the tip, the apex being blunt or jagged,

coarse. The branches of the stellate tufts in Group B are more slender, hardly taper toward the apex except of those like No. 3 of the prothorax which end in finely drawn points. More often, however, as in the majority of the tufts, the branches terminate into a single or double or triple fairly coarse non-divergent points. Fraying or barbs are usual in all the principal hairs or spines of both groups. Nos. 0, 3, 4, 5, 7, 13, and 14 of the prothorax, Nos. 1, 8, 13, and 14 of the mesothorax, and Nos. 1 and 13 of the metathorax are large stellate tufts in Group B, but are either spines, spinelike, tiny or very long and prominent in Group A. No. 7 of the meso- and metathorax are thick spines of varying lengths according to species, but that on the metathorax is normally split into two or more coarse points in Group B; constantly single in Group A. Two new species of Group B have the mesothoracic spine (hair 7) rather weak, often branched, its small tubercle, unlike those of all other species, not fused with the plate of No. 6. On the other hand, the mesospine of new species *d* is quite long but not very thick, nearly like a thick normal hair. All but one species of Group A have No. 10 (of the pleural group) on the pro- and meso-thoraces modified into thick short single spines; in two species Nos. 9, 10 and 12 of the three thoracic segments are reduced to short thick spines. But new species *d* and *g* (Group A) have No. 10 long and normal. Except in new species *m*, Group B has No. 9 long and branched on the three thoracic segments; No. 10, outside of the *powelli* complex, *dvari*, and two new species, is about as long as 9 but single on all segments. No. 12 is similar to 10 though usually longer on the pro- and mesothorax, but always more slender and very much shorter on the metathorax. Prothoracic hairs 9 and 10 of an undescribed species *m*, are spines of moderate lengths and thickness, 10 somewhat exceeding 9 in both respects. These are single but comparatively much less stout than the pleural spines in Group A. These are among the most marked departures from the general direction of hair development in Group B, which are equalled by the absence of spines from the thoracic pleural hair groups in two species of Group A.

Prothoracic hairs 1 to 3, otherwise known as the shoulder hairs, arise from a single common plate in nearly all species of both groups. The same is true with 5 to 7. Exceptions to these are distinctive specifically. Such as in new species *j* where hair No. 1 is on its own plate separate and some distance away from

that which bears 2 and 3; and in an undescribed species, *e*, which has its hairs 1 to 7, sometimes 0 to 7, on a common conspicuous plate. Two species of Group A have pro-13 and 14 on a single plate. Sometimes hair 4 in an undescribed species, *d*, has the tubercle attached to the plate from which 5 to 7 spring.

On the mesothorax only the plates of 6 and 7 are fused; but in an undescribed species *j*, these are on separate small tubercles. Again this species is unique in having meso-13 non-stellate, i. e., long and single. Unlike that on the pro- or the metathorax, meso-6 is not internal to 7, but closely anterior or external to it.

Hair 6 also arises from the large tubercle bearing the spine, or No. 7, of the metathorax in all species of Group A, and in the only *Rachisoura* known locally. The point of attachment, however, in *Rachisoura* (undescribed species, *i*) is at the very base of the tubercle some distance from the base of the spine itself. In species where 6 is not so attached, it is also located close to this point.

THE INDIVIDUAL HAIRS

Hair O.—Found only on the prothorax, is a tiny tuft with from about six to over twenty branches, and situated close to the shoulder hairs in Group A; a large stellate tuft, though not quite as large as the other stellate hairs, situated more or less directly behind hair No. 4 in Group B.

No. 1.—Spinelike, variable in length according to species, single or split into two on the prothorax of Group A; either more or less like this on the meso- and meta-thoraces, or that on the mesothorax is very long, single, or as in new species *d*, this is a tiny tuft on both the meso- and meta-thoraces. In Group B, No. 1 is a large stellate tuft on all thoracic segments, the branches stiff, terminating in single, double or triple points, except in an undescribed species, *j*, which has No. 1 of the meso- and meta-thoraces slender, weak, split into two to about half a dozen branches, sometimes single.

No. 2.—Invariably single, slender on the prothorax in all species of both groups; about the same on the mesothorax, but branched on the metathorax (except in one species) of Group A; nearly the same on the meso- and meta-thoraces of Group B, though occasionally branched on metathorax.

No. 3.—In Group A single, shorter than 2 on the prothorax; longer, single or branched on the meso- and meta-thoraces.

This is stellate on the prothorax of Group B, often slightly larger than 1, and with the branches ending in fine-drawn single points; usually quite long but single on the mesothorax; also single but much shorter on the metathorax.

No. 4.—In Group A single, usually equal in rank to No. 2 on the prothorax, about the same on the mesothorax, a tiny tuft on the metathorax. In Group B a stellate tuft, like No. 1, on the prothorax, stellate but smaller on the metathorax, single, slender on the mesothorax.

No. 5.—In Group A either spinelike, similar to No. 1 or much longer, with fine-drawn tip on the prothorax; invariably long, single on the mesothorax; but tiny, single, branched on the metathorax. In Group B long, slender, single on the prothorax, similar but longer on the mesothorax, stellate tuft on the metathorax. The only exception is an undescribed species, *j*, which has its pro-hair 5 split into fairly stout branches.

No. 6.—In both groups slender, fairly long, single, on plate with, and internal to, 7 on the prothorax; closely anterior or slightly external to, and on plate with, 7 on the mesothorax; internal to and on plate with 7 on the metathorax in Group A, not on that plate in Group B except in one species. Again undescribed species *j* differs in having pro-6 as strong as, and slightly longer than, No. 5, and having two or more branches; while its meso-6 is on a plate separate from that of 7.

No. 7.—In Group A similar to 1 to 5 on the prothorax; thick single spine, varying in length according to species on the mesothorax; thicker, single, but may be longer or shorter than meso-7 on the metathorax. This is, in Group B, stellate on the prothorax; single, thick spine (though rather small and often branched in two new species) on the mesothorax; thicker, more or less curved toward the apex and usually with one or two shorter branches on the metathorax; the *powelli* complex often has three shorter branches on the metathoracic spine.

No. 8.—In Group A short with two or three relatively thick branches, or a fairly large tuft of six or more branches on the prothorax; invariably a tiny tuft on the meso- and metathoraces. In Group B stellate, as No. 1 on the prothorax, also stellate but smaller and with fewer branches on the meso- and metathoraces.

No. 9.—In Group A long, stout, single, frayed on all segments, except in these species which have this modified into very thick spine on one or more segments. In Group B long, branched,

frayed on all segments, except in new species *m* which has only its meta-9 branched, while its pro-9 is modified into a slender spine.

No. 10.—In Group A modified into very thick spine on the pro- and meso-thoraces, and in certain species also on the meta-thorax; but in two species long, single, similar to 9. In Group B this hair is more slender, single, either about as long as 9 or much shorter. The *powelli* complex, like new species *m*, has this reduced into a slender spine. This unusual peculiarity of the *powelli* complex has not been mentioned before by any of the workers who dealt with *powelli*.

No. 11.—Tiny, single or branched; comparatively larger and with more branches (when branches are present) in Group B than in Group A.

No. 12.—Single, usually longer than 10 on the pro- and meso-thoraces in both groups, but that on the metathorax much less in rank.

No. 13.—Most internal of the ventral hairs, variable. In Group A either fairly strong though short, single or branched, or a tiny tuft on the prothorax; tiny tuft with a few or many branches on the mesothorax (apparently absent in two species); very thick, branched spine on the metathorax of two species; fairly strong with a few to several branches in others. Stellate tuft on all segments of Group B, usually the largest on the thorax, particularly that on the metathorax. But undescribed species *j* is unusual since its meso-13 is a long, single hair.

No. 14.—In Group A, nearly always similar and equal in rank to No. 13 on the prothorax; tiny tuft with a few to many branches on the mesothorax; absent on the metathorax. In Group B this is stellate on the pro- and meso-thoraces, often larger than 13 on the pro-, lesser in rank on the meso-thorax; absent on the metathorax.

ABDOMEN

Arrangement of the dorsal abdominal hairs is closely similar to that of anophelines; the ventral differs slightly. While No. 10 is ventrally located in *Anopheles*, this is lateral, anterior to 8 in *Tripteroides*.

The principal abdominal hairs of Group A, that is, Nos. 1, 5, 6, 9 and 13 of I to VII, and 7 of I and II are usually either thick, spinelike or long, stout, but single. Nos. 1, 5 and 9 are

stellate or nearly so in three species but these are not of the same type as the stellate tufts of Group B. Hairs O, 1, 5, 8, 9, 13 and 14 are large stellate tufts in Group B.

Undescribed species *e* is unique because its abdominal hairs 6, 7, and 9, sometimes also 8, arise from a large common plate on segments I to V.

Marked changes in sizes or make-up of certain hairs on different segments occur in a few species of Group A. Generally, however, most of the principal hairs gradually decrease in size and length from the anterior to the posterior segments. This is equally true, though to a lesser degree, with the large stellate tufts in Group B.

The marked differences in certain hairs of Group A may be used to subdivide the species of the group into smaller units. Thus—

(A) Hair No. 1

- (a) About equal in rank, though relatively short on abdominal segments I–VII . . . undescribed species *b*, *c*, and *e*.
- (b) Very long on IV to VII, short or different on I–III or on II and III . . . undescribed species *a*, *d* and *g*.
- (c) Long on all segments . . . *microcala* and *nepenthicola*.

(B) Hair No. 9

- (a) A strong tuft with about ten to more than twenty branches on I to IV or I to V . . . undescribed species *d* and *g*, and *nepenthicola*.
- (b) Thick, single spine . . . undescribed species *c* and *e*.
- (c) Moderately thick, split into two or more branches . . . undescribed species *a* and *b*, and *microcala*.

(C) Hair No. 13.

- (a) Very thick but short, single or divided into two or more unequal thick points on I to IV or I to V . . . undescribed species *c* and *e*.
- (b) Being moderately strong, at least on segment I, branched . . . undescribed species *a*, *b*, *d* and *g*, and *microcala*, *nepenthicola*.

THE INDIVIDUAL HAIRS

Hair O.—Present on I or VII. Invariably tiny, sometimes wanting on some segments of *Anopheles*, but well developed, either thick or spinelike, or large stellate tuft in the majority of *Tripteroides*. It is, however, weak, though not as tiny as in anophelines, in undescribed species *c*, *d*, and *e* of Group A. All species of Group B have hair O large and stellate.

Hair 1.—Present on I to VIII. Variable in Group A, according to species, as well as on different segments of certain species. Large stellate tuft in Group B except in undescribed species *j* where this is rather weak compared with other tufts.

Hair 2.—Absent from some segments or some individuals of all species in Group A. Stellate, large, present on II to VII in Group B. Absent also in what appears to be an unusual kind of *Rachisoura*—newly found, and the only one yet known in the Philippines.

Hair 3.—On I to VIII. Tiny, single or branched; or a tiny tuft in both groups; slightly more developed in some species, or on certain segments than in others.

Hair 4.—On I to VII. Similar to 3, but often longer, in both groups.

Hair 5.—On I to VIII. Spinelike in most species of Group A; long like 6 in others; strong tuft in one; small tuft on I to III but long hair on IV to VIII in one species. Stellate in Group B.

Hair 6.—On I to VIII. Very long, single on I to VI in Group A, much reduced on VII, tiny tuft on VIII. Variable in Group B, but long on I to VII in most species; long only on I to VI in undescribed species *m* and *n*. With at least one of those on I to III split into two equal branches, rarely three. One or more of those on I to V are branched in some species, while some individuals have one or more of those on VI and VII split into branches.

Hair 7.—On I and II nearly as long as 6 with which it arises from a common plate; single in all species of Group A, sometimes branched into two or three in some species of Group B. Very much reduced and on separate plate of other segments, but relatively long in undescribed species *j*.

Hair 8.—On I to VII. Situated on lateral side of segment, anterior to 6 and posterior to 10. Tiny, single, or branched in Group A; much longer, stellate in Group B.

Hair 9.—On I to VIII. More or less similar to 5 according to species in Group A; invariably stellate like 1 to 5 in Group B. When this is stellate in Group A, the branches are markedly unequal in lengths, quite stout, each tapering appreciably from about middle to apex, and terminating into a coarse, jagged or clean-cut point. The branches of the large stellate tufts in Group B are not so unequal in lengths, hardly taper toward the apices, each ending in a single, double, or

triple points. Moreover, the branches are evenly spread (when in the natural position) into a complete circle, or semi-circle; unlike those of Group A which are spread less than 150° at most.

Hair 10.—On II to VII. Tiny, single or branched in both groups. Situated on the lateral side of the segment anterior to 8.

Hair 11.—On I to VII. Tiny, single, but longer than 10; that on VII often branched in both Groups A and B.

Hair 12.—On II to VII. Variable in position on different segments, usually anterior to 11 on II, external to 11 and close to the base of either hair 6 or 8 on other segments. Often single on the more anterior segments, and branched on the others. About the same in either group, except in undescribed species *j* of Group B in which this hair is unusually long.

Hair 13.—On I to VIII. The most anterior of the ventral hairs on segment I, being closer to the thorax than the most anterior dorsal hair, O; but becoming more and more posterior in position on each succeeding segment in Group A; relatively constant in location on different segments in Group B. Very variable in type in Group A as discussed above; large stellate tuft in Group B, being the largest hair on some segments.

Hair 14.—Not found in any species of Group A, or in the only known local *Rachisoura*. Large stellate tuft in Group B; the members of the pair very close to each other, except on VII, where they are widely apart; the pair arises very close to the posterior border of each segment.

Abdominal segment VIII bears only five pairs of hairs, the homology of which is extremely difficult to determine. More for convenience than from any definite reasons, these hairs are proposed to be regarded (starting from the most dorsal pair) Nos. 1, 5, 3, 6, and 13. No. 1 or the most dorsal pair is usually the largest on this segment, but it is a tiny tuft in undescribed species *d* and *e*. No. 5 is the second most dorsal, ranks usually second to No. 1 but longer and more stout where No. 1 is weak. No. 3 is usually a tiny tuft. No. 6 equals 5 in most species. No. 13 is on the underside of the segment below the most ventral comb tooth in Group A, but is on the lateral side immediately posterior to the more ventral comb teeth in Group B. This is strikingly different in undescribed species *j* where it is the largest hair (tuft) on VIII.

The hairs on the siphon and anal segment, like the comb-, pecten-, and saddle-teeth, show group and specific differences, but

these will be dealt with in subsequent papers on classification of *Tripteroides*.

SUMMARY

1. A complete new set of numeral hair designations for the pupa is proposed. This is based on the homology or apparent homology between the hairs of the pupa and those of the larva, such homology being fairly well indicated when the pupa is still in its original position inside the larval skin. The number proposed for each pupal seta is exactly the same as that of the larval hair to which it corresponds. The widely accepted numeral scheme for the hairs of anopheline larva is used and referred to here.

2. A discussion on the elimination, reduction, or increase in sizes, and changes in position of hairs during pupation is given. It is shown that only three of the nineteen pairs of hairs on the head of a *Tripteroides* larva, and only nine of the forty-two pairs on the thorax are represented on the cepalothorax of the pupa. According to this, we consider the postocular hairs as the only ones that remain of the hairs on the head of the larva; the anterothoracic as the representatives of the prothoracic larval hairs; the dorsal and supra-alar as the only two not eliminated from the mesothoracic larval hairs; while the meta-thoracic larval hairs are represented by the three metanotal setæ.

3. It is also shown that though the great majority of hairs undergo considerable reduction in sizes during pupation, some, like the superior postocular hair and the lateral tufts on abdominal segments VII and VIII, increase greatly in sizes. It is likewise indicated that a hair may still exist in the pupal stage even when already eliminated from the larval stage; just as a hair may not be represented in the pupal stage even when well developed in the larva.

4. Similarly, it is shown that the general similarities in arrangement of pupal hairs between different genera, subgenera, groups and species cannot, in some cases, be a guide to identify the different setæ. This is due to the varying positions of certain hairs in relation to each other. Moreover, the relative positions of some hairs are altered when the pupa is freed from the larval skin, and stretches to assume its normal shape. Abdominal hairs 3, 4, 6, and 8 are specially affected by the stretching of the pupa.

5. Differences in hairs on the head between the larva of an *Anopheles* and that of a *Tripteroides* are discussed and shown to be more in types and arrangement rather than in actual number. Only the post-clypeal hair or No. 4, and that which springs near the apex of the maxillary palp or No. 16 are not represented in *Tripteroides*. Changes in position of hairs are well indicated by the inner clypeal or No. 2 of Group B, subgenus *Tripteroides*. In two species it is located on the fronto-clypeus, but in all the others, including those of Group A, this springs from the pre-clypeal plate. Movement or instability in position of this hair is further indicated by individuals which have a member of the inner clypeal pair located on the pre-clypeal plate while the other member arises from the fronto-clypeal plate.

6. The usual method of regarding the most anterior of the frontal hairs in culicines as *B* seems erroneous for *Tripteroides* where this is not only the most anterior but also the most internal. In numeral designation this is No. 5 and should, therefore, be *C* instead of *B*. The hairs on the head are discussed individually.

7. The number and arrangement of hairs on the thorax and abdominal segments I to VII closely resemble those of anophelines. The differences displayed on segments VIII to X are obviously due to the differences in the development of these parts between an *Anopheles* and a *Tripteroides*. The different thoracic and abdominal hairs are discussed individually.

ILLUSTRATIONS

PLATE 1

- FIG. 1. *T. nitidoventer*. Right half, dorsal side of abdominal segments IV and V, showing larval hairs in solid lines, and pupal setæ *in situ* (dotted lines). a and b = tips of branches of the stellate tufts.
2. *T. microcala*. Left half, dorsal side of abdominal segments V, VI and VII, showing larval hairs in solid lines, and pupal setæ *in situ* (dotted lines).
 3. *T.* (undescribed) species *d*. Right half, dorsal side, abdominal segment I of larva, showing larval hairs in solid lines, and pupal setæ *in situ* (dotted lines).
 4. *T. monetifera*. Ventral side right half of head showing larval hairs in solid lines and pupal setæ *in situ* (dotted lines). Note the increase in size of pupal hair No. 14.
 5. *T. monetifera*. Right half, dorsal side of the thorax, showing the larval hairs in solid lines, and the pupal setæ *in situ* (dotted lines).
 6. Dorsal portions of two larval heads showing difference in position of hairs 2 and 5.
 - (a) left side, undescribed species *a* of Group A.
 - (b) right side—*Tripterooides nitidoventer* of Group B.

NOTE.—The different figures are not drawn in the same scale.

PLATE 2

- FIG. 1. Reproduced from Plate VII of Baisas, showing pupal hair notations slightly modified from the scheme of authors. Represents dorsal side, left half, of a *Culex* (*Culex*).
2. Reproduced from Plate IV of Rozeboom and Knight, showing the numerical pupal hair notations they introduced. Represents *Anopheles farauti*.

PLATE 3

- FIG. 1. *T. dyari* of Group B. Parts of a pupa showing the metanotal and abdominal hairs. Right half represents the dorsal side; left half, the ventral.
2. *T.* (undescribed) species *m*. Anterior portion of larva showing right half, dorsal hairs; left, half, ventral hairs. The dotted lines represent the visible pupal setæ. Insertion at left of head is an enlargement of part of pre- and fronto-cyepal plates.
 3. *T.* larva (undescribed) species *b*. Terminal part of abdomen (lateral view). *ct* = comb teeth; *pt* = pecten teeth; *st* = saddle teeth.
 4. Thorax of *Tripterooides* larva, undescribed species *b*. (Left half represents ventral side, right half dorsal side). Note shortness of all hairs.

PLATE 4

- FIG. 1. Comb teeth, saddle teeth and pecten teeth of undescribed species *m*.
2. Head of *Tripteroides* larva, undescribed species *b*. (Left half ventral side, right half, dorsal side).
3. *Tripteroides* undescribed species *m*. Posterior portion of larva showing right half, dorsal hairs; left half, ventral hairs. Segments VIII-X from lateral aspect. Dotted lines represent visible pupal setæ.
4. Abdominal segment IV of *Tripteroides* larva, undescribed species (Left half represents ventral side; right half, dorsal side).
Note.—shortness of all hairs. *st* = saddle teeth.

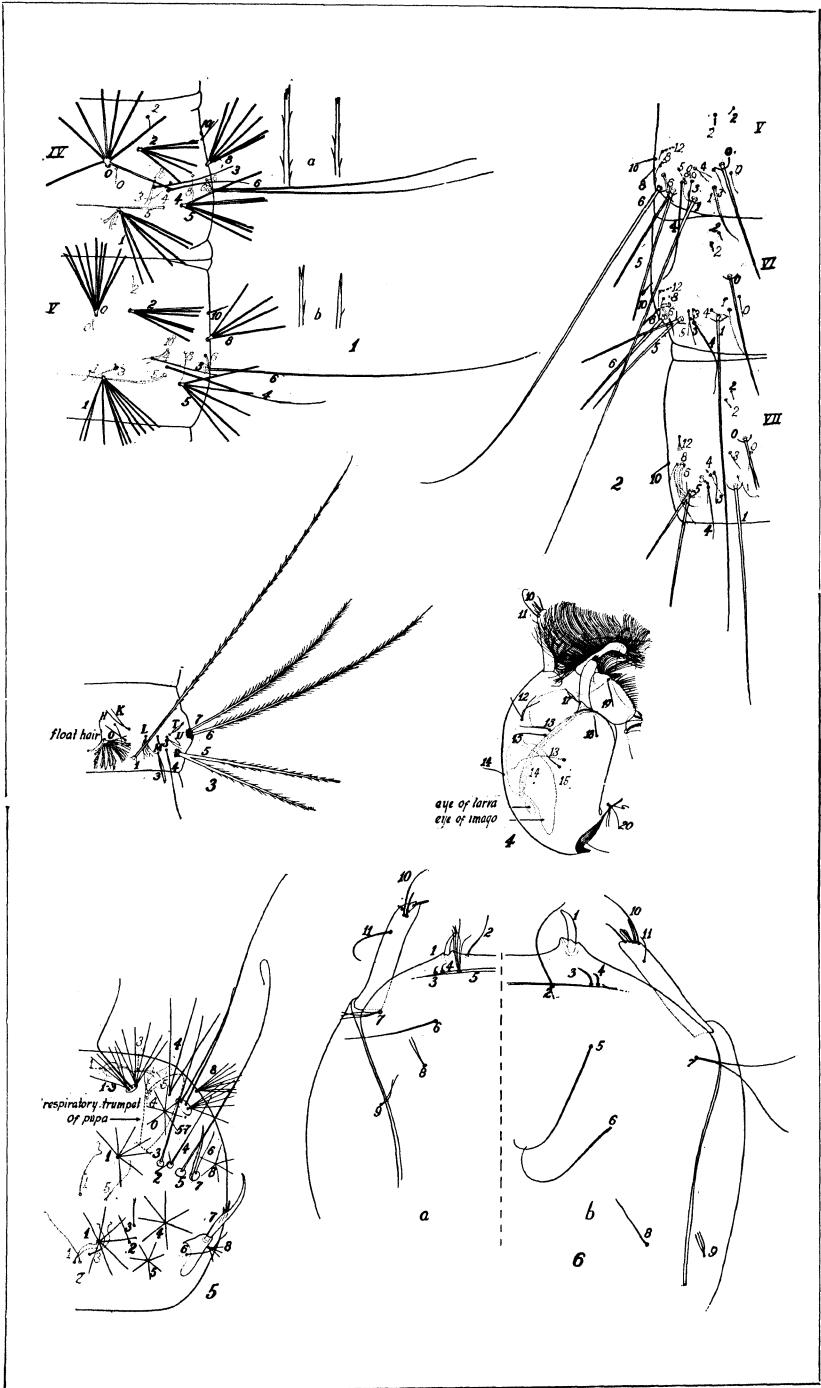


PLATE 1.

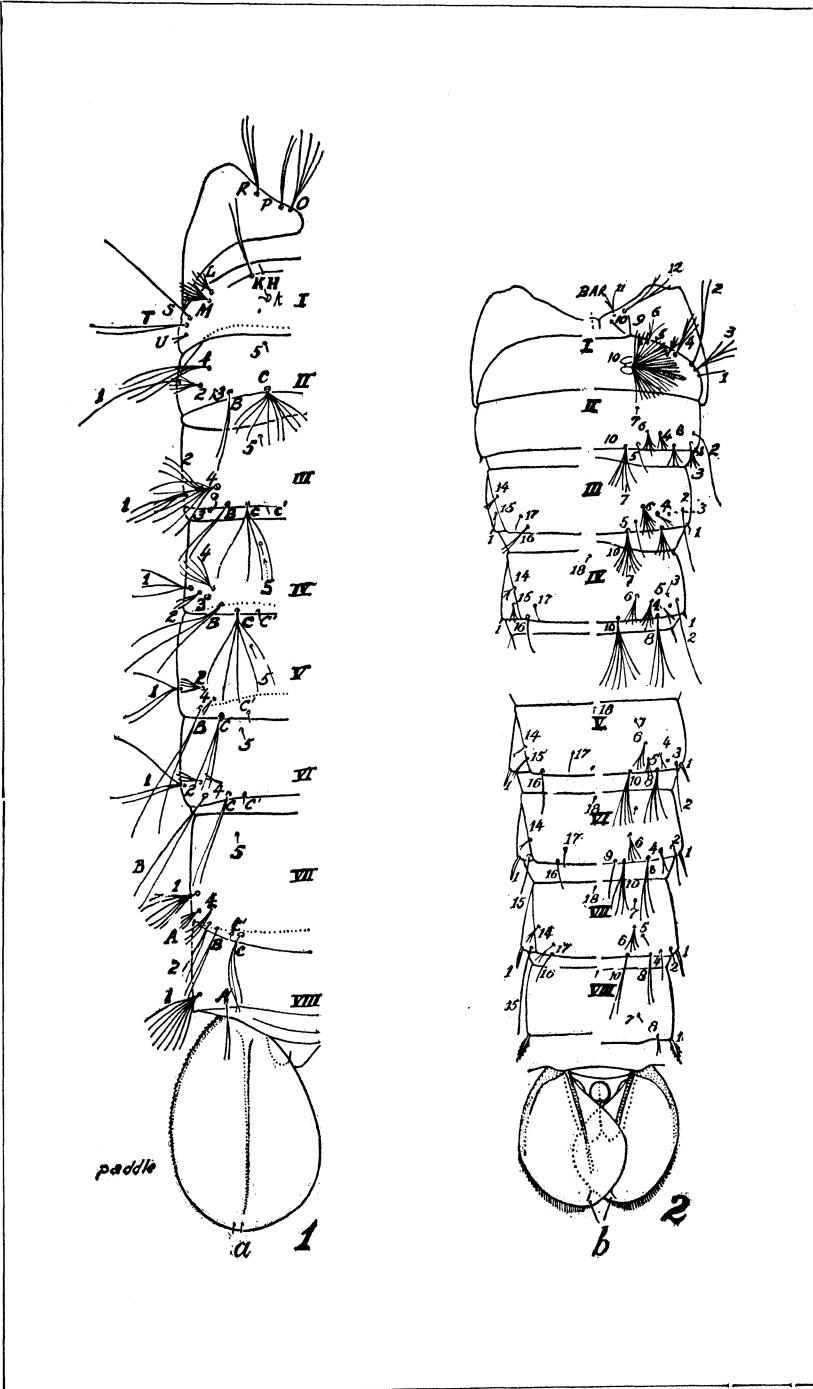


PLATE 2.

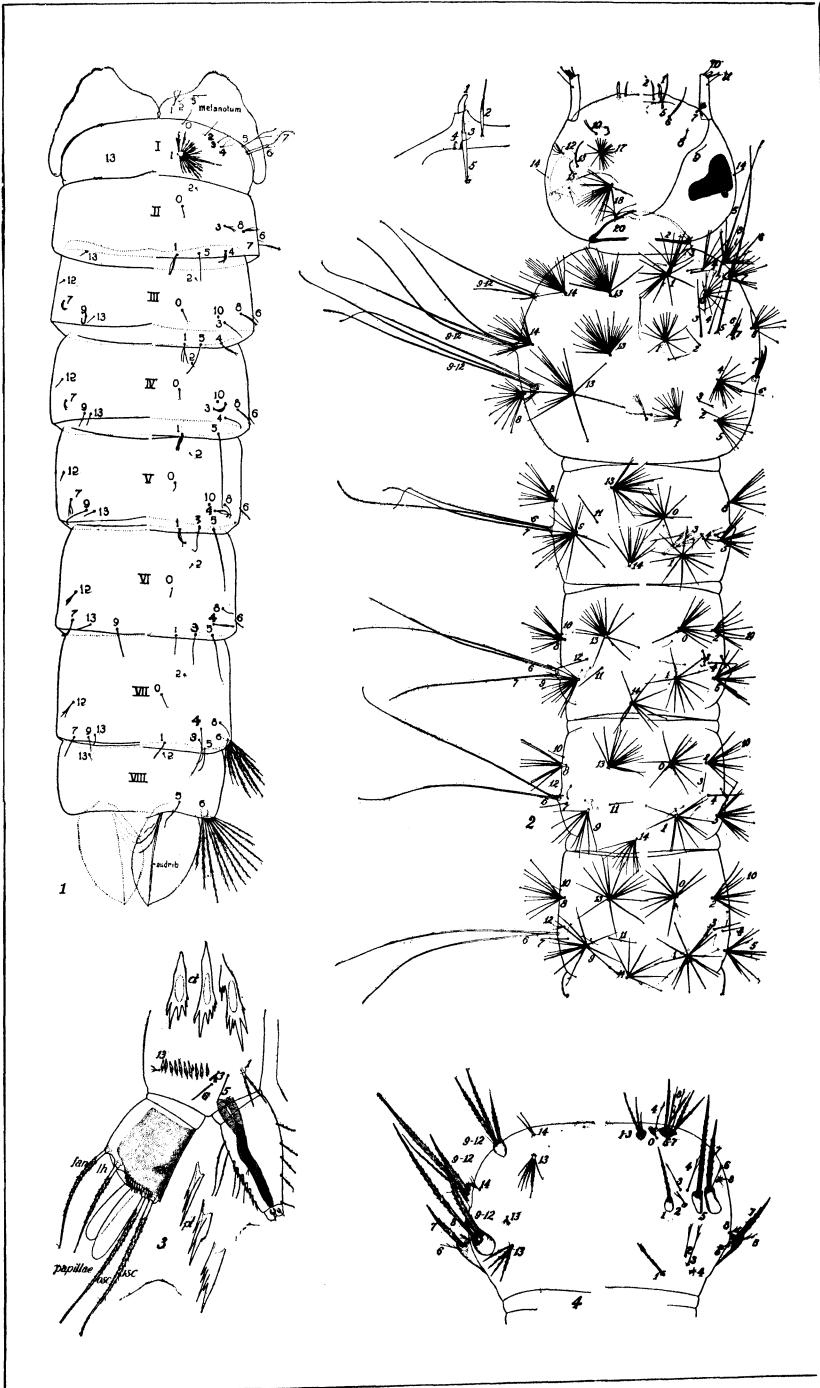


PLATE 3.

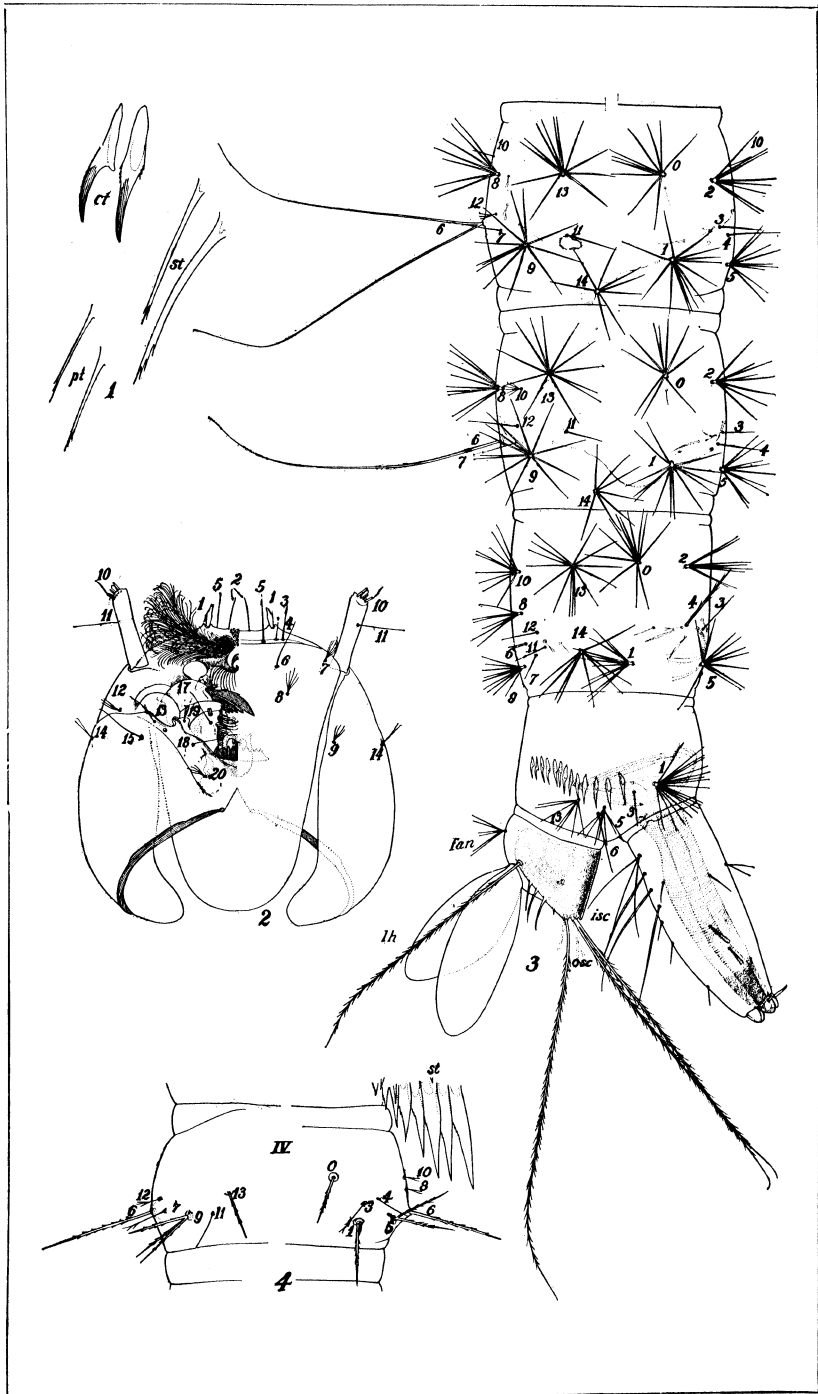


PLATE 4.

BLOOD-CHEMISTRY STUDIES IN LEPROSY III. TOTAL CALCIUM, DIFFUSIBLE AND NON-DIFFUSIBLE CALCIUM, ALBUMIN AND GLOBULIN ¹

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The study of calcium in leprosy, which in the past several years had attracted the attention of many leprosy investigators, has been centered chiefly on the question of whether or not in those afflicted with this disease a calcium deficiency exists. The interest in this study undoubtedly had its inception from the clinically manifested evidence of the occurrence of bone salts resorption in the hands and feet of the afflicted, especially in those of the advanced stage. The approach into the problem has been directed mainly to the determination of calcium balance and the total concentration of calcium in the whole blood or serum. However, as will be observed in the review given below, such methods only yielded variable results in the hands of the different workers. Further study of this important problem is deemed necessary.

BRIEF REVIEW OF LITERATURE

Underhill, Honej and Rogert ² reported that two leper subjects by the balance method, especially the more advanced, manifested a definite tendency to retain calcium. They interpreted this finding to indicate that in the organism a deficiency of this element exists. Along the same line, Boulay and Leger ³ obtained results on three cases which failed to confirm this observation of the aforementioned workers. They reported that the retention tendency was observed only in one and in the other two there was hyperexcretion. From the examination of eleven cases, Reyevski ⁴ reported the balance as positive but only in those whose leprosy remained stationary. This result, including that which he obtained from blood examination, suggested to him that "during the acute stage of the

¹ Published with the approval of the Director of Hospitals.

² Underhill, F. F., J. A., Honej, and L. J. Bogert. *Jour. Exp. Med.*, *32*, (1920), 41-63.

³ Bouley, A., and M. Leger, *Sec. Path. Exot.*, *15*, (1932), 865.

⁴ Reyevski, A. S. *Arch. f. Schiff-u Trop. Hyg.*, *34*, (1930), 651-57.

disease decalcification takes place, blood $[Ca]^{++}$ falls and $[K]^{+}$ rises.”

In the examination for total calcium content in whole blood, Concepcion and Salcedo⁵ reported their findings on 37 lepers as normal except in a few paroled cases where the calcium content showed a slight abnormal increase. Leman, Liles and Johansen,⁶ from the serum examination of 54 cases, failed to observe a deviation from normal in the serum content of this constituent. In similar examination of 47 cases, Wooley and Ross⁷ reported this also to be normal. Villela,⁸ on the other hand, from the serum analysis of 113 cases, claimed that 51 or about 45 per cent gave values that were abnormally low. He reported this abnormality to occur mostly in the neural type and not in those with lepra reaction. The study on 70 lepers by Cruz, Lara and Paras⁹, however, showed that it is in the great majority of those with reaction where the value was observed below normal. Only in the non-reacting did they find it to remain within normal range. These findings appear to have gained support from the works of Badenoch and Byron¹⁰ on 54 cases, and of Herrera¹¹ on 62 cases. In a study by Nishikawa¹² on 38 cases the serum level was reported to be slightly lower than normal. Otsuka and Yoshinaga¹³ reported it normal in the macular form and low in nodular, especially in the neural type.

CURRENT VIEW REGARDING THE STATES OF BLOOD CALCIUM¹⁴

To state briefly, the universally accepted concept today considers calcium as it exists in this body fluid to be constituted mainly of the diffusible and the non-diffusible form. The for-

⁵ Concepcion, I., and I. Salcedo. *Jour. Phil. Is. Med. Assoc.*, 6 (1926) 154.

⁶ Leman, I. I., R. T. Liles, and F. S. Johansen. *Am. Jour. Trop. Med., Baltimore*, 7 (1927) 61.

⁷ Wooley, J. S., and H. Ross. *U. S. Pub. Health Rpts.*, 46 (1931) 641.

⁸ Villela, G. G. *Int. Jour. Leprosy*, 6 (1938) 63.

⁹ Cruz, M., C. B. Lara, and E. M. Paras. *Jour. Phil. Is. Med. Assoc.*, 8 (1928) 216-221.

¹⁰ Badenoch, A. G., and F. E. Byron. *Trans. Roy. Soc. Trop. Med. Hyg.*, 26 (1932) 253.

¹¹ Herrera, R. M. *Siglo Med.*, 95 (1925) 394.

¹² Nishikawa, T. *La Lepre* 3 (1932) No. 2.

¹³ Otsuka, R., and T. Yoshinaga. *Trans. 10th Meet. Jap. Lep. Assoc., La Lepre*, 9 (1938) Suppl. 32.

¹⁴ For comprehensive review of various works on the subject, readers are referred to Schmidt, C. L. A., and D. M. Greenberg. *Physiol. Review*, 51 (1935) 297.

mer is regarded as practically all in an ionized state and is the fraction of physiologic and clinical importance, whereas the latter is looked upon as nearly all bound to proteins and believed to be biologically inert. These two fractions are said to account for most, if not all, of the concentration of total calcium in this body fluid.

It can be seen from this concept that the above-cited studies based on the estimation of total calcium content in blood are evidently devoid of clinical significance unless the protein concentration is also known. Further approach to the problem on the basis of this newer knowledge would thus appear to be of no little interest.

PREVIOUS STUDY BASED ON NEW CONCEPT

The examination of the diffusible and the non-diffusible calcium simultaneously with the albumin and globulin in the serum of lepers was attempted only by Wooley and Ross.⁷ From a study of 53 lepers, they reported the average for the diffusible and the albumin-globulin ratio as considerably low, increasing abnormally in the non-diffusible and the globulin. Only in a few instances did they find the level approximating the value for the control. Thus, they were led to the conclusion that "the clinically improving cases are accompanied with an increase in the diffusible and the albumin-globulin ratio and a decrease in the percentage of the globulin and the non-diffusible calcium."

The evidence obtained from the above study, particularly with regard to the diffusible, undoubtedly is significant and it is deemed necessary to have this field studied farther. It is with the ultimate objective to help supply the much needed information that the present work has been undertaken.

SUBJECTS

From our previous studies of the inmates of this Colony it was our observation that cases with complication of lepra reaction, especially the febrile type, are most readily susceptible to undergo abnormal changes in the concentration of their serum constituents. Accordingly, in the belief that they would make ideal subjects to meet the present objective, they were taken to constitute most of the cases. Thus, of the 19 selected, 12 were from this group, 3 were those without reaction but advanced, and 4 were also without reaction, but quiescent.

METHODS OF ANALYSIS

Blood of about 20 cc. was drawn from each patient for the analysis of various constituents. After having allowed the drawn blood to clot, the resulting sera were worked out at once. A portion of the serum was used for the determination of the total calcium, albumin and globulin and the rest was subjected to ultrafiltration for the analysis of the diffusible and the non-diffusible calcium. The procedure for ultrafiltration and the colorimetric analysis for albumin and globulin were carried out in detail according to the improved technique described by Greenberg and Gunther¹⁵. The ultrafiltrate was analyzed for the diffusible according to the gasometric method of Van Slyke and Sendroy¹⁶. Only those ultrafiltrate giving a negative biuret test were used. For the analysis of total calcium, the Tisdall modification¹⁷ of the Kramer-Tisdall method was employed. The value for the non-diffusible was obtained by subtracting the value obtained directly for the diffusible from that of total calcium.

RESULTS

The individual findings obtained in lepers are given in Table 1.

TABLE 1.—Results obtained in 19 cases of leprosy, showing partitions of serum calcium and proteins.

Case No.	Milligrams per 100 cc. serum			Grams per 100 cc. serum		Condition of leprosy
	Total calcium	Diffusible calcium	Non-diffusible calcium	Albumin	Globulin	
1----	8.60	4.27	3.80	2.54	6.17	With lepra reaction.
2----	9.20	6.00	3.20	2.91	5.55	Do.
3----	7.80	4.68	3.12	2.54	5.21	Do.
4----	8.80	5.40	3.40	3.45	3.78	Do.
5----	9.23	4.46	4.77	5.73	1.89	Do.
6----	9.23	5.90	3.33	4.13	2.54	Do.
7----	7.60	4.50	3.10	3.21	4.55	Do.
8----	8.22	5.96	2.96	2.78	5.05	Do.
9----	6.82	5.80	3.20	3.32	4.81	Do.
10----	8.45	5.96	2.49	2.54	4.71	Do.
11----	9.90	6.10	3.80	4.04	3.00	Do.
12----	9.92	5.03	4.89	4.53	3.38	Do.
13----	10.70	4.75	5.95	5.20	2.21	Clinically negative.
14----	10.80	4.90	5.40	4.73	2.74	Do.
15----	9.76	5.58	4.70	4.90	2.44	Do.
16----	9.90	5.17	4.78	4.08	3.52	Do.
17----	10.80	5.64	4.66	4.52	2.46	Advanced.
18----	9.79	5.64	4.15	4.42	2.22	Do.
19----	9.30	6.20	3.10	4.40	3.09	Do.

¹⁵ Greenberg, D. M. and L. Gunther. *Jour. Biol. Chem.*, 85 (1920-30) 491. Greenberg, D. M. *Jour. Biol. Chem.*, 82 (1929) 545.

¹⁶ Van Slyke, D. D., and J. Sendroy. *Proc. Sec. Exp. Biol. Med.*, 23 (1926) 167.

¹⁷ Tisdall, F. F. *Jour. Biol. Chem.*, 56 (1923) 439.

To facilitate comparison, the maximum and minimum limits and the average value taken for the control and those obtained for the three groups of leprous cases are arranged in Table 2.

TABLE 2.—Figures from Table 1 compared with control arranged to show only the minimum, maximum and the average.

Constituents	Control			Reaction cases		
	Min.	Max.	Ave.	Min.	Max.	Ave.
Total calcium.....	mg. 9.0	mg. 11.0	mg. 10.0	mg. 6.82	mg. 9.92	mg. 8.65
Diffusible calcium.....	4.2	6.8	4.96	4.27	6.1	5.33
Nondiffusible calcium.....	4.1	7.2	5.07	2.36	4.89	3.41
Albumin.....	g. 3.77	g. 5.24	g. 4.4	g. 2.54	g. 5.73	g. 3.34
Globulin.....	1.96	3.55	2.63	1.88	6.17	4.35

Constituents	Quiescent cases			Advanced cases		
	Min.	Max.	Ave.	Min.	Max.	Ave.
Total calcium.....	mg. 9.76	mg. 10.7	mg. 10.17	mg. 9.3	mg. 10.3	mg. 9.8
Diffusible calcium.....	4.75	5.58	5.10	5.64	6.2	5.83
Nondiffusible calcium.....	4.70	5.95	5.21	3.10	4.66	3.97
Albumin.....	g. 4.08	g. 5.2	g. 4.73	g. 4.4	g. 4.52	g. 4.45
Globulin.....	2.21	3.52	2.73	2.22	3.09	2.59

Total calcium.—An examination of the data compiled in the said tables will show that the serum level for total calcium suffers abnormal reduction only in lepra reaction group. This finds confirmation in the previous study of this constituent by us¹⁹. Of the 12 cases in this group, 7 or about 58 per cent show values that are definitely below normal. No appreciable difference in the average value can be noted between the different groups except in that with reaction where it is observed to be definitely below normal.

Diffusible calcium.—The serum level of this constituent, both in the reaction group and in the quiescent and the advanced, is, without exception, within the range of normal limits. Compared with the control, the average (Table 2) appears higher in the 3 groups of cases, the advanced having the highest, next the reaction group, and least the quiescent.

Non-diffusible calcium.—In the case of this constituent, the serum level in 10 out of 12 reaction cases (about 83 per cent) is subnormal, and only in 1 out of 3 cases (about 33 per cent) in the advanced group where it is found to be abnormally low. In the quiescent group, it is all well within normal range. The average, compared with the control, is practically

the same as that in the quiescent and appreciably low both in the advanced and the reaction groups.

Serum proteins.—The fate for the albumin in general appears to follow the same trend as in the case for total calcium, that is, abnormal reduction only in cases with lepra reaction complication, otherwise normal. Of the 12 cases in this group, 10 or about 83 per cent, show values that are definitely subnormal. The average in this group is markedly low, but in the other two groups it does not appear to differ appreciably from the normal. In the case of the globulin, its serum level is raised markedly above normal in 9 of 12 cases (75 per cent) in the reaction group and practically normal in the quiescent and advanced groups. The average value is definitely above normal in the group with reaction and practically normal in the other two groups.

DISCUSSION

Before discussing the results just presented it may be well to touch first upon those evidences which have given rise to the contention of the existence of a deficiency in calcium in this disease. These are: (a) the finding of Underhill and his associates,² based on calcium balance measurement, of a definite tendency of the organism to retain this element, with the apparent support it gained from the work of Reyevski;⁴ (b) the abnormal reduction in the serum total calcium level^{8, 9, 10, 11, 12, 13}; and (c) the low finding in the serum diffusible.⁷ As regards the first, it should be realized that the various data reported in this study, besides the fact that they lack complete accord and are in conflict with that obtained by Boulay and Leger,³ are only based on two cases. It should further be reckoned that the application of the balance method to the investigation of human subjects, especially in diseased conditions, could not likely yield decisive results, even if it is carried out with the most scrupulous care, because of the complicating factors involved. The situation in the case of that revealed from total calcium examination is still less convincing because on the basis of the newer knowledge, the claims cited, besides being also variable and quite in conflict with those of others,^{5, 6, 7} could not have clinical meaning unless the serum protein concentration is also known.

Coming now to the diffusible, the present study, as seen from the results just presented, failed to confirm the low

finding reported by Wooley and Ross for this constituent. As already pointed out, not a case of the nineteen patients subjected to the analysis, irrespective of the presence of major complication like lepra reaction and the advancement of the disease itself, was its level found to have undergone abnormal lowering. But this disagreement, as will be noted, is more apparent than real and in fact their finding for this constituent can serve, instead, to establish the results obtained in this work. Thus, if on re-examining the data of the aforementioned workers the low normal limit of 4.2 for the diffusible is used instead of the 5.5 which the said workers took for this purpose, 43 or 81 per cent of the 53 cases whom they subjected to the examination will be found to have values that fall well within the range of normal, and only in 10 or 19 per cent where this drops below normal. But even in these cases, 5 will be seen to approximate closely the limit of normal and only 3 would be in the zone which, according to the experience of other investigators, could only be compatible with the existence of tetany that is caused by parathyroid insufficiency. Whether the marked abnormality in these latter cases is caused by the existence of an actual calcium deficiency or due to faulty methods in the analysis, this paper will not attempt to discuss. It may seem pertinent, however, to mention that in the absence of tetany, low values could result from a poorly prepared membrane that has been utilized in the ultrafiltration or compensation dialysis and from a membrane that has been badly impregnated through repeated use. Which of the two limits just considered could justifiably represent the actual or at least approaching the true value is of course of importance to determine. For this matter, we can only state for the present that we find justification in the adoption of 4.2 from the consideration of the following: (a) our previous survey on serum total calcium and serum proteins of those residing in this Colony yielded values which revealed to be quite comparable with those reported in the literature, thus showing that climatic factor, etc., do not have any appreciable influence, if at all, upon the concentration of these constituents. It does not seem likely, therefore, that the diffusible low level would also deviate appreciably, if at all, from this value; (b) it represented a much larger series of different groups of normal individuals than that in the value taken by Wooley and Ross. In the latter the normal individuals that it represented can be said to be composed of practically one class of such individuals whose standard of

living, etc. are above average; (c) it is the widely accepted value among investigators; and (d) it is in accord with that obtained from any dialysis experiments by various investigators and from that obtained by the use of direct biologic method.

It could be seen plainly from the above that there was no valid reasons to consider this serum constituent to be deficient in this disease as Wooley and Ross would lead us to believe. Theoretical considerations of the mechanism that is involved in the equilibrium relationship between calcium and proteins, which the recent studies of McLean and Hastings¹⁸ have proved to exist in this body fluid, would seem to provide means by which this contention could find further support. To facilitate discussion on this point let us for the moment touch briefly upon this mechanism. From the works of the above-cited investigators it appears that the calcium ions, protein ions and the calcium salts of proteins, behave as if there was equilibrium between them; that this behavior appeared to obey mass action law and could be expressed by the equation

$$\frac{[\text{Ca}]^{++} \times [\text{Protein}]^{\text{=}}}{[\text{Ca Proteinate}]} = K \quad (1)$$

in which K varies with the pH of the normal serum. Now, on the basis of the conditions by which the constituents under consideration in this study are known to exist, the application of the above equation would justify limiting the determining factors for the equilibrium, mainly, to the diffusible calcium, the non-diffusible calcium and the albumin. The equation, accordingly, could evidently be represented by

$$\frac{[\text{Diffusible Ca}]^{++} \times [\text{Albumin}]^{\text{=}}}{[\text{Non-diffusible Ca}] \text{ (Ca-albuminate)}} = K \quad (2)$$

As may be seen then from this latter equation,¹⁹ in calcium deficiency, mass action law would have us expect the level of both the diffusible and the non-diffusible to come down low. But as

¹⁸ McLean, F. C., and A. B. Hastings. *Jour. Biol. Chem.*, 108 (1935) 285.

¹⁹ The present data could not be treated strictly quantitatively, in the first place because they are not expressed in molecular concentrations which is a requirement of the expression, and secondly, they are believed to approximate only the conditions. Necessarily, therefore, they can at best be discussed qualitatively and this is believed sufficient to meet the purpose of this study.

the results show, while the non-diffusible actually suffered abnormal reduction in accordance with this expectation, the diffusible level failed to have undergone similar fate. It can thus be seen that the contention in the existence of such a deficiency can neither, on this basis, be satisfactorily explained. Neither could the data of Wooley and Ross be, because, even granting for the sake of argument, that their finding for the diffusible was really low, the non-diffusible, which should also be low as expected to be found in conditions where there is such deficiency was shown, instead, to be increased abnormally.

Now, to view the results from another angle, equation 2 can be seen to help explain satisfactorily the fall in the level of the albumin as the one accountable for the reduction that occurs in the non-diffusible. The results obtained in this study appears to help affirm this assumption. Assuming this to be the case it becomes quite plain that the low results obtained in the total calcium could be due to the fate that befell the non-diffusible, the diffusible having shown to have not undergone abnormal lowering. As for the increase in the globulin, it may be surmised that this probably, considering the well-known functional value of this constituent in the body defense mechanism, is a product elaborated at the expense of the albumin in an effort to overcome the ill-effects caused by the lepra reaction attack and such other causes.

As can be noted from the discussion the reference to the equation was practically limited in explaining the deficiencies. While it may not be entirely out of the scope of the present work, it is thought worthwhile considering also the fact that from the equations given, by increasing the total concentration of protein, the reaction trend would be toward increasing the concentration of the constituents that suffered deficiencies and this tendency will continue to be so with increase of supply of the required substance until the dissociation constant of the equilibrium has been restored to its original state. It thus appears quite suggestive that protein therapy or adequate protein diet, or both, may prove beneficial in the treatment of lepra reaction cases where the above-cited deficiencies are found to occur mostly. It may be pointed out that calcium drug may have similar effect in the matter of restoring the equilibrium dissociation constant by elevating the level of the non-diffusible and may therefore also prove beneficial. As a

matter of fact the experience²⁰ in this Colony has shown this to have really appreciable ameliorating effect in the treatment of the reacting cases. However, as already discussed above, the focus of disturbance is not in the calcium but in the protein component system and for this fact protein may prove to be more effective.

SUMMARY AND CONCLUSION

The present investigation involving analysis of the serum for its content of total calcium, diffusible calcium, non-diffusible calcium, albumin and globulin in nineteen lepers has been undertaken with a view to help solve the long controversial question of whether or not calcium deficiency exists in leprosy.

The inadequacy of the data compiled from previous studies of the earlier investigators based on the determination of calcium balance and of the concentration of total calcium in the whole blood or serum was discussed.

In this study the presence of major intercurrent diseases, like lepra reaction and the advancement of the disease itself, was shown to have no appreciable influence, if at all, upon the normal level of the diffusible. The low results observed by Wooley and Ross for this constituent were shown to be more apparent than real and that they rather serve, instead, to establish the finding reported in this study.

The great majority of the cases with lepra reaction revealed a general abnormal lowering in the serum level of total calcium, non-diffusible calcium and the albumin and an abnormal shift above normal of the globulin. The non-reacting cases failed to show appreciable abnormal alterations, if at all, in these constituents. The explanation for the conditions found in the reaction was given on the basis of an equilibrium relationship assumed to exist in this body fluid between calcium and proteins.

From the consideration of the facts given in the above discussions, the writer is led to conclude that in leprosy there is no deficiency of calcium, at least in so far as the serum physiologic calcium that is measurable in terms of the diffusible is concerned. The abnormal rise in the level of the globulin

²⁰ Roxas-Pineda, E., C. Nicolas and C. B. Lara. *Jour. Phil. Is. Med. Assoc.* (1928), 207.

is believed to be at the expense of the albumin which causes its fall to below normal and this effect upon the latter in turn causes the lowering in the non-diffusible and in the total calcium.

Protein therapy is suggested as worth giving a trial in the treatment of leprosy cases suffering from lepra reaction attack, especially in those manifesting low albumin in the serum.

PHILIPPINE SOLAR SALT INDUSTRY

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Salt production through the solar process has, perhaps, been practiced for centuries in the Philippines and has, through the years, gone through considerable evolution towards more efficient methods in many of the producing provinces. The methods now in use, however, are not as efficient nor are they as productive of a pure salt as the solar salt producing methods practiced in some other parts of the world.

Cox et al (1915), Ablan et al (1940), Montalban (1930), Seale (1914), and Herre et al (1920) all refer to the fact that the poor quality of the locally produced salt has a deleterious effect on the fish preserved with it. Tressler (1920) has shown that calcium, magnesium and sulfates as impurities in salt retard the penetration of salt into fish during curing. Dunn (1946) has shown that herring fillets are struck through sooner during brining if the salt is pure. Hess (1942) has shown that impurities in salt affect the keeping quality of cod press juice. Shelf life of salt fish may, therefore, be extended by the use of pure salt. Tressler (1923) and Phalen (1917) point out that salt for many industrial purposes must be of high purity. Table 1 gives the results of some analyses of local and foreign salts. This table illustrates that the local salt is not as pure as solar salt produced in other areas and suggests that salt of equal quality could be produced here if some changes were made in the present practices.

TABLE 1.—*Analyses of samples of sea salt*

Radicals	Puerto Rican ¹	California ²	Bahaman ²	Manila
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Sand and insolubles	0.07	0.008	0.13	0.06
Sulfate (SO ₄)	0.97	0.021	1.72	4.07
Calcium (Ca)	0.50	0.025	0.45	0.40
Magnesium (Mg)	0.04	0.000	0.47	1.48
Sodium chloride (Cl) calculated	98.52	99.94	97.23	91.93
Chloride (Cl)	58.72	60.70	59.44	-----
Ferric oxide and alumina (Fe ₂ O ₃ and Al ₂ O ₃)	Traces	-----	-----	-----

¹ Produced by a modified improved Oriental process. This salt had not been washed.

² From Tressler, A. K. Bureau of Fish Doc. 884 (1920).

Local methods.—In the solar salt process the first requirements are a hot sun, preferably brisk breezes of low humidity, and large areas of impermeable land near the sea. These requirements are found in several provinces in the Philippines but the industry is for the most part located in Rizal, Bulacan, Cavite, Bataan, and Batangas provinces. In these provinces, the so-called, improved Oriental process is practiced. In this process, as employed in the Philippines, areas used as fish ponds in the wet season are used to produce salt during the dry months.

Most of the fish pond area is employed for concentration ponds where the seawater, 10 to 20 centimeters deep, is evaporated down to a more or less saturated solution. Usually, for ease in operation, this is done in three or more separate ponds. The raw seawater may be evaporated in the first pond from 3.5°Be to 4.5°Be, in the second to 6°Be, in the third to 8°Be, and in the fourth to about 12 to 15°Be. In the concentrating ponds, the sediment settles, and the iron sulfide, calcium carbonate and some of the calcium sulfate are deposited. This brine, at about 15°Be, is then dipped with buckets into crystallizing ponds where it is evaporated almost to dryness and the salt recovered. These latter ponds are about 5 meters by 7 meters equipped with board sides and tile bottoms, and usually represent from 1/10 to 1/15 of the entire area at the salt works.

Everyday, during the season, the ponds are filled to a depth of about 1 cm. and late in the afternoon after each day of evaporation the salt is raked into a pile on the side of the crystallization bed and the pond refilled. This process is continued throughout the season, without any change, until the brine level builds up with a heavy brine containing a large percentage of the magnesium salts. When this happens, the salt producer will probably let the pond go for a day or more without adding fresh brine, and will then, after harvesting the salt, splash out of the pond the remainder of the brine. Owing to the high magnesium content, this method of handling produces a most inferior product. It is even possible at times to find crystals of pure magnesium sulfate intermixed with the salt. As explained above, it is the common practice of the salt producers in the Manila area to fill the crystallization beds with brine of 12 to 17°Be which is the point at which calcium sulfate begins to precipitate, and thus practically all the calcium sulfate is found

in the final product as an impurity. Further, it may be noted that the practice of using an unsaturated brine in the crystallizers results in a lower yield since a portion of each day is spent in evaporating the brine to a point where salt will begin to form at 25°Be.

A great part of the salt produced is sold as it is harvested, but a considerable portion is stored, both by speculators and producers, in the hope that there will be a better market during the non-producing season. During the period of storage, up to twenty per cent of the weight of the salt is lost owing to the moisture being absorbed from the air in such quantities that the piles of salt, literally, drip. This loss could be lessened by producing a purer salt which would have a lower percentage of the highly hygroscopic magnesium and calcium salts.

In the provinces of Ilocos Norte, Ilocos Sur, La Union, and Pangasinan, salt is prepared by the old Oriental leaching process. Their process is described by Tressler (1920). Ablan et al (1940) in an extensive field study of this process came to the general conclusion that this method of salt production was not economic and suggested, that in certain places, the improved Oriental process might be profitably introduced.

California practice.—The American salt making process in general is similar to the improved Oriental process but the details of the process vary greatly. The operations are conducted in various ponds. These are: (1) the storage or intake pond into which the salt water is received from the bay, (2) concentrating ponds, and (3) crystallizing ponds.

Some of the works have automatic gates which open when the tide is at flood and close when it begins to ebb. The salt water remains in the intake pond for various lengths of time, and is pumped into the concentrating ponds to a depth of 25 to 50 cm. before the next sea water is taken in. It then goes through the different ponds, becoming more concentrated, until it reaches the crystallizing ponds. It is run into these, when it reaches a strength of 25°Be, to a depth of 15 centimeters or more. This depth of brine causes the deposition of large crystals which, over the extended period of evaporation, grow into massive solid crystals of nearly pure salt. Here the brine evaporates until it has reached a density of 29°Be, at which time the bittern is either discarded or evaporated in other ponds to a density of 32°Be. This salt, formed from

the heavier bittern, is less pure. The process is repeated until the end of the season or until a thick enough bed of salt is obtained to make the harvesting economical.

The sea water is usually pumped from the intake pond to the concentrating ponds, through which it flows by gravity. The brine may then flow by gravity or be pumped into the crystalizing ponds, depending on the lay-out of the land.

All of the ponds have mud bottoms and often a split is made in the harvesting. That is, all the salt except the bottom 5 centimeters will be taken first and then the bottom part will be removed and used where a cheaper salt can serve. In the modern plants, machinery is now used to remove the salt from the beds. Often the harvested salt is washed with brine from the concentration ponds and with fresh water just after it is harvested. By this treatment some of the producers get salt of over 99.5 per cent sodium chloride content. It is possible to get a relatively pure product with this simple washing process because the crystals are large and solid. Impurities are only on the outside surfaces of the crystals and the mother liquor and washwaters drain free. Further, in the storage of the large solid crystals under conditions of high humidity, less salt is lost than when storing small crystals.

Experimental results.—Several experiments were conducted on a salt farm in Las Piñas, Rizal. The first experiment was designed to determine the effect on purity of salt obtained from brines of different densities. A bed 5 meters by 7 meters was filled to capacity, about 5 cm. in depth. No salt came down until the fourth day and on the 5th day rather large hollow hopper shaped crystals formed. Table 2 gives the analyses for magnesium in the various samples.

TABLE 2.—*Effect of brine density on magnesium content*

Days after filling	Brine density	Magnesium
	Per cent	Per cent
4.....	14
5.....	23.5
6.....	28	0.51
7.....	29.5	0.62
8.....	31.5	2.34
.....	39	8.09
Sample from control pond.....	31	0.82

This table illustrates how a somewhat greater purity can be obtained at the lower brine densities, but this reduction in

magnesium content is of too small a magnitude to be of any practical significance. This is because the standard practice under local production methods involving daily harvests results in the formation of relatively small hollow salt crystals. These crystals have a relatively high surface to volume ratio which retains a great deal of the impure mother liquor. Further they are of such shape that the mother liquor does not drain as freely as it would from large solid crystals. Simple washing experiments on these salts also failed because the purity could not be improved enough to make the washing practical.

The failure of the foregoing experiment in developing a method of producing a purer salt led to two series of experiments designed to illustrate how a greater operational efficiency could be achieved. In these experiments one crystallizing pond was filled with the brine at about 14° Be—the density at which it is usually added to the crystallizing pond. After it had evaporated to about 25° Be it was pumped into a second pond. In these experiments over a two week period an average daily production of 56 kilograms was realized from the experimental plot, whereas only 38 kilograms were harvested from the control plot. The control plot was operated exactly the same as the regular procedure for this particular salt works. This experiment indicates that for a given total area of salt works it should be possible to reduce the area of crystallization beds by about one third the present space devoted to such use and still obtain the same yield. The area then made available can be used as additional concentration ponds to concentrate the brine to 25° Be. This should result in considerable savings to the operators as the investment in preparing crystallizing ponds is quite high. It should also reduce harvesting costs to some extent.

Conditions affecting rate of evaporation.—It is apparently the belief of the salt producers that evaporation is more rapid from shallow ponds, and also that evaporation proceeds more rapidly over the tile in the crystallization ponds than from deeper ponds with a mud bottom. To determine any bases of these contentions experiments were made in small pans. Clear white enamel photographic pans and black plastic photographic pans were used. The tile was set in mud placed in an enamel pan. In the experiment conducted over a mud bottom an enamel pan was used with about 2.5 cm. of soil. The measurement of evaporation was determined by weighing after eight hours in the sun,

and again after standing overnight. Table 3 gives the results of these experiments.

TABLE 3.—*Effect of bottom surface and depth on evaporation.*

Type of pan and bottom	Initial depth of water cm.	Kg. of water evap. per sq. m.	Kg. of water evap. per sq. m.
		8:00 a.m. to 4:00 p.m.	24 hrs.
Tile bottom.....	1.5	6.0	8.7
Mud bottom.....	1.5	6.3	8.4
Black plastic.....	1.6	7.2	8.3
Clear white enamel.....	1.7	4.6	6.7
Idem.....	1.15	4.6	6.4
Idem.....	5.2	5.8	8.1
Black plastic.....	1.15	7.0	8.5
Idem.....	5.0	7.0	9.2

These experiments show that the rate of evaporation is not greatly influenced by depth of water at the depths tested when the bottom does not reflect the sun's rays. It is indicated, though, that when the bottom reflects the sun's rays the evaporation proceeds more rapidly from the deeper water. The difference in the rates of evaporation between the experiments with tile and mud bottoms is not considered to be significant. There is, obviously at the depths tested, an advantage in having the bottom of a color which will absorb the heat rays from the sun. The difference in the evaporation for 24 hours between the deep and shallow water levels for the black plastic containers can be explained on the basis of the greater latent heat of the deeper brine at sunset.

Table 4 gives temperature and density variations at various points on a salt farm over the period of most active evaporation. The depths in the various ponds were about 2 cm. in the crystallizing pond and about 4 cm. in the concentration pond and at least 15 cm. in the ditch. It is an interesting observation to note that the temperature of the brine in the ditch was higher at the bottom than at the surface. This is explained by the fact that the brine in the ditch evaporates throughout the day and is then lower in level than the crystallizing ponds when refilled. When additional brine from the last concentrating pond at a lower density is brought in it does not mix with the remainder of the heavy brine in the ditch but just flows in over the surface. The sun then heats the mud bottom of the ditch and this heat is only slowly absorbed by the brine. Actual tests showed that the brine at the bottom of the ditch was of greater density than that at the surface.

TABLE 4.—Temperature and density value at various places on a salt farm ³

Time	Ditch bottom		Ditch surface		Crystallization pond		Concentration pond ⁴	
	Temp.	Density	Temp.	Density	Temp.	Density	Temp.	Density
	<i>Centigrade</i>	<i>Baume</i>	<i>Centigrade</i>	<i>Baume</i>	<i>Centigrade</i>	<i>Baume</i>	<i>Centigrade</i>	<i>Baume</i>
9:00	36	15	32	15	39	27	37	20
10:00	40	16	35	16	43	28	41	21
11:00	43	16	35	16	43	29	42	22
12:00	47	16	33	16	45	29	43	23
13:00	46	15.5	37	15.5	46	30	44	24
14:00	46	16	37	16	46	30	44	24
15:00	45	16	37	16	39	31	38	25
16:00	43	16	35	16	40	31	38	25

³ Temperature is in degrees centigrade and density in degrees Baumé.

⁴ The concentration pond here referred to was a small tile-surfaced pond, normally used for crystallization.

Table 5 gives the evaporation and rainfall during the salt making season for the San Francisco Bay area and also the corresponding data for the Manila area.

TABLE 5.—Evaporation and rainfall in millimeters

Month	San Francisco			Manila		
	Rain	Evap.	Net evap.	Rain	Evap.	Net evap.
December				63	155	92
January				24	170	146
February				12	200	188
March				13	265	247
April	35.0	86	51	31	280	249
May	29.0	135	106	130	235	105
June	17.0	168	151			
July	0.0	198	198			
August	0.0	198	198			
September	0.0	125	125			
October	20.0	75	55			
Salt season total	101.0	985	884	278	1,305	1,027

From these data it is seen that there is about 16 per cent greater net evaporation in the Manila area than in the San Francisco area during the salt making season. We may therefore assume on the basis of the weather alone that local conditions are satisfactory for the introduction of the California method. The following disadvantages may be considered, however, in the introduction of the new system:

1. The use of deep brine in all the ponds might make it necessary to use pumps. Lack of electrical power and cost of pumping equipment might make this type of operation too expensive.

2. The problem of displaced labor might be acute in certain producing areas.

CONCLUSIONS

1. The operating efficiency can be increased and the cost of production somewhat decreased by concentrating the brine to the point at which salt begins to form, prior to placing brine in the crystallization beds.
2. Favorable conditions exist for the introduction of more efficient production technics.
3. In order to produce a purer salt the present practices must be considerably modified.
4. Because of the crystal characteristics of Philippine salt, it is difficult to purify it by washing.
5. Within certain limits the depth of the evaporating brine has no significant effect on the rate of evaporation.

RECOMMENDATIONS

1. Serious consideration should be given to the application of the California method of salt production in the construction of new salts works.
2. Old operators should review their production costs and consider the application of more modern methods.
3. Additional experiments should be made demonstrating the feasibility of improved methods under the prevailing conditions.

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STUDIES ON SCYLLA (CRUSTACEA: PORTUNIDÆ), I. REVISION OF THE GENUS¹

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THREE PLATES

Scylla serrata (Forskål), *S. oceanica* (Dana), *S. tranquebarica* (Fabricius), and the new variety *S. serrata* var. *paramamosain* comprise the group of crabs that are called *alimango* (Tagalog and Visayan), *rasá* (Ilocano), and *alama* (Pangasinan). They are generally regarded as our most valuable crabs, and it is rather strange that we know very little about their biology. The present work has for its aim the following objectives:

(1) To study the biological peculiarities of the animals, so that measures for their propagation can be adopted.

(2) To study the mode of reproduction and the development of the young to the size at which sexual maturity is attained.

(3) To study their bionomics—the economic relations of the different phases in the life history of the crabs.

(4) To show the advisability of enacting wise fishery laws designed for their conservation and proper exploitation.

The work started with the assumption of previous authors that *S. serrata* comprises the only representative of the genus in the Philippines; hence, the external morphological features were not scrutinized very closely. The writer, however, was aware from the beginning of the existence of what apparently was a variety, which fishermen around Manila Bay call *bulik*, meaning motley-spotted. These crabs are characterized by their carapace, abdomen (in female only), and legs being bizarrely ornamented with rather large polygonal pigmented areas having shades of grayish to whitish, the spots bordered by purplish or dark-brown lines. The color markings are more distinct in medium-sized crabs, but in the bigger and older ones the pigmented areas on the carapace become indistinct, owing to their being obscured by deposition of sediments or

¹ This paper proposes the revision of the genus to include three species and one new variety based on external morphology and gametogenesis. More detailed data on spermatogenesis and oögenesis of the different forms will be treated in a subsequent paper.

algal growth which give the carapace a muddy appearance. The general coloration is greenish with shades of brownish gray in some places of the body including the chelipeds and legs. The *bulik* crabs grow bigger than any of the other forms, some specimens measuring about twenty-three centimeters across the greatest width of the carapace.

In some places in Quezon Province the *bulik* group is known as *banhawin*, and the other kinds *mamosain*. For convenience, the two terms are adopted throughout the discussion for grouping the crabs. The *mamosain* group is characterized by the absence of color markings like those found among the *banhawin*, or *bulik*. Some whitish spots may be present on the carapace and legs, but, generally, they are indistinct and are mostly confined on the last legs. The general coloration in *mamosain* is something like a combination of rust-color (ferruginous) and dark brown; the shades of color may vary, but the general greenish tint, characteristic in *banhawin*, does not appear. The *mamosain* (referring only to *S. serrata*) as distinctly hole-dwellers; hence, they are commonly met with in brackish swamps. Among the fishermen in the Batangas Province, they are known as *alimango sa butas* (crabs in holes); this habit, is in contrast to the decided propensity of the *banhawin* toward a roving life.

At first there was no plan to go into the question of taxonomy. But in the course of the study the following problems occurred:

- (1) Variations in the modes of spermiogenesis.
- (2) Somewhat corresponding deviations in the process of oogenesis.
- (3) Differences in the form and structure of chromosomes.

These features together with the external differences discussed above as well as differences in bionomics led the writer to suspect the existence of more than one species.

MATERIALS

The crabs used in these studies were bought from the markets in Baguio, Manila, Batangas, Batangas Province, and from places around Dagatdagatan Experimental Station at Malabon in Rizal Province.

METHODS

Crabs of different sizes were dissected during different months—March, April, May, June, July, August, September,

and December. The conditions of the gonads were studied to determine the probable range of the spawning season, and the relative sizes at which these crabs attain sexual maturity.

Pieces of the testes and of the ovary obtained by cutting across the organs were fixed, using different fixatives, such as Zenker; Carnoy and Lebrun; modified Bouin with urea; modified Flemming, including Benda: chrome-aceto-osmic: Gatenby: strong Flemming without acetic acid, and Flemming's strong solution with 40 per cent formaldehyde in place of acetic acid. The best result in chromosome fixation was obtained with modified Bouin of the following formula:

Picric acid, saturated solution.....	parts....	75
Formaline (strong)	do.	15
Glacial acetic acid.....	do.	10
Urea crystals	gr.	0.5

With Gatenby's-Flemming's strong fluid without acetic acid, and iron hæmatoxylin, good results were obtained showing Golgi bodies and fat globules.

Different combinations of stains were tried. The best results were obtained with iron hæmatoxylin, acid fuchsin and anilin blue. This combination stains the chromatin black, the cytoplasm and fibers red in various shades, and the metaplasms of the secretory cells, blue.

Double embedding in collodion and paraffin was employed for pieces of ovary containing mature eggs. After dehydration the tissues were soaked in collodion dissolved in equal parts of ether and absolute alcohol for about two weeks; then passed through either cedar oil or clove oil, in the meanwhile the collodion film formed removed around the tissues. The tissues were then passed through equal parts of absolute alcohol and benzene; through pure benzene, and then benzene and soft paraffin (in solution). The tissues stayed in the last solution about a week. The tissues were then embedded in pure hard paraffin. Good sections of eggs were obtained by this method. The usual method of preliminary infiltration with soft paraffin in the oven was avoided to reduce the chances of the tissues becoming too brittle from overheating. The sections of ovary were cut 7 microns thick; those of the testes, 5 microns thick.

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Family PORTUNIDÆ

(Swimming Crabs)

Portunidæ MIERS, Challenger Report, Zool. 17 (1886) 169.

Carapace depressed, moderately transverse, usually widest at last antero-lateral spines. Front horizontal. Orbits and eye-stalks nearly always of moderate length. Lateral teeth usually from five to nine. Last legs usually adapted for swimming, with terminal joints ovate, flatly expanded.

Genus SCYLLA de Haan, 1833

Scylla DE HAAN, Fauna Japonica, Crust (1833) p. 11; A. MILNE-EDWARDS, Ann. Sci. Nat. Hist. Zool. (4) 14 (1860) 228, 249; Archiv. du Mus. 10 (1861) 347.

Carapace transverse, broad, moderately convex, with an almost unbroken surface. Front proper well delimited from inner supra-orbital-angles, cut into four teeth; its breadth (excluding supra-orbital angles) between a fourth and fifth of greatest breadth of carapace.

Antero-lateral borders oblique, arched, longer than postero-lateral, cut into 9 teeth of nearly equal size.

Orbits without any dorsal inclination; two nearly closed fissures in the upper wall; inner angle of lower border dentiform and prominent. Antennules folded nearly transversely. Ba-

sal antennal joint produced to form a lobule lying in the orbit; flagellum, of good length, standing in the orbital hiatus.

Epistome sufficiently long fore and aft, not sunken. Buccal cavern squarish, broader than long; efferent branchial channels cavernous, but not defined by ridges.

Chelipeds massive, longer than any of legs; arm wrist and hand with definitely placed spines; hands deep and full, not prismatic, not costate.

Legs stout, moderately compressed; in fourth pairs merus and carpus shortened and broadened, and propodite and dactylus typically foliaceous for swimming.

Abdomen of male rather broadly triangular, consisting of 5 segments, third to fifth terga being fused. First tergum much concealed beneath carapace.

SCYLLA SERRATA (Forsk.). Plate 1, fig. 1

Cancer serratus FORSKAL, Descript. Anim. p. 90.

Lupea tranquebarica H. MILNE-EDWARDS, Hist. Nat. Crust. 1 (1834) 448.

Scylla tranquebarica DANA, U. S. Explor. Exped. Crust. 1 (1852) 270; STIMPSON, Acad. Nat. Sci. Philad. (1858) 38; STIMPSON, Smith Misc. Coll. 49 (1907) 75.

Scylla serrata DE HAAN, Fauna Japonica Crust. (1850) 44.

Scylla serrata DE HANN Fauna Japonica, Crust. (1860) 44; KRAUSS, Sudofr. Crust. p. 26; MIERS, Ann. Mat. Nat. Hist. 5 (1880) 238; MIERS, Chall. Rept. Brachyura 17 (1886) 185; DE MAN, Arch. fur Naturges., Jahr. 53 (1888) 332; CHIA-JUI SHEN, The Crabs of Hongkong. The Hongkong Naturalist 3, No. 1 (1932) 32.

Carapace about two-thirds, or a little less, as long as broad, practically smooth, except for a faint granular ridge running obliquely inwards across either branchial region from last spine of antero-lateral border.

Front cut into four lobes or bluntish teeth of about equal size and prominence. Antero-lateral border cut into nine sharply acuminate teeth of about equal size. Posterior border forming a curve with postero-lateral borders, points of junction sometimes slightly thickened.

Merus of external maxillipeds oblique but not having antero-external angle distinctly produced in a lateral direction.

Chelipeds not quite twice length of carapace in adult male, but shorter than in female and young male. Arm with three spines on anterior border, and two on posterior border one terminal, other submedian; a strong spine at inner angle of wrist, outer angle being rounded and armed with one, or sometimes,

two spines or teeth. Hand with three spines or tubercles, one being in front of apex of wrist joint, other two being side by side behind finger-joint, outer of these two sometimes obsolescent.

Legs unarmed: dactyli strongly sulcated, their anterior and posterior margins fringed with brushlike hairs.

Abdomen of male broadly triangular: oval in young families, but becomes more circular in outline in big females.

Remarks.—Carcinologists have hitherto recognized only one local species under this genus. Miers (1886) recognized only *S. serrata*; and Stimpson (1907) seems to be of the opinion that *S. serrata* and *S. tranquebarica* are synonyms. Both Dana (1852) and Stimpson placed *S. oceanica* as a variety under *S. tranquebarica*. The present study attempts to establish three species and one new variety.

De Haan, in adopting *Scylla* for the generic name, must have had in mind the habitat and habits of the crabs. *Scylla* (Lat. from Gr. *Skylia*) is described in Greek mythology as a sea monster, dwelling in a cave in a precipitous cliff that guarded the entrance to a passage. She is said to devour any prey that comes within her reach. This allusion does not fit the *banhawin* (*bulik*) crabs, because they do not live inside the holes. The allusion fits *S. serrata*. Kraus (in Sudafr. Crust.) relates: "this species lives in great deep holes, and wears the dingy earthy color of its residence. They sit at the opening of their holes when the tide is coming in, to snap at the food which it brings them."

In *Scylla serrata* the outer of the two spines behind the fingerjoint is described as obsolescent (Plate 1, fig. 1b). This is so in the true *mamosain*, where in some cases especially in big males, the spine is reduced to a mere inconspicuous vestige. Among the *banhawin* group both spines are conspicuous; the outer one, however, is generally smaller.

Between the true *banhawin* and the true *mamosain*, there are two groups of individuals that seemingly occupy the intermediate positions in general coloration, one group closely approximating the *banhawin*, while the other resembling closely the *mamosain*. On the whole the differences in the shades of color and in the extent of pigmented areas can be passed on easily as simple variations that can be attributed to such factors as age and environment. But when these dissimilarities are supplemented by (a) differences in form and size of the chromosomes, and (b) differences in the process of

spermiogenesis and ookinesis, they then assume greater significance. Obviously, they are due to fundamentally deep-seated factors inherent in the distinctive make-up of the individuals. To serve as bases for description and for convenience, the group that closely resembles the true *banhawin* is designated as *parabanhawin* and those that closely approximate the true *mamosain* (*S. serrata*), as *paramamosain*. The true *banhawin* is identified in this paper as *S. oceanica*, and the *parabanhawin* as *S. tranquebarica*, the *paramamosain* is regarded as a variety under *S. serrata*.

SCYLLA OCEANICA (Dana) Banhawin. Plate 1, fig. 2.

Scylla tranquegarica var. *oceanica* DANA, U. S. Explor. Exped. Crust. 1 (1852) STIMPSON, Smith. Misc. Collection 49 (1907) 75.

Diagnosis.—This species can be distinguished from *S. serrata* by the following characteristics:

1. The general coloration is predominantly greenish, the shades in some places of the body becoming grayish green in bigger specimens. The carapace, legs, and abdomen are ornamented by large pigmented areas of whitish gray bordered by purplish dark-brown lines. These ornamental markings are absent in *S. serrata* in which only irregularly disposed small whitish spots may be seen on the carapace and on the last legs, and the general coloration is usually deep ferruginous brown; the shades of color may sometimes vary, assuming a light purplish brown.

2. *S. oceanica* ordinarily grows bigger. It is not unusual to see specimens that measure about nine inches across the widest portion of the carapace. - Probably bigger specimens may exist.

3. Brushlike setæ (Plate 2, fig. 2) are present quite abundantly over the carapace of *S. oceanica*. While in *S. serrata* the setæ appear to be shorter and are apparently confined only to the hepatic region just below the orbit.

4. They differ in habitat: *S. serrata* referred to in this paper as the *mamosain*, usually lives in holes; while *S. oceanica* (the *banhawin*) seemingly prefers a nomadic life, and is commonly caught in open seas.

5. Relatively, more pores perforate the carapace of *S. serrata*. The hypodermal papillary tubes (Plate 2, fig. 3) protrude through these pores. These minute tubes are extensions of the hypodermis and are, obviously, respiratory in function. (See section in bionomics.)

Other differences as revealed by cytology:

6. Their chromosomes differ in their physical make-up and in form.

7. The modes of spermiogenesis and oogenesis also differ. These and other cytological differences will be brought out more in detail in the course of the discussion.

Remarks.—Both Dana (1852) and Stimpson (1907) consider *S. oceanica* as a variety under *S. tranquebarica*. Stimpson pointed out the existence of two sufficiently distinct varieties. He gave as the distinguishing characteristics of *S. oceanica* the following: (1) the frontal teeth are blunt, with the median incision deepest; (2) the posterior teeth of the anterolateral margin is longer than in the other. Stimpson described the coloration in the species as follows: "carapax olive green above, white below; hands often reddish and spotted with green exteriorly; fingers always red, feet pale greenish, with dark spots below."

H. Milne-Edwards (1834) characterized *Lupea tranquebarica* as the biggest species of *Portunidae*, and, according to him, they may attain the length of from six to eight inches; the color is grayish green, and they inhabit the Asiatic seas. Presumably his specimen was *S. oceanica*, since this is the variety that grows very big, and the big ones are, apparently, sea-dwellers.

Notwithstanding their close similarity with regards to general coloration, the writer proposes to raise *S. oceanica* to the category of a distinct species and to include therein forms which are:

(1) Predominantly greenish or grayish green on carapace and legs, including chelipeds; these parts ornamented by large pigmented areas.

(2) Those lengths of chelipeds (in male) not more than twice the length of carapace; hands not reddish or purplish as a whole, though splashes of reddish color may appear.

If the writer were to consider one as a variety under the other, he would choose *S. tranquebarica*, on the ground that the general coloration and color markings on this group seem to be more variable; and on the basis that the germ cells of *S. tranquebarica* are heterogametic, they exhibit sexual digamy and dimegaly. While those of *S. oceanica* are apparently homogametic, a condition which implies more stability of character.

SCYLLA TRANQUEBARICA (Fabricius) Dana. (Parabanhawin). Plate 3, fig. 1.

Pertunus serratus RUPPEL, Krabben die rothen Meeres, p. 19, pl. 2, fig. 1.

Lupea tranquebarica MILNE-EDWARDS, Hist. Nat. Des Crust. 1 (1834) 448.

Scylla serrata DE HAAN, Fauna Japonica, Crust. (1850) 44; KRAUSS, Sudafr. Crust., p. 25.

Scylla tranquebarica DANA, U. S. Explor. Exped. Crust. 1 (1852) 270, pl. XVI, fig. 6; STIMPSON, Acad. Nat. Sci. Philad. (1858) 38; STIMPSON, Smith. Misc. Collection 49 (1907) 75.

Diagnosis.—Differs from *S. oceanica* by the following characters:

1. General coloration varying from deep purplish drab-green to lighter in shade; overall greenish background which is characteristic of the true *banhawin* (*S. oceanica*) generally showing only on the carapace and on some portions of the legs.

2. Large pigmented areas generally distinct only on the last legs; indistinct on the other legs and on abdomen of female. Chelipeds usually purplish; fingers red, often tipped with white.

3. Relative differences in the size of the chelipeds more apparent, especially so in males, where the chelipeds are enormously big in relation to the body. In adult males the length of the chelipeds is more than twice that of the body.

4. As in *S. oceanica*, the nurse cells in the gonads are distinctly vacuolated; in size the auxocytes compare favorably with those of the aforementioned.

5. Unlike those of *S. oceanica*, however, the sperms of *S. tranquebarica* exhibit sexual digamy and the ova show sexual dimegaly.

Remarks.—The variations in general coloration and in color markings within the species are quite diverse; it is difficult to determine whether they should be regarded as simple external variations, or something that preclude existence of races or varieties. These need further cytological studies.

According to Stimpson, these species are found on the shores of the continent of Asia, chiefly in muddy estuaries. They are sold in great numbers in the markets of Hongkong and Canton.

In the Philippines the market supply of these crabs generally comes from the fishponds; considerable quantities of the crabs are also caught from the muddy shores of bays, coves, and chiefly the muddy estuaries.

SCYLLA SERRATA var. *Paramamosain* var. nov. Plate 3, fig. 2.

Characters.—The general configuration of the body is very similar to that of the typical species. In both the body is relatively thicker, appears to be more compact, and the carapace looks more convex than that of either *S. oceanica* or *S. tranquebarica*. The H-like mark on the carapace is relatively faint; the figure is deeply impressed in both *S. oceanica* and *S. tranquebarica*.

Variety *paramamosain* differs from the typical species by the following characters:

1. Median pair of frontal lobes slightly more anteriorly produced than the two laterals.
2. Outer of the two spines at the base of the fingers, though smaller than the inner, neither obsolescent nor dentiform; it is quite prominent. In the species, especially in big males, the outer spine becomes vestigial.

Some cytological differences

3. The ova of *paramamosain* exhibit sexual dimegaly. The condition in the sperm has not been determined.
4. The form and the apparent physical constitution of the chromosomes of *paramamosain* differ from those of the *ma-mosain* (*S. serrata*).
5. The modes of spermiogenesis and ookinesis also differ in these two groups.

Color.—It is rather hard to distinguish offhand the variety from the typical species in so far as general coloration is concerned. There is an apparent tendency in the variety, however, to assume a lighter shade of color, which is usually brownish with splashes of gray. Usually, there are patches of bluish green at the angles of the joints of the legs and chelipeds. The spines in the chelipeds are of this color excepting the tips. Small pigmented areas, but rather irregularly disposed, may be seen on the last legs; these areas consist of groups of whitish spots, and as in the species, they are not bordered by distinct lines.

On the whole the shades in color and the color markings may vary with such factors as age or environment. Also, there are no distinctive external differences. Hence, despite differences in the physical constitution of their chromosomes and in the modes of spermiogenesis and ookinesis, it seems safer with the present state of our knowledge tentatively to place *paramamosain* as a variety.

Key to the Philippine *Scylla*.

- a*¹. General ground color greenish, grayish green or olive-green; sometimes with shades of purplish or reddish generally on chelipeds and legs. Contour of body not very distinctly convex; H-like mark on carapace relatively deep.
- b*¹. Carapace and legs, including chelipeds, predominantly greenish or grayish green; large polygonal pigmented areas present on all legs, including chelipeds, and on abdomen in females; chelipeds in adult males not more than twice length of carapace—*S. oceanica*.
- b*². Carapace olive-green, purplish with greenish tint, or purplish brown; large polygonal pigmented areas distinct only on last legs, and a few may be seen on the abdomen in females; chelipeds often reddish or purplish, length in adult males more than twice length of carapace *S. tranquebarica*.
- a*². General ground color deep rusty-brown, purplish brown to light brownish gray; dorsal contour of body more distinctly convex; H-like figure on carapace relatively less deep.
- b*¹. Color varying from deep rusty brown to the purplish brown; outer spine on base of fingers obsolescent, becoming vestigial on bigger specimens; frontal teeth about same level..... *S. serrata*.
- b*². Color generally brownish gray with patches of bluish green at joints of legs and chelipeds; median pair of frontal teeth slightly produced anteriorly; outer spine on base of fingers unequal but not obsolescent *S. serrata* var. *paramamosain* var. nov.

Dimorphism.—Usually the right cheliped is bigger than the left, but in cases which are apparently not very uncommon, the left is bigger than the right. The difference in size between the chelipeds is more pronounced in males than in females, and is quite exaggerated among the *paramamosain*, but more so in *S. tranquebarica* (*parabanhawin*). In these groups, especially in males of *tranquebarica*, the chelipeds appear to be enormously big in relation to the size of the body. The hand is thickly inflated and smooth; the fingers are very large, thick, and strong, curved and furnished with large thick teeth. In males the circumference of the hand measured at the base of the fingers almost equals the width of the carapace.

Changes in the form of the abdomen as the crab approaches maturity.—There are individuals with abdomen oval, instead of triangular, and considerably broader than the abdomen in males, but not broad enough to compare with that of a mature female (Plate 2, figs. a, b, and c). These are immature females; their sternal concavity is deep as in males, and the vulva is rather reduced in size. The abdominal appendages are also relatively reduced in size. Studies made on the stained sections of the gonads of two crabs—one, a *mosain*, and the other a *banhawin*—revealed the presence of

oöcytes and immature ova in different stages of development. In the individuals studied, there were no indications of the presence of developing male germs, so that apparently no copulation had previously taken place. As the crab grows older, the abdomen increases in width, and becomes more or less rounded.

As stated previously, the present study was started with the presumption that there is only one species. Hence, in the earlier part of the investigation, no attempt was made to classify the crabs. The discovery of existing differences, which obviously point to the existence of more than one species, made it necessary to change the methods. A systematic checking of the results thus far obtained is also made imperative. Some of the materials that were used in this checking are included in the Table 1 to show the degree of dimorphism as shown in the difference of the size of the chelipeds; and also, to show the difference in the general coloration and color markings.

TABLE 1.—Showing some of the characteristic features of the Philippine species of the genus *Scylla*.

Species	Measurements of carapace		Circumference of palm ^a		General coloration and color markings
	Width	Length	Right	Left	
	cm.	cm.	cm.	cm.	
<i>S. oceanica</i> (<i>banhawin</i>):					
Female	11	8	9	7.4	Greenish with large pigmented areas on carapace, legs and abdomen.
Do.	11	8	8	7	Do.
Do.	12	8.2	7	9	Do.
Male	12	8.2	7.5	9.1	Do.
Female	19.5	13.6	13	11.5	Carapace drab-green due to algal growth.
<i>S. tranquebarica</i> (<i>parabanhawin</i>):					
Male	12.8	8.7	12.7	(^b)	Light brownish purple; big pigmented areas on last legs only. Crab still soft.
Do.	14.2	9.6	13.7	12.4	Carapace greenish; chelipeds purplish, large pigmented areas on last legs only. Circumference of chelipeds almost the same as width of body.
<i>S. serrata</i> (<i>mamosain</i>):					
Male	10.5	8	8.5	7.2	Deep rusty brown; scattered whitish spots on last legs.
Immature female.	7.3	5.3	4.8	3.5	Deep purplish brown; whitish spots on last legs.
Do.	6	4	3.8	3.2	Do.
<i>S. serrata</i> var. <i>paramosain</i> :					
Female	9	6.5	6	5.3	Light purplish brown; with splashes of bluish green on joints of legs and chelipeds, whitish spots on last legs.
Male	10	7.2	9	8	Same color marking as foregoing.
Female	11.7	8.2	7.2	6.4	Dark purplish brown; with splashes of ferruginous areas on other parts of body.

^a Measurements were taken at the base of fingers.

^b Missing.

GENERAL DISCUSSION

The separation of *S. oceanica* from *S. tranquebarica* as distinct species is amply justifiable. The external differences of these species supported by other characteristic features indicated by variations in the modes of spermiogenesis and of oökinesis; and by the peculiarities in the form and physical constitution of their chromosomes, etc.—these are quite sufficient bases.

Aside from their ecological preferences, the *banhawin* (*S. oceanica*) are distinctly different from the *mamosain* (*S. serrata*) in their external features. The presence of large polygonal pigmented areas that mark the carapace, all of the legs including the chelipeds and abdomen in females, make the former group easily recognizable from the latter. In *mamosain* only whitish spots may be seen here and there, on the carapace and on the legs, but on closer examination these spots appear to be groups of pigmented dots, and they are not delineated by distinct boundary lines. There is no possibility of mistaking a *mamosain* from a *banhawin*.

Because of their close similarity in general external appearance and in coloration, the writer tentatively places *paramamosain* as a variety under *S. serrata*, notwithstanding their cytological differences.

Undoubtedly, the study on the genetics of these groups will prove very interesting. Experimental breeding will furnish evidences from fertility-sterility test held by many as an objective method of demonstrating species validity. On the whole, capacity to interbreed with fertile offspring is regarded as a very significant evidence in any consideration of the degree of consanguinity of closely similar stocks.

The segmented character exhibited by the chromosomes, and in some cases the tendency of chromosome-constituents towards the formation of a somewhat loosely arranged groups, are altogether significant. Those arrangements of chromosomal components make possible the so-called "translocation", or "displacement," in which a piece of chromosome becomes transversely detached and joins the chromosome of another pair. This segmental interchange gives rise to a new linkage group, since the genes contained in the translocated section are now free from the genes with which they were previously associated; they may become a part of another linkage group constituted by the chromosome to which they have become

attached. This had been observed in many animals; it may have been taking place in these crabs too—a possibility which is hinted by the physical constitution of the chromosome.

Translocation, or displacement, is regarded as having a great influence in the evolution of new species, since it provides a rapid means of chromosome differentiation which must have a great influence on the evolution of new races, varieties, subspecies, and species.

From observations embracing differences in general coloration, color markings, and other external features, the writer suspects that besides the ones discussed in this paper, there are at least other variations.

The existence of *mamosain* (*S. serrata*) in considerable number in certain regions in the Philippines appears to be correlated with the existence of extensive mangrove swamps. The relation is obvious, on the ground that these crabs are distinctly fossorial mud-dwellers. The mangrove with its stiltlike roots and a variety of other plants with similar growth habits, especially *Senneratia pagatpat* Blanco, *S. caseolaris* (L.) Engl., and *Aegiceras corniculatum* (L.) Blanco, are common on the quiet coastal areas. The tangle of roots holds debris that were brought down by rains and that drifted with the tides until it decays. In and upon the mud is found a remarkable assemblage of marine, freshwater, and terrestrial animals. A habitat with such conditions gives ample protection to the crabs, and wonderfully fit their predaceous and scavenger habits.

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ILLUSTRATIONS

PLATE 1

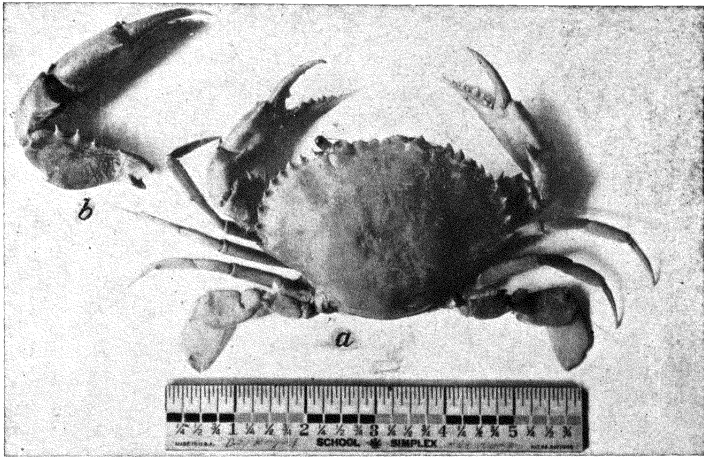
- FIG. 1. (a). *Scylla serrata* (Forskål); female.
(b). *Scylla serrata* (Forskål); left cheliped of male showing the spines behind the finger joint; the outer has become vestigial.
2. *Scylla oceanica* (Dana); female.

PLATE 2

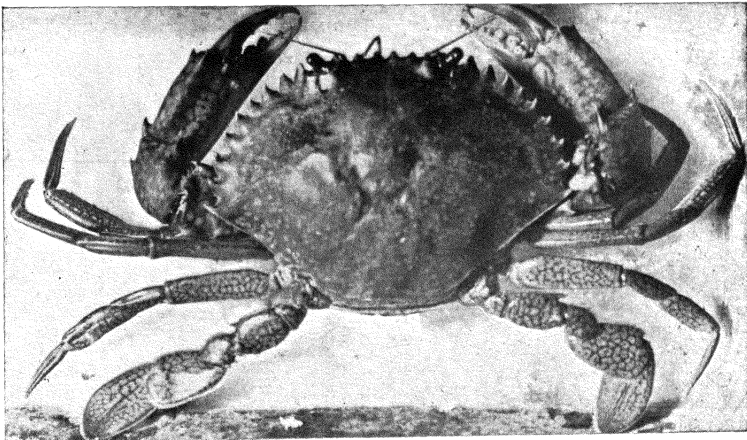
- FIG. 1. (a). Abdomen of a female *S. oceanica*; width of carapace 19.5 cm.; length, 13.6 cm.
(b). Abdomen of young female *S. oceanica*: width of carapace 11.6 cm.; length, 8.2 cm.
(c). Abdomen of a female *S. serrata* var. *paramamosain*: width of carapace 11.6 cm.; length, 8.3 cm.
2. Terminal portion of a brushlike seta from the carapace of *S. oceanica* (*banhawin*); $\times 1350$.
3. A hypodermal papillary tube taken from the carapace of the same specimen; $\times 1350$.

PLATE 3

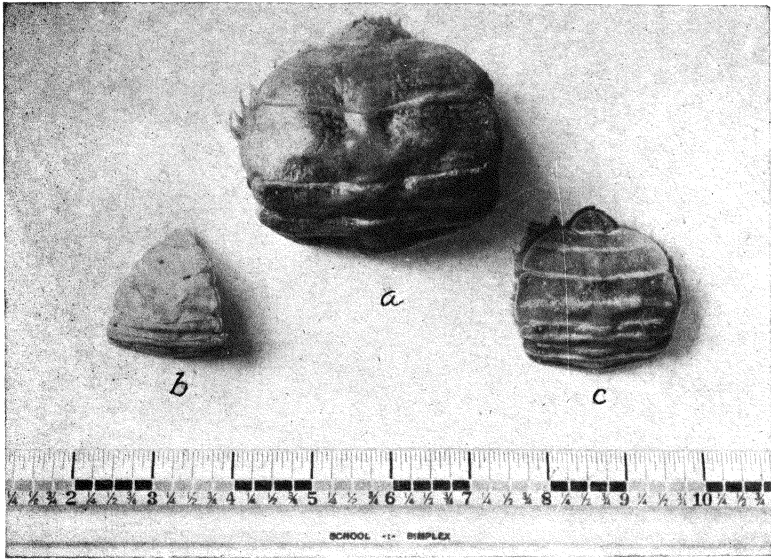
- FIG. 1. *Scylla tranquebarica* (Fabr.) Dana; male.
2. *Scylla serrata* var. *paramamosain* var. nov.; female. (Note the two spines behind the finger joints, which are almost equally prominent.)



1



2



1

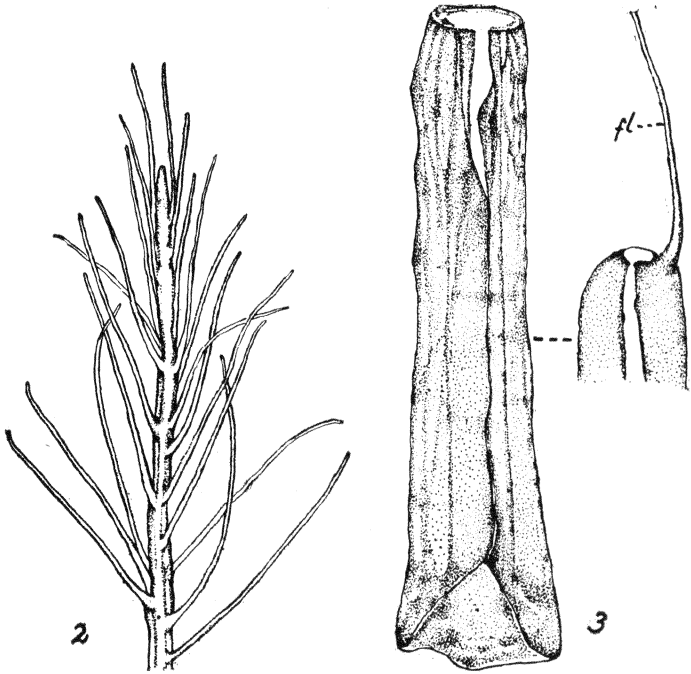
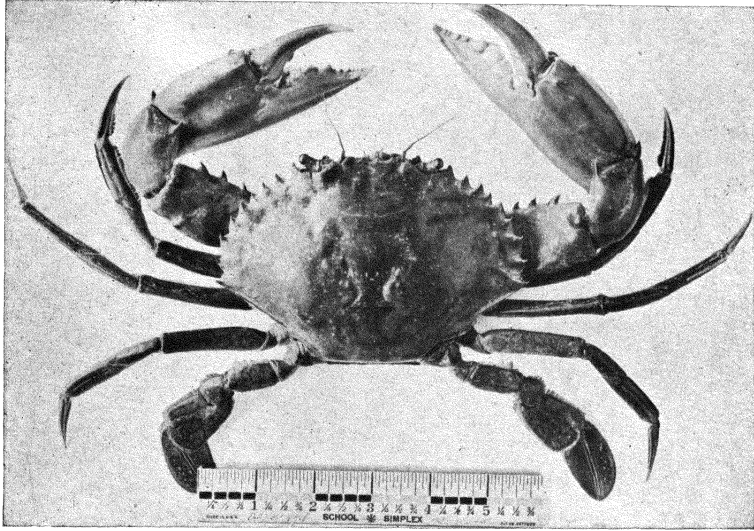
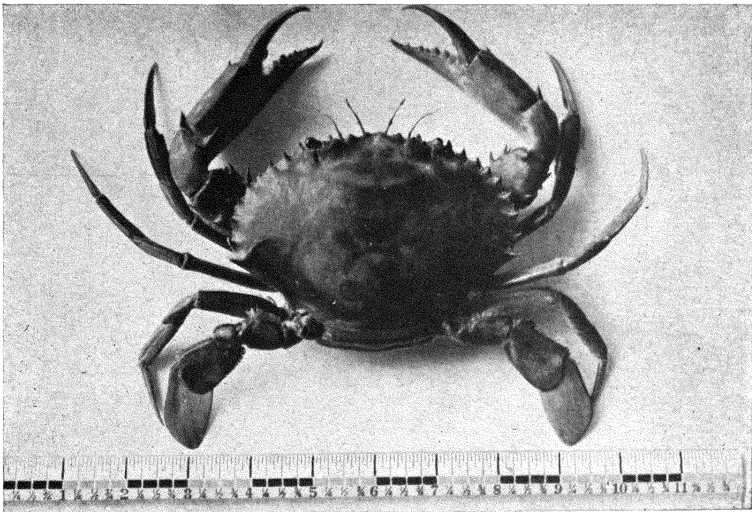


PLATE 2.



1



2

ANALYSIS AND COMPOSITION OF MANILA ELEMI

By GLORIA D. MANALO and AUGUSTUS P. WEST¹

Manila elemi is one of the well-known minor forest products of the Philippines. It is a resin that is contained in the bark of the pili tree, *Canarium luzonicum* (Blume) A. Gray, and oozes out when the bark is cut.

It is used in pharmacy as an ingredient in plasters and ointments. It is employed in making paints, varnishes, lacquers, and also as a constituent in the manufacture of plastics and printing inks. Locally it has served as varnish and as material for caulking boats. Forest dwellers roll the resin in leaves and use it as an illuminant. A large torch, thus prepared, gives a light that burns for many hours and can be seen far away.

For many years Manila elemi has been exported from the Philippines but the quantity shipped annually has varied considerably. In 1940 the amount sent abroad was valued at ₱90,264.²

By operating a pilot plant for the manufacture of commercial products from Philippine resins, like Manila elemi and copal, very likely important new industries could be developed.

Resin obtained from different locations usually contains more or less foreign matter (leaves, twigs, etc.) and varies in composition. For industrial purposes it is desirable to ascertain the quality of Manila elemi and also the amount of individual resin constituents. We have devised an accurate and convenient method of analysis and the details are given in this paper. There are also included the data on some characteristic samples of Manila elemi, as determined by this procedure.

Clover³ and also Bacon⁴ have carried out extensive researches on Manila elemi collected in the Philippines. Their investigations were confined particularly to the volatile oil obtained from this resin. A review of their work⁵ is given in Bulletin 20 of the Philippine Bureau of Forestry.

¹ Formerly of the Bureau of Science, now Institute of Science.

² Annual Report. Insular Collector of Customs, Manila. (1940) One peso equals 50 cents United States currency.

³ Philip. Jour. Sci. 2 A (1907) 1.

⁴ Philip. Jour. Sci. 4 A (1909) 93.

⁵ West, A. P., and W. H. Brown. Philip. Bur. For. Bull. 20 (1920) 40.

The name elemi is a term that is applied to a variety of resinous products obtained from different countries and having different botanical origins. In the Philippines only one elemi resin is collected and this is obtained from *Canarium luzonicum* which grows abundantly at low and medium altitudes in the primary forests of Luzon, Mindoro, Ticao and Masbate. It is the only Philippine tree that gives this resin in sufficient quantities for profitable collection.

In addition to *Canarium luzonicum* there are various other species of *Canarium* in the Philippines. *Canarium ovatum* grows abundantly in southern Luzon. It produces nuts known as pili nuts and is said to give an annual yield of about 33 kilos. These, when roasted, are very tasty and nutritious. They are used in making confections and, by many, are considered superior to almonds.

The oil ⁶ from pili nuts has good keeping qualities, and a composition similar to peanut oil.

On account of the popularity of pili nuts the tree, *Canarium ovatum*, is called the pili-nut tree. The name "pili" is also applied locally to other *Canarium* species such as *C. luzonicum*. The latter also yields edible pili nuts but they are much smaller than those obtained from *Canarium ovatum*.

Manila elemi is also known by the Spanish name, "brea blanca" (white pitch). When the resin first exudes from the tree it is always soft and oily and has a very fragrant odor. On standing, however, it gradually loses volatile constituents and hardens.

Forest ranger Rabaya ⁷ investigated the elemi industry in the province of Tayabas. Concerning *Canarium luzonicum* and elemi resin he states:

Pili tree is deciduous. It changes its leaves once a year during the dry season. At the beginning of the dry season (in the month of February in the Province of Tayabas), some trees begin to shed their leaves. The falling of the leaves becomes general as the dry season advances, so that in the latter part of March and April most trees are leafless or nearly so. Early in May, young leaves begin to grow and their purplish red color renders the trees conspicuous for miles. ... It appears to thrive best in Southeastern Luzon, where there are no distinct dry and wet seasons. It is also grown in the Islands of Masbate and Samar. In the Province of Tayabas alone, it is estimated that there are close to 25,000 pili trees available for resin tapping.

⁶ West, A. P. and S. Balce. Philip. Jour. Sci. 23 (1923) 29.

⁷ Bureau of Forestry Report not published.

Tapping begins in the early part of July, or as soon as the new leaves become green and mature, and continues until March when the trees shed their leaves. The length of the tapping season is, therefore, a little over 8 months.

A young tree of 15 centimeters in diameter (B. H.) yields an average of 2 kilos of resin per month or 16 kilos per season, a 60 centimeter tree yields 60 kilos, while a tree 1 meter in diameter, 120 kilos or more. It is claimed that pili trees growing along the gulleys produce more resin.

The greater bulk of the resin exported to foreign markets comes from Tayabas Province, principally from the towns of Gumaca, Calauag and Lopez. During the year 1925, a little less than 100,000 kilos of resin were collected in Tayabas Province alone, and if prices warrant extensive collection, it is believed that as much as 300,000 kilos can easily be produced in one season.

In Masbate,⁸ according to Forester Zschokke, the trees are tapped at the beginning of the rainy season and the process is repeated every other day until December. The resin is collected once a month and one man can take care of 75 to 100 trees. The trees must be visited regularly to get good returns. The resin can be gathered at almost all seasons, but towards the end of the dry season the flow is very slight. Collections are made from the same trees year after year.

Clover says that he has seen large-sized trees on which at least ten pounds of the exudation had accumulated probably within a month. Bacon estimates that a mature tree will yield an average of 45 kilos per year. He says that he has seen as much as 32 kilos on a large tree. This amount represented a two months flow.

The volatile portion of the resin is called elemi oil and is usually obtained by steam-distillation. Clover collected samples of elemi from a number of trees. These were distilled and the optical rotation, specific gravity, and refractive index of these distillates determined. The results varied considerably. Clover concluded that this variation was due to a difference in the resin obtained from individual trees. He isolated various terpenes from his numerous samples. According to his investigations:

The combined results obtained by a careful examination of the oils from 21 individual samples of resin establish the true composition of elemi oil so far as these samples may be considered as representative of the aggregate product. In several cases, notably in the last sample examined, substances were obtained which were not encountered in any other; it seems possible, therefore, that were the investigation continued, still others

⁸ West, A. P. and W. H. Brown. Philip. Bur. For. Bull. 20 (1920) 42.

would be found in which new constituents would appear, although such cases would be rare and the substances themselves would constitute so small a proportion of the aggregate oil that they would scarcely need to be taken into account.

It is obvious that in considering Manila elemi or the oil obtained therefrom as products of a species, we must deal with an aggregate sample of these products; a sample derived from so great a number of individual trees that the peculiarities of the individuals disappear. If the native gatherer of resin utilizes a large number of trees and regularly removes the resin from them in small portions, the product which he places upon the market will be nearly homogeneous and a representative sample; but if he obtains his resin from a limited number of individuals his product will not be representative and, if he utilizes resin which has accumulated upon the trees in large quantity, it will not be homogeneous.

Granted that we have a representative sample of resin, the composition of the oil will also be influenced by the following factors:

- (1) The age of the resin.
- (2) The temperature of the distillation. This factor will largely determine the proportion of the high-boiling part of the oil and will influence the composition of the terpene portion, because some of the terpenes suffer a change at higher temperatures.
- (3) The length of time used in the distillation. This factor will influence only the proportion of high-boiling oil.

Yield of oil.—In the first seven samples examined considerable difference was found in the oil content. While there may be a certain amount of variation shown by the individual samples in this respect, it is thought that the differences found are more directly connected with the age of the resin. As previously noted, Schimmel & Co. state that the yield of oil is from 15 to 30 per cent. In several cases where I have examined samples of fresh, soft, resin purchased in Manila, I have always found that total yield to be from 25 to 30 per cent of the weight of the resin.

Bacon investigated the volatile oil separated from numerous specimens of elemi resin obtained from individual trees. His experiments verified the conclusions of Clover that elemi terpene oils vary a great deal in their boiling points and optical rotation.

By the distillation of elemi in vacuo, Bacon obtained from 12 to 18 per cent of terpenes and from 12 to 15 per cent of a higher-boiling oil. The distillation residue, usually amounting to about 70 per cent of the elemi, is a light-brown, transparent, solid resin, with a brilliant fracture. It is completely and easily soluble in the cold in the following solvents: alcohol, ether, benzol, petroleum ether, ligroin, xylol, chloroform, amyl acetate, acetone, methyl alcohol, carbon tetrachloride, ethyl acetate, turpentine, amyl alcohol, and glacial acetic

acid. Bacon thought this product has commercial possibilities as a varnish gum. He subjected it to destructive distillation. He says:

One kilo of this residue was distilled in a 2-liter Jena flask. It melts quietly with very little darkening and no foaming, evolution of gas, or other signs of decomposition. As the temperature is increased, considerable cracking and evolution of water soon takes place and the whole mass becomes very dark, the oil beginning to distill at a vapor temperature of 200° C. The whole distillation is very quiet with no foaming or frothing and very little evolution of gas. The oil at first is green, then an intense, fluorescent blue and toward the close of the distillation almost white. The total distillate was 670 cubic centimeters of which 40 were the aqueous layer. Three hundred and ten grams of black tar were left in the distilling flask. The oil, shaken out with dilute alkalies, gave 18 grams of acids, while after saponification with alcoholic potash a further 7 gram of acids were obtained. The neutral oils distilled in vacuo gave fractions at 10 millimeters of about 90 grams each . . .

There were no indications of any separable, individual products, and nitration and oxidation of these fractions under various conditions gave no promise of obtaining individual compounds. This oil obtained by the destructive distillation of elemi is evidently a resin oil of the same general character and useful for the same purposes as other resin oils.

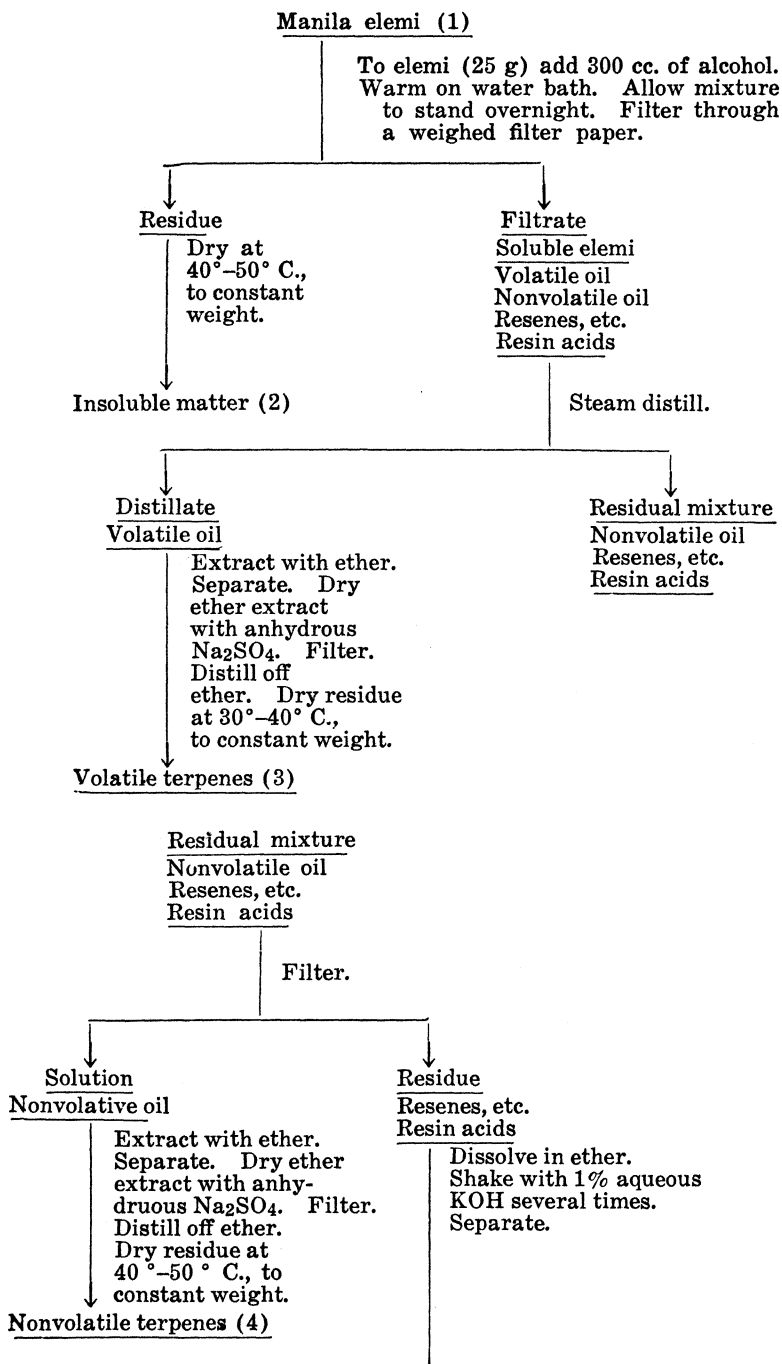
EXPERIMENTAL PROCEDURE

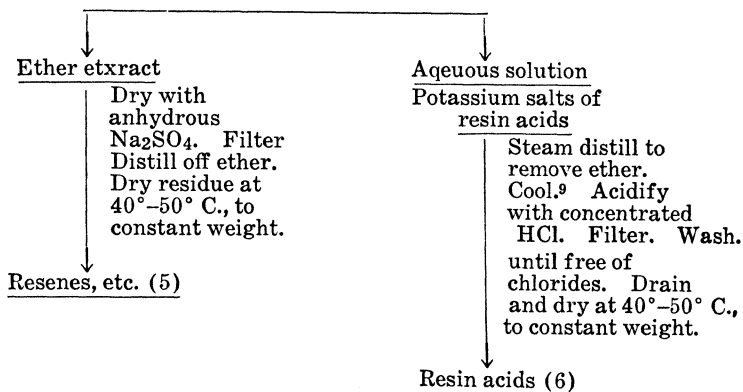
The samples of Manila elemi used in this investigation were obtained from F. E. Zuellig Company (resin dealers), Manila. The resin was collected in Tayabas province.

Acid number.—The acid number was ascertained by treating approximately 1 gram of elemi resin with 50 cc. of a mixture consisting of neutral absolute alcohol and benzene (25 cc. each) and titrating directly with tenth-normal alcoholic potassium hydroxide using phenolphthalein as indicator.

Saponification number.—For this determination approximately 1 gram of elemi resin was treated with 50 cc. of absolute alcohol after which 25 cc. of tenth-normal alcoholic potassium hydroxide were added. The mixture was heated on a steam bath with a reflux condenser for 2 hours. The solution was then cooled and the excess alkali titrated with tenth-normal sulphuric acid in the presence of phenolphthalein.

Manila elemi analysis.—Preliminary experiments were carried out to ascertain a convenient method for separating the constituents of Manila elemi. The procedure outlined below gave satisfactory results.





⁹ If a precipitate separates out at this stage proceed according to the following remarks on this outline of analysis.

Insoluble matter.—Manila elemi (25 g) is treated with 300 cc. of alcohol (95 per cent). The mixture of elemi and alcohol is heated on a steam bath and shaken occasionally for about a half hour. It is then allowed to stand overnight to facilitate subsequent filtration. The insoluble matter consisting of foreign material settles out on standing leaving a fairly clear supernatant liquid. The mixture is filtered through a weighed filter paper. The insoluble matter is washed with alcohol and the filtered washings are added to the soluble elemi solution. The filter paper with the insoluble matter is allowed to drain on layers of filter paper after which it is dried in an oven at from 40° to 50°C., until the weight becomes constant.

Soluble elemi.—The alcoholic solution of elemi is steam distilled to remove the terpenes. This process usually requires about 20 hours to get most of the volatile terpenes. The small portion that steam distills with difficulty can be included in the nonvolatile terpenes that are subsequently obtained.

The distillate (in portions of about 100 cc) is extracted with ether until it no longer has a milky appearance. Generally one extraction for each portion is sufficient. The combined ether extracts are dried with anhydrous sodium sulfate. The clear solution is filtered into a weighed flask and the ether distilled off. In order to eliminate the last traces of ether the flask is placed in an oven and heated for about 3 hours at a temperature of from 30° to 40°C., or until the weight becomes constant. The residue consists of the terpenes (3).

The residual mixture from the steam distillation is filtered to remove the solid residue. The filtrate, containing some non-volatile oil, is treated in the same manner as the volatile oil except that the last traces of ether are removed by heating at a temperature of from 40° to 50°C. The residue is the non-volatile terpenes (4).

The solid residue is dissolved in ether and shaken several times with aqueous potassium hydroxide (1 per cent). The ether extract is separated from the aqueous solution and manipulated like the ethereal extract containing the nonvolatile terpenes (4). The final product contains resenes (5) and related substances (amyryns, etc.).

The aqueous solution from the ether extract is steam distilled to remove ether and cooled to room temperature. A small amount of a white precipitate may sometimes appear at this stage as the separation of resenes and potassium salts of resin acids may not be complete. Ether is somewhat soluble in water and a small amount of resene constituents in the ether may remain with the aqueous solution of potassium salts. If a white precipitate forms it should be removed by filtering through a weighed filter paper. It is then dried to constant weight at from 40° to 50°C. This weight is added to that of the resenes (5).

By acidifying the aqueous solution of the potassium salts with concentrated hydrochloric acid the amorphous resin acids are precipitated. These are filtered through a weighed filter paper and washed with water until they are free of chlorides. The filter containing the acids is allowed to drain thoroughly after which it is dried in an oven at from 40° to 50°C., until the weight of the resin acids (6) becomes constant.

Water in Manila elemi.—This resin usually contains a small amount of water, less than 5 per cent. The presence of water can be proved by adding to an interior portion of the resin some powdered anhydrous copper sulfate which immediately turns blue. Water is conveniently determined by difference, that is, the difference between 100 per cent and the sum of the percentages of all the other constituents contained in the elemi.

Elemi constituents.—The data (Table 1) show that high-grade Manila elemi, containing only a small amount of insoluble matter, consists principally of resenes together with some resin acids and volatile terpenes. It also contains a very small amount of nonvolatile terpenes. The resenes are not acted upon by alkalies and other common chemical reagents. This

characteristic is said to enhance the value of resene resins for the manufacture of varnishes.

TABLE I.—Composition of Manila elemi.

Constituent	Sample		
	1	2	3
Insoluble matter	<i>Per cent</i> 1.00	<i>Per cent</i> 0.35	<i>Per cent</i> 0.57
Terpenes:			
Volatile	17.40	25.21	20.01
Nonvolatile	2.08	1.07	1.22
Resenes, etc.	61.44	55.50	58.95
Resin acids	15.33	16.02	18.00
Moisture (by difference)	2.75	1.85	1.25
Total	100.00	100.00	100.00

All three samples had the same general constituents but the percentage of any particular one varied somewhat in the different samples. Specimens of elemi from the same tree may not have the same composition due to ageing and weathering. Resin that has been clinging to a pili (elemi) tree for some time and has become rather hard and weathered will naturally have a composition somewhat different from soft resin very recently exuded from the tree.

The important constants of one of these samples (Table 1) are given below:

Sample No. 2:

Saponification No.	28.53
Acid No.	18.50
Ester No.	10.03

Here again these data show that Manila elemi contains only a comparatively small amount of free resin acids and saponifiable matter.

M. Mladenovic¹⁰ analyzed a sample of Manila elemi by a method quite different from the one we used and obtained 24 per cent of volatile oil, about 15 per cent of resin acids and about 60 per cent of resenes and related substances. These results are similar to the data given in Table 1.

In accordance with the procedure in the text, the resin acids (6), were prepared from elemi resin (sample No. 3, Table 1). These acids gave the following constants:

Saponification	125.00
Acid No.	108.47
Ester No.	16.53

¹⁰ Bull. Soc. Chim. Roy. Yougoslav. 8 (1937) 175.

As shown by the data this product consists of a mixture of free acids and a saponifiable substance.

During recent years considerable research has been done on the resene and resin acid portions of Manila elemi. Each of these was found to consist of a mixture of substances. Further investigations along these lines should be carried out.

SUMMARY

Manila elemi is a resin that is contained in the bark of the pili tree, *Canarium luzonicum* (Blume) A. Gray. This tree grows abundantly in low and medium altitudes in the primary forests of Luzon, Mindoro, Ticao and Masbate.

When the bark of the pili tree is cut the resin oozes out. At first it is always soft and has a very fragrant odor. On standing, however, it gradually loses volatile constituents and hardens. The resin is said to flow best during the rainy season and accumulates in large masses of more than 30 kilos. It is used in making plasters, ointments, paints, varnishes, and for various other purposes.

An accurate and convenient method was devised for analyzing Manila elemi. This resin was found to consist principally of resenes together with some resin acids and volatile terpenes. By steam distilling the resin the volatile terpene oil passes over into the distillate leaving a residue of resenes and other elemi constituents. These various groups of residual substances are separated from each other by appropriate procedures.

The resenes are not acted upon by alkalies and other common chemical reagents. This characteristic is said to enhance the value of resene resins for the manufacture of varnishes.

Using a different method of analysis M. Mladenovic obtained results similar to those recorded in this report.

BOOKS

Books reviewed here were received by The Philippine Journal of Science from their respective publishers.

REVIEWS

Surface Active Reagent; Theoretical Aspects and Applications. By C. B. Young and K. W. Coons. Brooklyn, Chemical Publishing Co., Inc., 1945. 381 pp. illus. Price, \$6.00.

Information obtained from this book will prove of great value to chemists and other technical men of industries. This book contains numerous tabulated data and illustrations, and a list of selected references at the end of each chapter.

The first part of the book deals in detail with the theoretical side of surface tensions, the relation between surface tension and other chemical and physical properties of matter and the structures and effects of surface active agents. Methods of determining surface tension are given. The apparatus used are described. Chemical and mathematical equations and a comprehensive table of such data as the trade names of the wetting agents, type or chemical compositions of the compounds and their use in industry and manufacture are also available.

The second part discusses extensively the utilization of the phenomenon of surface tension in various branches of industries. Many specific formulas for emulsions and other products based on the applications of surface tension agents are given at the end of each chapter.—C. N. C.

Fundamental Electronics and Vacuum Tubes.—By Arthur Lemuel Albert. New York, The Macmillan Co., 1947. 510 pp., illus. Price, \$6.00.

This book is devoted to a study of the fundamental principles governing the operation of electronic vacuum tubes and associated devices with the aim in view of imparting to the technical student a thorough knowledge of the great possibilities which the vacuum tube may be put into use in the ever expanding field of electronics.

The first chapter deals with the elementary concepts of matter, waves, electron, proton, positron, neutron, atomic structure, photon, quantum-treated in accordance with the latest theories and in a precise and clear style. This is followed in the next two chapters by the various processes of electron emission, the third chapter being devoted entirely to thermionic emission which is the most common type of electron emission used in commercial electronic today. The succeeding

five chapters treat of the electrical characteristic of practically all types of vacuum tubes, from diodes to multi, electrode vacuum, both gaseous and high vacuum types. The treatment is mathematical and includes a considerable number of characteristic curves and diagrams which may be of practical value to the technical researcher. The last seven chapters are devoted to the applications of electronic vacuum tubes apparently with especial reference to communication purposes—the use of vacuum tubes as voltage amplifiers, oscillators, including ultra high frequency oscillators, modulators, demodulators, etc. A discussion on the use of vacuum tubes as measuring devices, such as vacuum tube voltmeters, cathode ray tubes and photo-electric tubes, is also included.

References, questions and problems are provided at the end of each chapter, making the entire treatise a suitable textbook for any one who desires to have a thorough foundation in electronics.—E. P. R.

Dynamic Aspects of Biochemistry. By Ernest Baldwin. New York, The Macmillan Co., 1917. 456 pp., illus. Price, \$4.00.

This book gives a good idea about enzymes, with their functions and properties well discussed. The role they play in the utilization of food substances by the animal and human body is well presented. The book gives a good discussion on the ability of simple organisms to utilize simple substances for their needs, deriving their energy from the energy locked in complex substances. It also shows the dependence of higher forms of animal life for their subsistence on higher forms of animal and plant.

Students on the fundamentals of fermentation should take note of this book for its well written accounts on carbohydrates, nitrogen, proteins, fats and the end products of metabolism. This book is an excellent text or reference for students in fermentation.—R. R. O.

Inorganic Process Industries. By Kenneth A. Kobe. New York, The Macmillan Co., 1948. 371 pp., illus. Price, \$6.00.

The book is an able presentation of the processes involved in the operation of some inorganic chemical industries. The first chapter is devoted to technical literature on related subjects. It gives a practical approach to the first problem confronting a researcher or a technologist seeking information on matters pertaining to his field of activities. The other chapters give a thorough description of the manufacturing processes, the function of each equipment as a unit as well

as an integral part of the whole system and diagrammatic illustrations of the steps involved in the processing of materials from their raw conditions to their final forms. From the accumulated information, so methodically presented and comprehensibly discussed, the researcher or professional man is placed in a position to understand thoroughly the conditions under which the different units of a system operate to attain the desired results at a minimum expense.

The theoretical aspects of each process is also ably discussed, with a classified list of the references wherefrom detailed technological information on the various phases of the manufacturing operations may be secured.

The economic side has not been neglected. The relative costs of production by different processes and the marketing problems relative to trade names, commercial gradings, method of shipping, etc. of products are thoroughly discussed in the most practical way.

The book as a whole is a valuable guide for technical men engaged in teaching, research, factory control or consulting activities and for students of industrial technology. It should form an integral part of their reference libraries.—R. H. A.

Zinsser's Textbook of Bacteriology. Revised by David T. Smith and others. 9th ed. New York, Appleton-Century-Crofts, Inc., 1948. 992 pp., illus. Price, \$10.00.

Zinsser's Textbook of Bacteriology is already known and has been used by medical students since its first publication in 1910. The 9th edition, 1948, of the book which was revised and edited by the students of the author gives in detail the modern conception of the biological characteristic of the organisms and the reactions of the living tissues to the bacteria and their products.

The book is divided into seventy-seven chapters. The outline and arrangement of the chapters remain the same as in the eighth edition with the exception of the chapter dealing with Pleuro-pneumoniae-like organisms and the Testing in vitro of sulfonamides and antibiotics (penicillin and streptomycin) sensitivity which are new additions. The nomenclature is based on Bergey's Manual of Determinative Bacteriology, 6th edition, 1948. (For example in chapter XXXIII *Salmonella typhosa* and Typhoid fever, the causative bacillus of the typhoid fever, had many names: *Bacillus typhosus*, *Bacillus typhi abdominalis*, *Salmonella typhi*, *Eberthella typhosa* and finally *Salmonella typhosa*.)

Quite a long list of antibiotics is presented with their agent, source, range of activity, toxicity, properties and uses.

The definition of every subject is simple and sufficiently comprehensive, and every discussion is clear and accurate based on up to date findings of known researchers. The book contains every phase of bacteriology, from bacteria, moulds fungi, filterable viruses, their environment, metabolites, modes of infection and control to immunology, antibodies and complement fixation. In the discussion of the normal blood typing it also shows the importance of the detection of the Rh factor, which is important because of its immunizing ability.

Extensive work on filterable viruses has been recorded and supported with electron micrographs. The medical mycology is fairly discussed with many recent illustrations of the causative organisms. Due to the clear and accurate presentation of facts and the inclusive and thorough coverage of everything regarding bacteria known to date, the Zinsser's Textbook of Bacteriology is highly recommended for medical students, medical practitioners and health officers not only for their study but also as a guide for extensive work. The book is also valuable for the extensive references cited in it.—M. B.

A Textbook of Heat for Upperclassmen. By LeRoy D. Weld. New York, The Macmillan Co., 1948. 436 pp., illus. Price, \$5.00.

A glance on the table of contents will show that the subject matter treated is adequately covered. The outstanding feature of the book is its plain and simple treatment of well-known theorems and laws; this style is well shown in Chapter I when the author made use of Longfellow's character in "Song of Hiawatha" Pak-Puk-Keewis "who can pass readily from one another of a great variety of forms" to avoid confusion in the often use of expressions as *transfer of heat*, *heat of vaporization*, etc. And though he intended this textbooks for upperclassmen familiar with differential and integral calculus, he proceeded to show step by step the derivation of every formula—thus keeping the treatment well within the comprehension of the usual run of students. For those who want to delve deeper in the subject, a list of references is appended to each chapter. In short, here is your "Textbook of Heat" in eleven easy chapters.—L. G. A.

THE PHILIPPINE JOURNAL OF SCIENCE

A SUPPLEMENTARY GUIDE FOR RAPID IDENTIFICATION OF THE LARVÆ OF ANOPHELES MINIMUS FLAVIROSTRIS (LUDLOW) AND ANOPHELES MANGYANUS (BANKS)¹

By RUFINO B. GAPUZ and DOMINGO SANTIAGO
Of the Malaria Control Division, U. S. Public
Health Service, Manila

FOUR PLATES

King (1932), in his descriptive notes on the three Philippine *Anopheles* of the funestus-minimus subgroup, described the larvæ of *Anopheles minimus flavirostris* (Ludlow) and *Anopheles mangyanus* (Banks) as follows:

Anopheles minimus var. *flavirostris*.—Clypeal hairs simple and unfrayed, outer and posterior occasionally forked; the posterior hairs as a rule do not extend beyond the base of the inner (with the head in a horizontal position); inner submedian prothoracic hairs usually with more than 21 branches; leaflets of thoracic palmate tapered to a short point, without a filament; tergal plate of segment 1 narrow, oblong; plate of second segment deeply concave with the small median plate or a portion of the main plate detached; tergal plates on segments 3 to 7 usually convex posteriorly and narrowed toward ends; anterior tergal hairs (hair 0) usually arise well away from the plate; antepalmate hairs (hair 2) of segments 2, 3, and 7 branched from the basal third; dorsal surface of larva with heavy subdermal pigmentation.

Anopheles mangyanus.—Clypeal hairs similar to the above except that the outer and posterior are longer, the latter extending to or nearly to the edge of the clypeus; inner anterior prothoracic hairs usually with from 18 to 23 branches; leaflets of thoracic palmate hairs with a fine

¹This study was made under the auspices of the U. S. Public Health Service in connection with the Philippine Rehabilitation Act of 1946 of the 79th Congress of the United States.

filament; tergal plates of segments 1 and 2 similar to var. *flavirostris*, those of segments 4 to 7 with broader ends; small submedian plates usually chitinized; anterior tergal hairs usually arise from the tergal plate, sometimes near the edge either just on or just off the plate; antepalpmate hairs of segments 2 and 3 usually branched from the middle third; antepalpmate hair of segment 7 simple, or occasionally forked apically, larvæ pigmented with abundant spots of opaque white that are collected into submedian streaks on the thorax.

Keys to larvæ of A. minimus flavirostris and A. mangyanus.— In 1934 Russell and Baisas made a key to the Philippine species of the genus *Anopheles*. The two species in question may be identified, thus:

- | | |
|---|---|
| 1. Inner clypeal hairs widely separated | 11 |
| 11. Inner and outer clypeal hairs simple | 12 |
| 12. Palmate 1 developed | 13 |
| 13. Tergal plates large | 14 |
| 14. Leaflets of thoracic palmate hairs extended into long slender filaments; antepalpmate VII simple or forked apically | <i>mangyanus</i> |
| Leaflets of thoracic palmate hair not extended into long slender filaments; antepalpmate VII branched basally | <i>minimus</i> var. <i>flavirostris</i> |

Russell, Rozeboom, and Stone (1934) adopted a key based on that by Russell and Baisas (1934), to wit:

- | | |
|---|-----------------------------|
| 1. Inner clypeal hairs widely separated | 12 |
| 12. Clypeal hairs simple | 13 |
| 13. Abdominal segment 1 with developed palmate hairs | 14 |
| 14. Abdominal tergal plates large | 15 |
| 15. Thoracic palmate leaflets produced into long slender filaments; abdominal segment 7 with antepalpmate hairs (No. 2) single or forked apically | <i>mangyanus</i> |
| Thoracic palmate leaflets not produced into long slender filaments; abdominal segment 7 with antepalpmate hairs (No. 2) branched basally | <i>minimus flavirostris</i> |

In 1946, Baisas published a key to the larvæ of Philippine *Anopheles* based on natural groupings. It may be mentioned that this is now generally used in the identification of *Anopheles* larvæ in the Philippines.

The three species under Group *Myzomyia* (inner anterior clypeal hairs widely separated, tergal plates large) may be differentiated as follows:

- | | |
|---|-----------------|
| 1. Inner clypeal hairs with fine lateral branches; tergal plate II convex at the posterior border | <i>filipinæ</i> |
| Inner clypeal hairs simple; tergal plate II concave at posterior border | 2 |

2. Antepalmate VII simple or branched apically; leaflets of thoracic palmate extended into long points..... *mangyanus*
 Antepalmate VII branched near the base; leaflets of thoracic palmate taper into short blunt points..... *minimus* var. *flavirostris*

Bohart (1945) in his A Synopsis of the Philippine Mosquitoes, describes the larvæ of the above species as follows:

Anopheles (myzomyia) mangyanus (Banks).—The larva is characterized by its simple clypeal hairs, the short and stoutly branched prothoracic hair 1, the slender but well developed palmate hair on abdominal tergite I and the rat-tailed apices of the leaflets on the palmate hair of tergite IV. It is very close to *minimus flavirostris* which differs in the somewhat thicker apices of the leaflets on the thoracic palmate hair and in having antepalmate hair 2 of abdominal tergite VII single or apically forked.

Anopheles (myzomyia) minimus flavirostris (Ludlow).—The larva of this species closely resembles that of *mangyanus* but differs from it in having the apices of the thoracic palmate hair not drawn out into filaments and in having the antepalmate hair 2 of abdominal tergite VII branched basally.

It will be noted that of the three recognized Philippine species of the Group Myzomyia, *Anopheles filipinæ* Manalang is easily identified by the convex posterior border of the second tergal plate (large). But considerable difficulty has been encountered, especially by a novice, in the identification of *A. mangyanus* and *A. minimus flavirostris* (both with concave posterior border of tergal plate II). The thoracic palmate (Plate 1-A) and antepalmate VII (Plate 1-B) are not easy to locate, especially as in most cases the specimens are examined alive. Moreover, the character of the thoracic palmate leaflets can be appreciated best only when the high power objective (X 450) is used. This involves a considerable loss of time and may lead to erroneous identification especially when one has to examine hundreds of larvæ. When the thoracic palmate and the antepalmate VII are used as landmarks, even an experienced worker may have to take some time to arrive at a correct identification.

Oftentimes the aforementioned anatomical parts are detached or mutilated, in which case the examiner encounters considerable difficulty. The keys published by Russell and Baisas, Russell *et al.*, and Baisas, mentioned previously, cannot afford any relief.

When confronted by this predicament, few resourceful examiners may resort to King's description of tergal plates III to VII, which are "usually convex posteriorly" in *A. minimus flavirostris*, or have "broader ends" in *A. mangyanus*. Russell and Baisas (1934) also described tergal plates IV to VII as rounded

or blunt at the edges in *A. mangyanus*, tapering towards the edges in *A. minimus flavirostris*. However, these and other authors, for some reason or other, made no mention of the specific importance of the tergal plate or plates, since they invariably point to the thoracic palmate and antepalmate VII in their keys to larvæ of Philippine anophelines.

TAXONOMIC IMPORTANCE OF TERGAL PLATE VII

It has been observed that the seventh tergal plate, not to mention the other tergal plates, has a constant and definite shape, and that the shape of the tergal plate in *A. mangyanus* differs from that in *A. minimus flavirostris*. The posterior border of the seventh tergal plate in *A. mangyanus* is more or less a straight line (Plate 2-C), while in *A. minimus flavirostris*, it is convex or curved posteriorly (Plate 2-B).

This observation was subjected to an extensive and rigorous test, in the laboratory and in the field, in the hope of finding a variation or exception. Hundreds of specimens were examined and invariably the identification made according to the character of thoracic palmate leaflets and antepalmate VII corresponded with the identification made according to the character of the posterior border of the seventh tergal plate.

Carrying the test further, fifty *A. mangyanus* larvæ and also fifty *A. minimus flavirostris* larvæ were collected at different places and at different times and were individually bred out. Without exception, the imago identification was the same as the corresponding larval identification.

SUMMARY AND CONCLUSIONS

It will be seen that by the tergal plates alone, the three species under Group *Myzomyia* could be definitely and rapidly identified. The advantage of the seventh tergal plate over the thoracic palmate and antepalmate VII cannot be overemphasized. The first is easily located, cannot be detached, and the character of the posterior border can easily be appreciated even if live larvæ are examined as early as the second instar. On the other hand the thoracic palmate and antepalmate VII are easily detached or mutilated, and not easily located, and their characters are not easily evaluated especially when the specimen is examined alive.

A comparative illustration of the landmarks used in the identification of the larvæ of *A. minimus flavirostris* and *A. mang-*

yanus, both those adopted in keys to larvæ and those described in this papers, are shown in Plate 3 and Plate 4.

The following key to the larvæ under Group *Myzomyia*, that is, the larvæ with large tergal plates, may be adopted especially where rapid identification is desired.

1. Tergal plate II with convex posterior border *filipinæ*
Tergal plate II with concave posterior border..... 2
2. Tergal plate VII with convex posterior border.
minimus flavirostris
Tergal plate VII with more or less straight posterior border.
mangyanus

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ILLUSTRATIONS

PLATE 1

- FIG. 1. Thoracic palmate of *A. mangyanus* and *A. minimus flavirostris*, compared. Character of leaflets can best be appreciated by using high power magnification (X 450).
2. Antepalmate VII of *A. mangyanus* and of *A. minimus flavirostris*, compared. Its relation to other structures, indicated.

PLATE 2

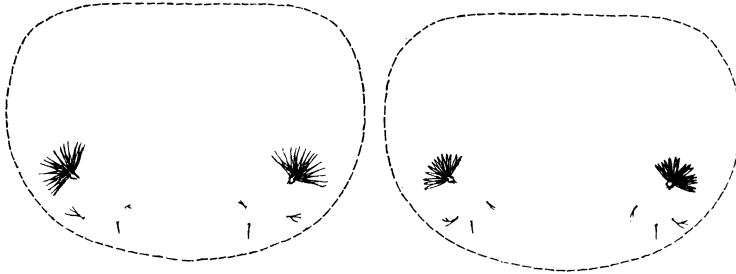
- FIG. 1. Tergal plates of *A. filipinæ*. Second tergal plate with convex posterior border.
2. Tergal plates of *A. minimus flavirostris*. Second tergal plate with concave posterior border. Seventh tergal plate with convex posterior border.
 3. Tergal plates of *A. mangyanus*. Second tergal plate with concave posterior border. Seventh tergal plate with more or less straight posterior border.

PLATE 3

- FIG. 1. Landmarks (second tergal plate, thoracic palmate, and antepalmate VII) used in the identification of *A. minimus flavirostris* according to keys of various authors.
2. Landmarks (second and seventh tergal plates) used in the identification of *A. minimus flavirostris* as described in this paper.

PLATE 4

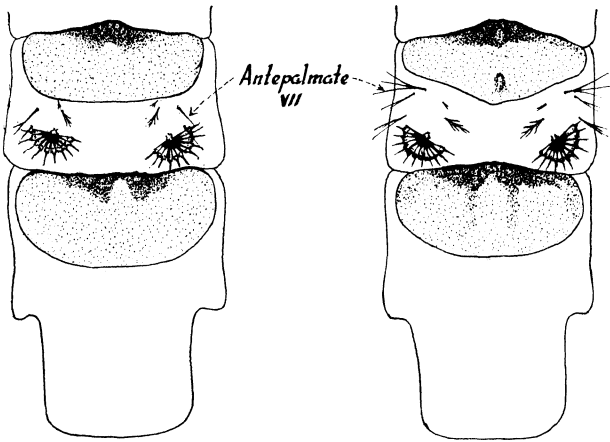
- FIG. 1. Landmarks (second tergal plate, thoracic palmate, and antepalmate VII) used in the identification of *A. mangyanus* according to keys of various authors.
2. Landmarks (second and seventh tergal plates) used in the identification of *A. mangyanus* as described in this paper.



A. mangyanus

A. minimus flavirostris

1



A. mangyanus

2

A. minimus flavirostris

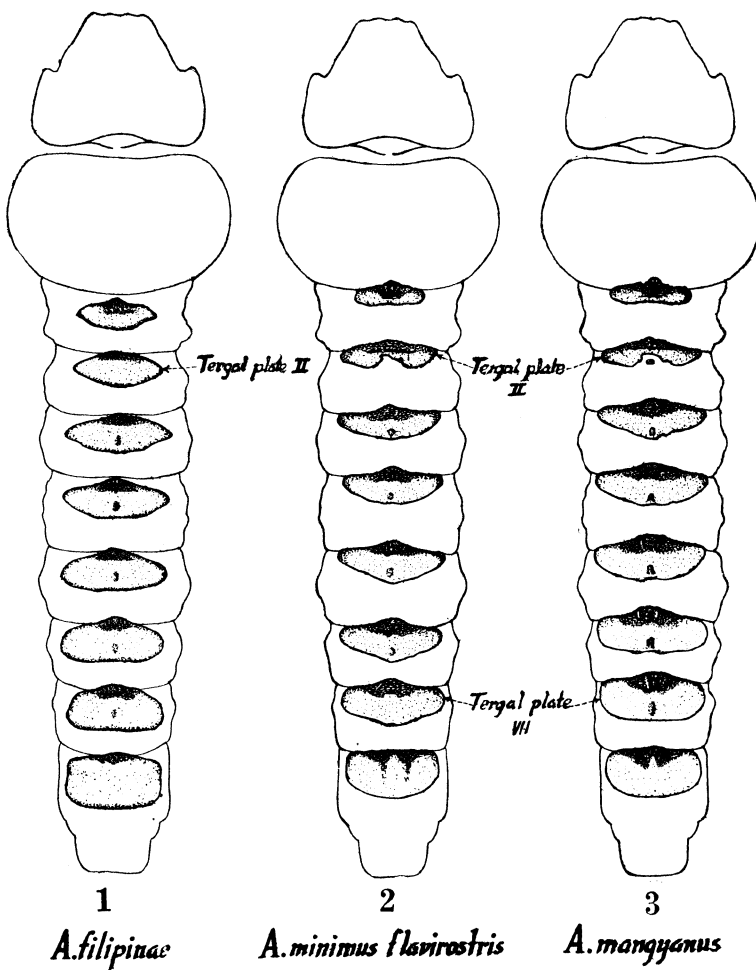


PLATE 2.

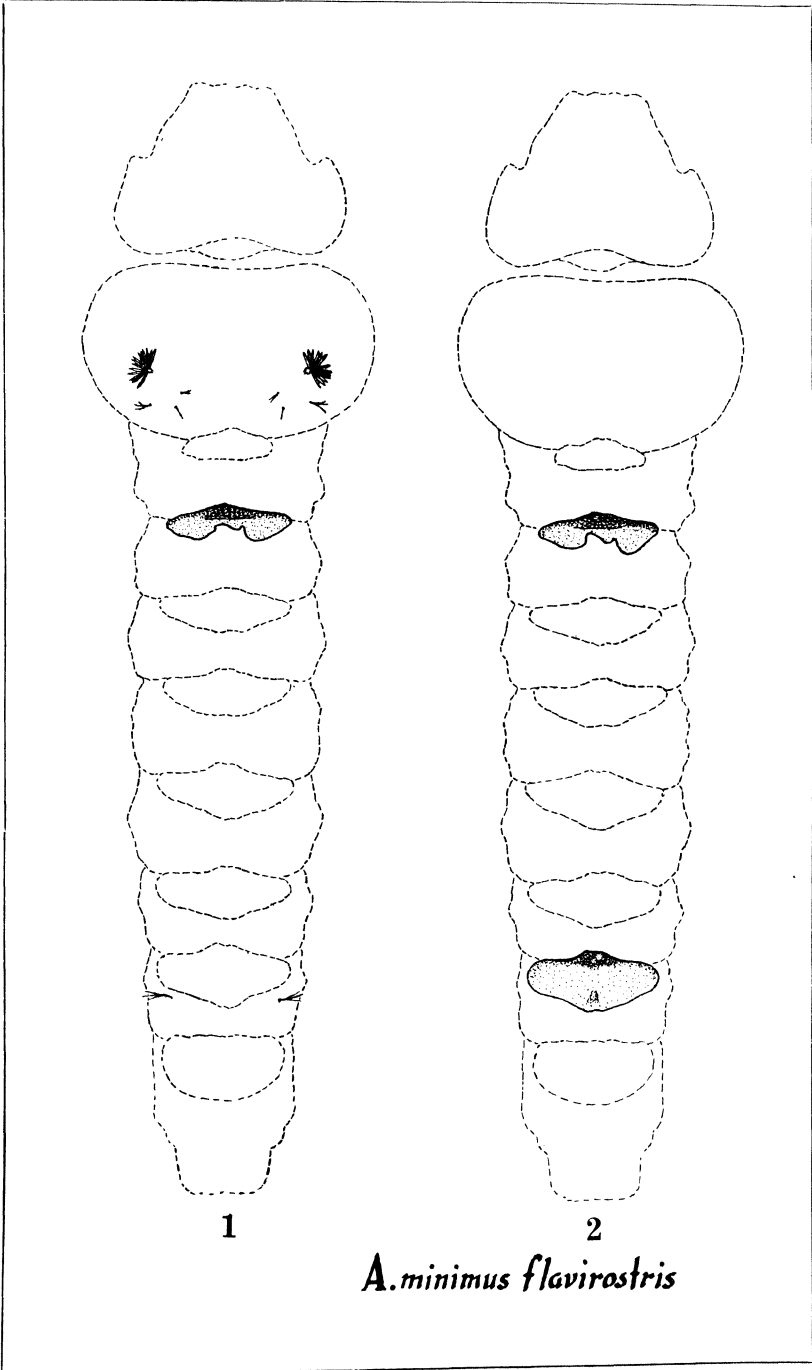
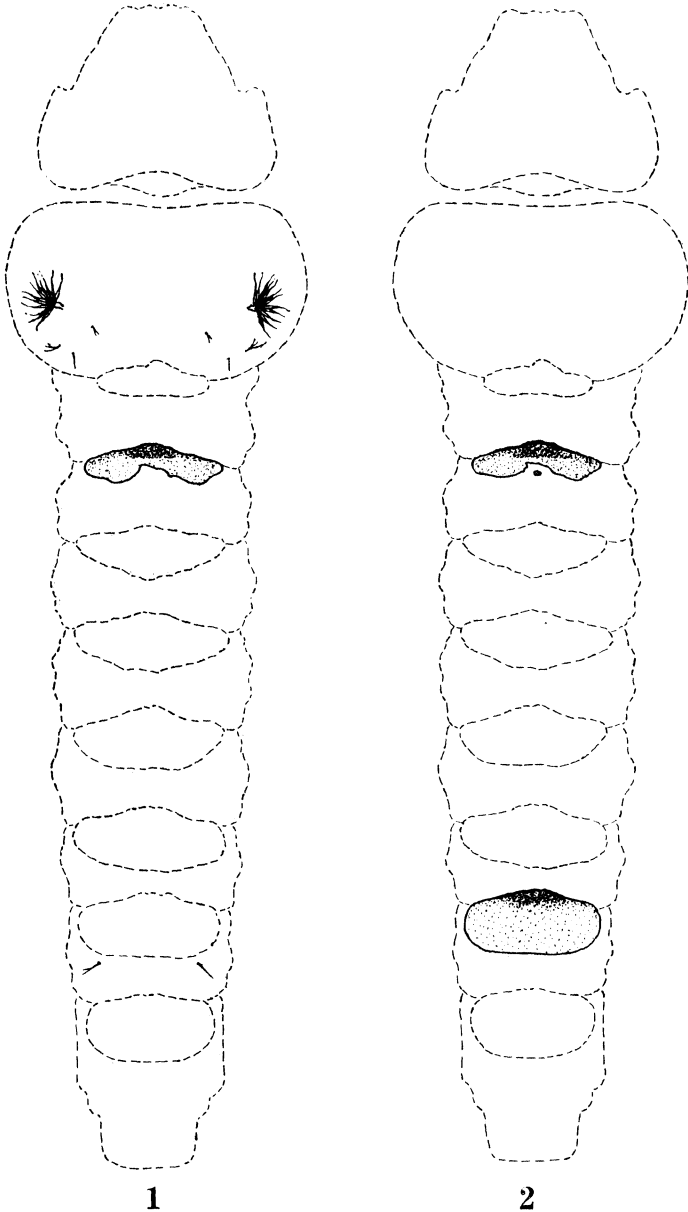


PLATE 3.



A. mangyanus

OBSERVATIONS ON THE MODE OF ACTION OF NAGANOL (BAYER 205) AS A TRYPANOCIDAL AGENT

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In the Philippines naganol¹ is extensively used in the treatment and prophylaxis of equine and bovine surra, a disease due to infection with *Trypanosoma evansi* (Steel, 1885). The dose of the drug ordinarily advocated and employed by most veterinarians is 0.5 gm. per 100 pounds of body weight, but there are those who claim that a large knockout dose should be used in order to effect Ehrlich's *therapia magna sterilizans*.

Before and during the early part of World War II, the writer conducted a series of *in vitro* and *in vivo* studies on the mode of action of naganol and other trypanocidal drugs. The object was to determine whether the drug has a direct trypanocidal effect and if it is more rapidly lethal to the trypanosomes in bigger doses. Several investigators, using various species of trypanosomes, have postulated that naganol has no direct trypanocidal effect, but according to the available literature the mode of action of the drug against *T. evansi* has not yet been studied.

MATERIALS

The strain of *Trypanosoma evansi* used in the *in vitro* studies was originally obtained from a naturally infected Philippine pony and was maintained in the laboratory in guinea pigs. The trypanosomes used in the *in vivo* experiments were from the blood of four horses, of which Horses A, B, and C were naturally infected animals which were brought to the laboratory for treatment. Horse C was a case which had relapsed from a previous treatment (drug used presumably naganol) instituted in one of the veterinary hospitals in Manila; Horses A and B were primary cases. Horse D was infected with trypanosomes from an experimental rat.

¹ Also known as Bayer 205, germanin, antrypol, suramin, moranyl, Forneau 309.

EXPERIMENTAL

Exposure of T. evansi to naganol in vitro:

Experiment 1.—On October 15, 1940, two drops of horse blood teeming with trypanosomes (100,000,000 per c.c.) were added to each of three tubes containing 5 c.c. of a medium composed of equal parts of horse serum and Locke's solution with 0.2 per cent glucose and 0.1 mg. naganol per c.c. of the serum-Locke solution. The same amount of infected horse blood was added to each of two tubes containing 5 c.c. of the serum-Locke-glucose medium but with no naganol. The mixtures were left at room temperature for a period of three hours, after which they were centrifuged and the sediments washed two times with 0.85 per cent sodium chloride solution. A drop of the sediment was examined under the microscope and if found positive for actively motile trypanosomes, one-half of the remaining sediment resuspended in 1 c.c. of the supernate was inoculated into a white rat. Three white rats, Nos. NR-1, NR-2 and NR-3, were each inoculated in this manner with the sediments of the test tubes containing naganol and two other rats, Nos. OR-4 and OR-5, were inoculated with the sediments of the control tubes which contained no naganol in the medium.

The number of trypanosomes inoculated per rat, in both the naganol and the control rats, was approximately 3,000,000 per 100 gram body weight, assuming that one-third of the original number was either lost or killed during the process of centrifugation.

Results.—The results are shown in Table 1. Rats NR-1, NR-2 and NR-3, which were inoculated with the naganol-exposed trypanosomes remained healthy, and no trypanosomes were seen in their peripheral blood during a six-month-period of observation. Control rats OR-4 and OR-5, on the other hand, showed the presence of trypanosomes in their blood on the fourth day from the time of inoculation and died on the seventh and eighth day, respectively.

TABLE 1.—*Showing the effect of naganol in vitro on the infectivity of Trypanosoma evansi*

Naganol conc.	Length of exposure <i>in vitro</i>	Trypanosomes before inoculation	Inoculated rats	Period of observation of rats	Result
<i>per c. c.</i>					
0.1 mg.	3 hours	very active	NR-1	6 months	Negative
0.1 mg.	3 hours	very active	NR-2	6 months	Negative
0.1 mg.	3 hours	very active	NR-3	6 months	Negative
0.0	3 hours	very active	OR-4	7 days	Positive on 4th day; died on 7th day.
0.0	3 hours	very active	OR-5	8 days	Positive on 4th day; died on 8th day.

Exposure of T. evansi to naganol in vivo:

Experiment 2.—On August 13, 1942, Horse A, whose blood was teeming with trypanosomes, was given 0.6 gm. of naganol per 100 pounds of body weight intravenously. This dose, which is higher than the usual initial therapeutic dose recommended by veterinarians in the treatment of surra in the horse, was calculated to give a blood concentration of approximately 0.14 mg. of the drug per c.c. The calculation was based on the probable blood volume of the animal, assuming that the total amount of blood in the horse is 9.7 per cent (Welcher, cited by Dukes, 1942) of the body weight and taking 1.06 as the specific gravity of horse blood. After the injection, blood from the animal was examined microscopically for trypanosomes from time to time during a period of twenty-seven hours.

Blood samples were withdrawn from the horse three hours and twenty-seven hours after the injection. One drop from each sample, which was positive for actively motile trypanosomes, was added to 5 c.c. of 1 per cent sodium citrate solution and 1 c.c. of the mixture was injected subcutaneously into a white rat (HR-6 was given the three-hour sample and HR-7 the twenty-seven-hour sample). The amount of naganol carried over with the horse blood into each rat was calculated to give a rat blood level of about 0.13 micrograms per c.c.

Results.—The results are given in Table 2. Actively motile trypanosomes were observed in the blood of Horse A during a period of observation which lasted for twenty-seven hours.

Rat HR-6 was observed for a period of forty-seven days; Rat HR-7 for one hundred seventeen days. No trypanosomes were seen in the blood of these animals during the respective periods of observation.

TABLE 2.—Showing the effect of naganol in vivo on the infectivity of *Trypanosoma evansi*

Source of trypanosomes	Approximate naganol conc. in horse blood	Period of exposure in vivo	Trypanosomes before inoculation	Inoculated rats	Period of observation of rats	Result
Horse A	0.14 mg.	3.13 hours	very active	HR-6	47 days	Negative
Horse A	0.14 mg.	26.88 hours	very active	HR-7	117 days	Negative
Horse B	0.14 mg.	2.00 hours	very active	HR-8	36 days	Negative
Horse B	0.14 mg.	3.00 hours	very active	HR-9	36 days	Negative
Horse C	0.14 mg.	2.17 hours	very active	HR-10	15 days	Positive on 9th day; died on 15th day.
Horse C	0.14 mg.	3.25 hours	very active	HR-11	22 days	Positive on 11th day; died on 22nd day.

Experiment 3.—On October 21, 1942, another naturally infected animal (Horse B) was treated with naganol to give a blood level of about 0.14 mg. of the drug per c.c. Blood samples were withdrawn two hours and again three hours after the injection of the drug. One drop from each of these blood samples was added to 5 c.c. citrate solution and 1 c.c. of the resultant mixture inoculated into a white rat (HR-8 was given the two-hour sample and HR-9 the three-hour sample).

Results.—The results are shown in Table 2. Actively motile trypanosomes were demonstrated in every blood sample of Horse B examined at different intervals during a period of twenty-one hours.

No trypanosomes were seen in the blood of Rats HR-8 and HR-9 during a period of observation of thirty-six days.

Experiment 4.—This experiment is the same as Experiment 3, except that the animal used (Horse C) was a case which had relapsed from a previous treatment with naganol.

Results.—The results are shown in Table 2. Actively motile trypanosomes were found in the blood of Horse C examined at different intervals during a period of twenty-one hours.

On the ninth day from the time of inoculation, Rat HR-10 was found positive for trypanosomes in the peripheral blood and died on the fifteenth day; Rat HR-11 showed the organisms on the eleventh day and succumbed on the twenty-second day. The long prepatent period and the protracted course of the infection in these animals are unusual and seem to indicate that either the virulence or the integrity of the parasites has been altered in some way by exposure to the drug.

Experiment 5.—On August 14, 1941, experimentally infected surra Horse D was given by the intravenous drip method massive doses of naganol in two installments. The first installment, at a dose of 0.7 gm. per 100 pounds of body weight, was administered continuously during a period of two hours; the second, after an interval of three hours at a dose rate of 1.3 gm. per 100 pounds of body weight, was given continuously for another period lasting two hours. The sum total of the drug given was approximately 2 gm. per 100 pounds of body weight, or four times the usual therapeutic dose. Calculated from the live weight of the animal, this was equivalent to a naganol blood level of about 0.48 mg. per c.c.

After the administration of the first dose and again after the second dose, blood was withdrawn and examined for trypano-

nosomes. Blood samples were also examined after twenty-two and twenty-eight hours from the time the first dose was given.

Results.—The results are given in Table 3. After the administration of the first and second doses, the blood of this animal was found swarming with trypanosomes; twenty-two hours after the administration of the first dose only a few but still actively motile trypanosomes were present; in the twenty-eight-hour sample no trypanosomes were found. (The results of this experiment will be reported in greater detail in another paper.)

TABLE 3.—Showing the result of blood examination of treated horses at different intervals after intravenous injection with naganol

Naganol treated horses	Approximate drug level <i>in vivo</i>	Microscopic findings in blood at different intervals											
		1.73 hr.	2 hr.	2.17 hr.	3 hr.	3.13 hr.	3.25 hr.	8.5 hr.	20.75 hr.	20.83 hr.	22 hr.	26.88 hr.	28 hr.
A	per c. c. 0.14 mg.		Swarming with actively motile trypanosomes		Swarming with actively motile trypanosomes	Swarming with actively motile trypanosomes						Few; trypanosomes, actively motile	
B	0.14 mg.		Swarming with actively motile trypanosomes	Swarming with actively motile trypanosomes	Swarming with actively motile trypanosomes		Swarming with actively motile trypanosomes			Markedly reduced; trypanosomes, actively motile			
C	0.14 mg.	Swarming with actively motile trypanosomes		Swarming with actively motile trypanosomes					Markedly reduced; trypanosomes, actively motile				
D	0.16 mg.											Few; trypanosomes, actively motile	
	0.48 mg.												Negative for trypanosomes

DISCUSSION

The results of the *in vitro* study reported in Experiment 1 show that naganol (Bayer 205) has a disarming action against *Trypanosoma evansi*, for although the exposed trypanosomes were actively motile when inoculated to rats they failed to cause infection. Several investigators (Nauck, 1925; Reiner and Kovestuky, 1927; Issekutz, 1933 and Hawking, 1939), working with different species of trypanosomes, have called attention to this disarming action of the drug. According to Reiner and Kovestuky (1927), Jancso and Jancso (1934) and Hawking (1939), this property of naganol has an opsonizing effect which renders the trypanosomes more sensitive to phagocytosis by the reticulo-endothelial system. Culbertson's (1939) observation on the more prompt action of germanin against *T. equiperdum* in old compared with young rats, which he believes to be related to a difference in the phagocytic capacities of the cells of rats of different age groups, and Hawking's (1940) success in culturing trypanosomes from the blood of a patient whose plasma-germanin level was 0.42 mg. per c.c., all seem to point to the conclusion that naganol has no direct trypanocidal activity.

The results of the *in vivo* experiments also point to the same conclusion, for it will be noted that the trypanosomes persisted in the blood of all the treated animals for twenty or more hours after the administration of the drug irrespective of dose size used. If the drug had a direct trypanocidal activity, a more prompt knockout effect could be expected by the use of large doses of it. This was not borne out by the results of Experiment 5 in which trypanosomes were seen in the blood of Horse D twenty-two hours after it was given massive doses of the drug.

Although the trypanosomes obtained from the experimental horses were not washed before inoculation into rats, the amounts of naganol carried over from the former to the latter are believed to be negligible. At most, the concentration of the drug in the inoculated rats could not have been more than 0.135 micrograms per c.c. of blood. Against highly virulent strains of *T. brucei*, Vierthaler and Boselli (1939) have found 1.3 mg. per 100 c.c. of blood (13 micrograms per c.c.) to be the smallest protective blood level of germanin (naganol) in the blood of rabbits. Against a strain of *T. rhodesiense*, Hawking (1939) has noted 0.2 mg. per 100 gm. rat (about 22 micrograms or

gamma per c.c.)¹ as the minimum effective dose. These amounts are 95 and 160 times greater than the calculated blood level of naganol in our experimental rats.

In rats inoculated with the blood of Horse C, the presence of a naganol-resistant strain of trypanosomes remains to be considered. It is to be recalled that Hawking (1939), using *T. rhodesiense*, has found germanin-resistant trypanosomes not to lose their infectivity upon incubation *in vitro* with as much as 1 mg. of naganol per c.c. of medium. With normal trypanosomes he found 0.1 mg. per c.c. to be sufficient to render the organisms noninfective to mice.

It is possible that Horse C, before coming to hand, had already been treated for surra with doses of naganol too small to be effective but enough to allow the trypanosomes to gradually develop tolerance against the drug, as has been observed by Van Hoof, Henrard and Peel (1938a) with *T. gambiense*. It is also possible that drug resistance may have been acquired after repeated exposures of successive generations of the strain to subcurative levels of naganol in the blood of one or more hosts of the same or different species. For these reasons, the potential danger of producing drug-tolerant strains of *T. evansi* through the unintelligent and indiscriminate use of naganol as a prophylactic and as a treatment for equine and bovine surra in the field should be borne in mind.

SUMMARY AND CONCLUSION

The effect of naganol against *Trypanosoma evansi in vitro* and *in vivo* was studied.

Virulent trypanosomes exposed *in vitro* for three hours to a naganol (germanin) concentration of 0.1 mg. per c.c. were rendered noninfective to white rats.

Blood swarming with trypanosomes obtained from two horses naturally infected with surra two, three and twenty-seven hours after the intravenous administration of naganol failed to infect white rats.

Blood obtained from a naturally infected horse, which had relapsed from a previous treatment (presumably with naganol), two and three hours after the intravenous injection of naganol, was infective to white rats which died after unusually long prepatent and patent periods. It is believed that the infection in this horse was due to a strain which was naganol-resistant

¹ Calculation in terms of blood level is by the present writer.

due to previous unsuccessful treatment with subcurative doses of the drug or as a result of repeated exposures of one or more generations of the strain to ineffective levels of the drug in the blood of one or more hosts of the same or different species. The potential danger of producing naganol-resistant surra organisms through the indiscriminate use of the drug in the field is pointed out.

In all of the naganol-treated horses, the trypanosomes were found actively motile up to twenty-seven hours after the administration of the drug. The organisms, however, were found to have markedly decreased in number at about the twentieth to the twenty-sixth hour.

The apparent lack of positive correlation between dose size of the drug and the rate of disappearance of the parasites in the peripheral circulation lends support to the hypothesis that naganol is indirectly trypanocidal.

ACKNOWLEDGMENT

The writer is much indebted to Dr. Zacarias de Jesus, former chief of the Parasitology and Protozoology Division, Bureau of Animal Industry and now Professor and Head, Department of Parasitology and Protozoology, College of Veterinary Science, University of the Philippines, without whose help and encouragement this study could not have been accomplished.

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COMPOSITION OF PHILIPPINE SINGKAMAS OIL FROM THE SEEDS OF PACHYRRHIZUS EROSUS (LINN.) URB.

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Singkamas oil is obtained from the seeds of an hairy herbaceous vine known botanically as *Pachyrrhizus erosus* (Linn.) Urb. Recently the composition of the oil was determined and the results showed that this oil consists principally of glycerides of oleic, linolic and saturated acids and is very similar in composition to kapok, rice, cottonseed, and peanut oils.

Brown and West¹ give the following description of *Pachyrrhizus erosus*:

Pachyrrhizus erosus is a rather coarse, somewhat hairy, herbaceous vine. The leaves are compound with 3 leaflets which are up to 15 cm. in length and 20 cm. in width. The flowers are pale blue or blue and white, 2 to 2.5 cm. long and borne in racemes which are up to 45 cm. in length. The pods are about 10 cm. long, 10-12 mm. wide, flat, hairy and contain from eight to ten seeds. The roots are large, fleshy, turnip-shaped. They are eaten raw or prepared in a variety of ways. The young fruits are sometimes eaten as a vegetable.

This species is a native of tropical America, but is now widely distributed in the tropics. It is thoroughly naturalized in the Philippines and is common in thickets. It is also extensively cultivated.

Heyne² stated that Greshoff found in the seeds 38.4 per cent of a colorless, limpid oil.

Lately several articles, dealing on the insecticidal property of *Pachyrrhizus erosus* beans, also known as yam beans, either alone or mixed with some other rotenone bearing plants were published. The results indicate the possibility of utilizing yam beans as insecticides.

L. B. Norton³ obtained by extracting the ground yam beans with ether, 1.4 per cent of the insecticidally active resin, after removing the oil.

¹ P. I. Bureau of Forestry, Bull. 20 (1920).

² De Nuttige Planten van Nederlandsch-Indie 2 (1916) 346.

³ Jour. Am. Chem. Soc. 65 (1943) 2257-60.

Shui-Luen Hwang⁴ reported to have obtained 0.56 to 1.01 per cent of rotenone from twelve samples. He further stated that oil expressed from the seeds contained rotenone to an extent to make it of insecticidal value.

EXPERIMENTAL PROCEDURE

The singkamas seeds used in this investigation were supplied through the kindness of Director Felix D. Maramba of the Bureau of Plant Industry. The seeds were ground to fine powder. The composition of singkamas seeds compared with soy beans is given in Table 1.

TABLE 1.—*Composition of Philippine singkamas seeds compared with Philippine soy beans.*

Constituent	Philippine	
	Singkamas seeds	Soy beans
	<i>Per cent.</i>	<i>Per cent.</i>
Moisture	9.3	5.
Oil (ether extract)	19.7	20.
Protein	29.5	39.7
Crude fiber	7.2	5.0
Ash	6.5	5.3
Carbohydrates (by diff.)	27.8	25.0
Total	100.0	100.0

As shown by the data singkamas seeds have a high protein content like soy beans.

Singkamas oil was prepared by extracting the ground seeds with ether. The extracted oil was purified by treating it with about 2 per cent of activated carbon. This treatment removes vegetable fibers and colloidal matter and produces a brilliantly clear yellowish brown oil.

The constants of this sample of Philippine singkamas oil are given in Table 2.

TABLE 2.—*Physical and chemical constants of Philippine singkamas oil.*

Specific gravity at 31°/4°C	0.9186
Refractive index at 31°C	1.4730
Saponification value	182.9
Acid value	2.6
Iodine number (Hanus)	84.1
Thiocyanogen value	56.8
Unsaponifiable matter	2.2

The saturated and unsaturated glycerides in singkamas oil were calculated from the iodine and thiocyanogen values in

⁴ Kwangsi Agri. 2 (1941) 296-80

accordance with the Official and Tentative Methods of the American Oil Chemists' Society. The results are recorded in Table 3. Included in Table 3 are compositions of other Philippine and American oils for comparison. As shown by the data Philippine singkamas oil is very similar in composition to rice, kapok, cotton seed and peanut oils. All these oils consist principally of glycerides of oleic, linolic and saturated acids.

TABLE 3.—Comparison of Philippine singkamas oil with other oils.

	Philippine oils.			American oils.	
	Singkamas oil	Kapok seed oil ^a	Rice oil (Hambas) ^b	Cotton seed oil ^c	Peanut oil ^d
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Glycerides of:					
Unsaturated acids—					
Oleic	32.9	49.8	45.6	35.2	52.9
Linolic	26.4	29.3	27.7	41.7	24.7
Saturated acids—	38.5	19.5	20.7	22.9	21.5
Unsaponifiable matter	2.2	0.8	4.0	-----	0.2
Total	100.0	99.4	98.0	99.8	99.3

^a Philippine kapok-seed oil (*Ceiba pentandra* Gaertner), analyzed by A. O. Cruz and A. P. West. Philip. Jour. Sci. 46 (1931) 131.

^b Philippine rice oil (Hambas variety), analyzed by A. O. Cruz and A. P. West. Philip. Jour. Sci. 47 (1932) 487.

^c American cottonseed oil analyzed by G. S. Jamieson and W. F. Baughman. Jour. Am. Chem. Soc. 42 (1920) 1197.

^d American peanut oil (Spanish type), analyzed by G. S. Jamieson, W. F. Baughman and D. Brauns Jour. Am. Chem. Soc. 43 (1921) 1372.

SUMMARY

Data recently published by several investigators showed the possibility of utilizing singkamas seeds as a source of insecticides.

Singkamas seeds have, like soy beans, a high protein content.

In this investigation the composition of Philippine singkamas oil obtained from the seeds of this plant by ether extraction was determined. The results indicate that the oil consists principally of glycerides of oleic, linolic and saturated acids. Singkamas oil resembles kapok, rice, cottonseed and peanut oils, although in different proportions.

A NEW LABRID AND OTHER INTERESTING PHILIPPINE FISH RECORDS

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The writer completed his Checklist of Philippine Fishes in May, 1948. This work lists 2,145 species actually known within the political boundaries of the Republic of the Philippines. Were one to include the names of those fishes recorded from nearby localities within 10 to 100 miles of Philippine soil, and certain to be captured in Philippine waters later on, the number would reach 2,300 or more. Intensive collecting almost anywhere in the Philippines will bring additions to the fish fauna of the Islands.

One of the least known regions of the Philippines, as far as its fish are concerned, is the east coast of Luzon, north of the latitude of Manila. I, therefore, take pleasure in presenting the description of a new labrid from that region. With it are also some notes upon a few other fishes, two of them new to the Philippines.

CHOERODON BALERENSIS, sp. nov.

Dorsal XII-8; anal III-9; pectoral II-13; scales in the lateral line 26, plus 3 on the caudal base; the tubules of the anterior half of the lateral line are branched, becoming simple posteriorly. Three scales above the lateral line to the first dorsal spine, 9 below. Dorsal and anal each with a high basal scaly sheath. 8 predorsal scales; a band of smaller scales behind the interorbital region above the posterior part of the eye, followed by a narrow naked area.

The form is oval, the dorsal and ventral profiles both uniformly convex, the depth 2.3 times in the length. The head is rather small, 2.8, the truncate caudal 3.5 times in the length. The large prominent eye is high up, 3.85 times in the head, its diameter a little less than the width of the slightly convex interorbital, 1.46 times in the snout, which is 2.63 in the head. The maxillary equals the interorbital, its posterior angle extending back below the anterior half of the eye, 3.57 in the

head. The canines are prominent, the outer pair of the mandible much the largest; no posterior canine. The preopercle with 9 rows of scales, its posterior and inferior limbs naked, its posterior border smooth; the opercle with 4 rows of scales, the two most posterior much the largest. The scales forming the posterior row at the caudal base enlarged and pointed.

Dorsal and anal relatively low, their real height concealed by the high basal sheath, the five posterior spines equal to or slightly longer than the snout; the membranes between the spines are deeply incised and prolonged in a filament extending beyond each spine. The soft dorsal equals the spinous in height. The first anal spine equals the eye, the third equals the snout, the second is nearly as long; the anal rays like the soft dorsal. Pectorals broad, the upper rays elongate, pointed, 1.16 in the head; ventrals short, not reaching the anus, 1.78 in the head; least depth of caudal peduncle 2.27 in the head; upper caudal rays slightly produced.

In life the general color dorsally was dusky, with a broad dusky or blackish band covering the posterior part of the body from the anterior part of the soft dorsal to the anal and back to the caudal base. Six brilliant orange bands with very dark blue margins girdled the body; the first descended from the eye, the second from the nape, the third from the dorsal origin, the sixth from the last dorsal spine and first dorsal ray. The lower part of the head and body was pale to whitish. Across the snout were two orange bands with indigo margins, and a broad orange band connected the eyes. The strong canine teeth were bright blue. The dorsal and anal each had a broad longitudinal orange band with deep indigo margins, their spines bright blue.

The tips of the dorsal filaments and margin of the soft dorsal and anal were indigo. The pectorals were clear yellow, the ventral spines blue, the rays orange. The caudal fin had a broad basal yellow band, the rest of the fin colorless.

In preservative, the orange cross bands blackened on the dorsal region but faded below, while their margins and the stripes and band on the head also blackened.

Here described from the type and sole specimen, 139 mm. long, obtained on a coral reef at Baler, Quezon (Tayabas) Province, Luzon. This fish is notable for its brilliant colors and striking color pattern. It was collected by Mr. R. B. Fox, anthropologist with the Philippine National Museum.

Key to Philippine Species of *Choerodon*

- A. Ventrals greatly produced, extending upon anal in adults; silvery spot below middle of spinous dorsal, with a dark patch below it.
C. obligacanthus
- AA. Ventrals not reaching anal.
- B. Body more elevated, depth 2.3 to 2.6 in length.
- C. Six transverse orange bands with deep blue margins on head and body..... *C. balerensis*
- CC. No pattern of cross bands.
- D. Pale abdominal color extends upward as wedge or bar to lateral line below middle of spinous dorsal; caudal peduncle with pale saddle..... *C. anchorage*
- DD. An orange or yellow band from pectoral axil to caudal base *C. zamboangæ*
- DDD. Pale line from snout through eye and small white spots on anterior scales of body.
C. margaritiferus
- BB. Body slenderer, depth 2.5 to 3.3.
- E. A broad dark band on side of body.
- E. A dark band from axil to pectoral to posterior part of dorsal, widening posteriorly; a broad silvery band above it..... *C. zosterophorus*
- EE. A broad curved dark band from above pectoral tip to posterior part of soft dorsal.
C. melanostigma
- EE. No broad dark band on side; a dark spot below 3 posterior dorsal spines; a large pale blotch between soft dorsal and lateral line.
C. schoenleini

Family SCYLLIORHINIDÆ

SCYLLIORHINUS TORAZAME (Tanaka)

Catulus torazame Tanaka Jour. Coll. Sci. Tokyo 23 (1908) 26, Plate 2. Fig. 2. Misaki, Sagami, Japan; Garman, Memoirs Mus. Comparative Zoology 26 (1913) 77, Misaki, Japan.

Halaehurus torazame Tanaka, Fishes Japan 5 (1912) 87; Schimdt, Rendu, Acad. Sci., U.S.S.R. (1930) 285, Figs. 1 and 2, Tokyo, Fusan, Misaki; Schmidt, Copeia, No. 2 (1930) 48, Figs. 1-3.

Scylliorhinus torazame Fowler, U. S. Nat. Mus., Bull. 100, 13 (1941) 36; Japan; Korea; after Tanaka.

Scylliorhinus rudis Pietschman, Anzieg. Akad. Wiss. Wien 45 (1908) 133, Japan.

Halaehurus rudis Tanaka, Fishes Japan 1 (1911) 13 Fig. 12.

This little catshark has hitherto been known only from Japan and Korea, and is now recorded for the first time from the Philippines.

Among the sharks purchased at the Dumaguete market for use in the zoology class at Silliman University, Professor Guillermo Magdamo noticed some that were unlike any he had ever seen before. On examination I found them to be typical specimens of the white-spotted catshark of Japan, from 225 to 330 mm. in length. These sharks were taken off Dumaguete, Negros Oriental Province.

This little shark may be recognized by its numerous small circular white spots or dots, sprinkled on a gray background.

This is an altogether unexpected addition to the Philippine fish fauna. As Professor Magdamo drily remarked, "It is a part of the Japanese invasion."

ACHIROPHICHTHYS KAMPENI (Weber and de Beaufort)

A specimen of this little known snake eel, family *Ophichthyidae*, was obtained from the Mantugil River, 42 kilometers from the sea, in the Municipality of Villar, Zambales Province, Luzon. It is known to the Negritos there as "banota."

This is the fourth specimen known, and the second Philippine specimen. It was previously recorded from the Pinacanauan River, at Barrio Lamug, Municipality of Peñablanca, Cagayan Province, Luzon. This is over 100 kilometers from the sea. It was originally described from Humboldt Bay, New Guinea, near the mouth of the Mbai River. I also collected it in the Papenoo River, Tahiti, about a kilometer from the sea.

The Zambales specimen is 395 mm. long, the depth 26.3 mm., the head almost 8 times in the length. The eye is about 20 times in the head, and 2.5 times in the noticeably narrow and pointed snout. The lateral line is conspicuously marked by a row of circular yellow spots surrounding the pores.

The specimen agrees very well with the descriptions of other specimens, but has 5 canines on the vomer instead of 3 or 4.

Family SERRANIDÆ

CHELIDOPERCA HIRUNDINACEA (Cuv. and Val.)

Centropritis hirundaceus Cuvier and Valenciennes, Hist. Nat. Poiss. 7 (1831) 450, Japan; Schlegel, Poiss., Fauna Japan (1842) 14, Plate 5, fig. 1, Nagasaki.

Chelidoperca hirundacea Boulenger, Cat. Fishes, ed. 2, 1 (1895) 305, Japan and Arafura Sea, off the Kei Islands. Jordan and Richardson, Proc. U. S. Nat. Mus. 37 (1910) 464, Suruga Bay and Sagami Bay, Japan; Tanaka, Fishes Japan 12 (1912) 343, Plate 92, figs. 296 and 297, Nagasaki to Tokyo.

Centropristis pleurospilus Günther, Reports Challenger Exped. Zoology I part VI, Shore Fishes (1880) 37, Plate XVI, Fig. D, Kei Islands.

Three examples, 53, 86, and 105 mm. in length, were taken by trawl at the entrance to Manila Bay, in 65 fathoms of water. Dorsal X-10; anal III-5 or 6; scales in lateral line 44. Our specimens all have a row of 5 black spots along the side; in the smallest specimen they form an almost continuous bar. With age the spots separate and eventually disappear in adult life.

This is another interesting addition to the Philippine fish fauna. Previously it has been known only from Japan and off the Kei Islands, which lie between New Guinea and Australia.

Family SCORPAENIDÆ

GYMNAPISTES NIGER (Cuv. and Val.)

This little severely stinging catfish is known from India through the East Indies to the Philippines. It seems to be rather common throughout its range, and is primarily a reef fish of shallow coastal waters. In the Philippines at least, it enters rivers and travels considerable distances from the sea.

Long ago I obtained it from the Tanjay River, Negros Oriental Province, less than a kilometer from the sea. In 1940, in company with Mr. P. R. Manacop of the Philippine Bureau of Fisheries, I collected it in a shallow rapid in the Cagayan River, Misamis Oriental Province, Mindanao, about 15 kilometers from the sea. In July, 1947, Mr. R. B. Fox, anthropologist of the Philippine National Museum, obtained 4 specimens from the Bañgan Labaw River at Villar, Zambales Province, Luzon. This locality is in the Zambales Mountains, 40 kilometers from the China Sea. These fish ranged in length from 59 to 89 mm. Specimens 85 to 89 mm. in length were several times as bulky as the shortest specimen.

This stinging fish is well known to the Negritos of the Zambales Mountains, who call it "napo". As scorpion fishes are characteristically marine reef-dwellers, it seems noteworthy that this species should leave the sea to dwell in hill streams. Apparently they like to live in shallow rapids, where their dark mottled forms blend indistinguishably with the volcanic gravel and stones that strew the bottom of the stream.

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OBSERVATIONS ON THE DISTRIBUTION OF TRYPANOSOMA EVANSI IN THE BODIES OF RATS AND GUINEA PIGS DURING DIFFERENT STAGES OF INFECTION

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INTRODUCTION

Since trypanosomes are blood-inhabiting protozoan parasites, most writers tend to take the attitude that the flagellates in an infected animal are found in all the body juices. They are said to be present in enormous numbers in one part of the body while but a few in another. Animals having many parasites in the peripheral circulation, when killed show them also in the organs. However, if they are not demonstrable by microscopic examination in the former, they are also not found in the latter. The blood of animals suffering from the disease is always infectious by animal inoculation, although there are periods during its course when the trypanosomes can not be found for days by microscopic examination of the peripheral blood. Plimmer and Bradford (1889) and others working with tsetsefly trypanosomes state that the lymphatics near the point of inoculation first show the parasite and that the blood of the animal may be infectious for two days before the parasites are found in it.

According to Voges (1901) the whole cycle of the parasite of "mal de caderas," a species of trypanosome of the *evansi* group, takes place in the blood; and it would seem that the experiments conducted to determine the place of multiplication in the body of the host tend to substantiate this statement. It is true that the trypanosomes are pretty evenly distributed in the body juices and that similar forms are found in all parts of the body. Further, Musgrave and Clegg (1903) state that when an animal, in the blood of which trypanosomes are present, dies, the organisms are then found in all organs; and conversely, where none appear in the former, they are also absent in the latter. They are generally distributed and multiplication forms do not appear in exceptional numbers in

any organ. However, they are usually somewhat more numerous in the spleen, liver and the lymphatic glands than in the bone marrow, and are seldom present in the medullary canal. They are found in the serous fluids and exudate of the joints, but rarely "in the urine". More recently, investigation in cattle and water buffaloes conducted by Manresa and Gonzalez (1936) showed that smears taken from all important organs of the animals with heavy peripheral infection at the time of killing, invariably showed the presence of surra organisms in the heart, liver, spleen and lungs. In other cases, however, the results were variable.

On the other hand, there are some investigators who differ with the general statement given above. They believe the parasites to be more numerous in certain organs, such as the lymphatic glands and the bone marrow, than in others. The results of the investigations of Schelling (1901) disclose that *Trypanosoma evansi* was not found in the spleen when it was present in the peripheral blood, and that the trypanosomes might be absent from the fluids and tissues but was constantly present in the bone marrow. The peritoneal exudate and bone marrow showed the parasites in the "budding form". The number of trypanosomes in the spleen varied greatly. The conclusion was drawn that the parasite undergoes multiplication in certain organs, while it is destroyed in others. Martini (1903) regards the spleen, lymphatics, bone marrow, and, to a less extent, the liver and the kidneys as the sites for the destruction of trypanosomes.

Citing the findings of Yorke (1911), Wolback and Binger (1912), and Stephenson (1922), Craig and Faust (1937) state that in African sleeping sickness, *T. gambiense* is found in the blood and lymphatic glands during the early or febrile stage of the disease. After the development of nervous symptoms the organism is found in the cerebrospinal fluid. It does not live within the tissue cells but may be found in the connective tissue spaces of the various organs and in the reticular tissue of the lymph nodes and spleen. It may be found in the intercellular spaces in the brain and is present in large numbers in the lymph channels throughout the body. Yutuc (1934) has demonstrated the presence of *T. evansi* after its prepatent period in the cerebrospinal fluid of horses by subinoculation and microscopic examination as early as five days and as late as twenty two days with an average of twelve days in ten out of seventeen animals.

In view of the divergent findings of the investigators cited in the foregoing, the present work was conducted with the following objects: First, to determine the distribution of surra trypanosomes in the body of rats during the prepatent period; Second, to estimate the degree of trypanosome density in various organs as well as in the blood during the patent period; Third, to determine whether or not the trypanosomes tend to appear in considerable numbers in some internal organs during periods when they can not be seen by the microscope in the peripheral blood (subpatent period) of guinea pigs.

MATERIALS AND METHODS

Animals used.—White and piebald rats and guinea pigs were employed in the investigation. The rats and a number of guinea pigs were obtained from the rat and guinea pig colonies of the Department of Bacteriology and Pathology, College of Veterinary Science, University of the Philippines, Pandacan, Manila. The rest of the guinea pigs came from the stock kept in the Department of Veterinary Medicine which have been raised from a single pair secured from the Institute of Hygiene, University of the Philippines.

Animal care.—The rats and guinea pigs were kept in galvanized iron cages with movable pans. All pans were cleaned once a week. The animals were supplied with abundant feed consisting of copra meal and first class rice bran. Green forage, mostly guinea grass was given in unlimited amount. Clean tap water for drinking was accessible all the time.

Strain of trypanosome used.—The organism, *Trypanosoma evansi* (Steel, 1885) used was recovered July 23, 1946 by sub-inoculation into a guinea pig from a water buffalo suffering from surra kept for sometime in the animal shed of the Bureau of Animal Industry, Pandacan. The organism has been maintained in the laboratory by continued passing through guinea pigs at appropriate interval.

Procedure employed.—In the first series of rats used in the study of the pre-patent period, infected blood was taken from the marginal ear vein of a guinea pig suffering from surra. The blood was aspirated in a one-cubic-centimeter syringe containing physiological saline solution to which a small amount of sodium citrate was added to prevent coagulation. One fifth cubic centimeter was inoculated subcutaneously into each rat. Inoculations of subsequent series of rats were made from

the heart blood of the infected rats killed in the course of the study. Before the parasite appeared in the peripheral blood, the rats were killed with chloroform. On autopsy impression smears of the important solid organs of the body were made; viz.—bone marrow, heart, liver, lungs, brain, kidneys, spinal cord and precural lymph glands. Occasionally other organs were included as may be noted elsewhere in this paper. In the process of posting the animals, care was taken in using clean instruments to avoid contamination of the smear of one organ with that of another. The average time consumed in the preparation of smears was approximately one half hour.

The smears were dried and fixed in air. The preparations were then immediately stained with Wright's stain and dried. Each slide was examined microscopically for surra organism. At least fifty microscopic fields were examined and the average per field computed.

In the study of the patent period the course of the disease was allowed to progress until the trypanosomes could be demonstrated by microscopic examination of the tail blood. In most instances the rats were bled to death or chloroformed when the blood was teeming with the causative agent. In the case of the subpatent period, the guinea pigs were the animals of choice, because of their resistance to surra trypanosome. The course of the infection is of a relapsing type, the guinea pig dying as a rule after a number of relapses, hence appropriate for this study. In the preparation of the smears, the same routine was observed as the prepatent period of work.

In the evaluation of the findings, the following key was employed:

- 0 = No trypanosome in 50 microscopic fields
- + = Less than one trypanosome per microscopic field
- 2+ = From one to five trypanosome per microscopic field
- 3+ = From 5 to 30 trypanosomes per microscopic field
- 4+ = Over 30 trypanosomes per microscopic field

RESULTS AND DISCUSSION

Prepatent period.—Table 1 shows that among the organs consistently examined for trypanosomes only the bone marrow failed to yield the organism, while the brain, heart, kidneys, and spleen showed the parasite once, the liver twice and the lungs three times.

In the case of the other organs, which were sporadically examined, the organism was never demonstrated microscopically. The data presented indicate that during the prepatent period the organism is also scarcely seen in the various solid organs examined. This agrees with the finding of Voges (1901) that the whole cycle of *T. equinum*, the causative agent of "mal de caderas," takes place in the blood of the vertebrate host. The occasional finding of the trypanosome in the organs examined can not be interpreted to mean that the parasites multiply and accumulate in considerable number in the internal organs during the initial period of the infection. Further, the morphological studies of the few organisms encountered did not show the presence of dividing forms.

TABLE 1.—Distribution of trypanosomes in the body of rats during pre-patent period of the infection

Organs examined	Rat number													
	1	2	3	4	5	6	7*	8	9	10	11	12	13	14
Adrenals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brain	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bone marrow	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heart	+	0	0	0	0	0	0	0	0	0	0	0	0	0
Kidneys	+	0	0	0	0	0	0	0	0	0	0	0	0	0
Liver	+	0	0	0	0	0	0	0	0	0	0	0	0	0
Lungs	+	+	0	0	0	0	0	0	0	0	0	0	0	0
Pancreas	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spleen	0	0	+	0	0	0	0	0	0	0	0	0	0	0
Lymph gland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	1	1	1	1	1	1	4 hrs.	5 hrs.	1	1	3	3	3
	Days killed after infection													

* Mouse

Patent period.—In the first series of rats as shown in Table 2, the animals were bled to death at the height of the infection, that is when the peripheral blood was teeming with trypanosomes. Since it was impossible to examine all the animals at the same time, some of the killed rats had to be kept in the refrigerator for as long as two days. The distribution of the surra organisms appears decidedly different in the various organs examined. The heart and liver consistently showed heavy trypanosome burdens ranging from 2+ to 4+ in the former and 3+ to 4+ in the latter. The kidneys and the lungs come next with a trypanosome density of + to 4+. In general, the brain, bone marrow, and the spleen showed light trypanosome contents (0 to +). It is apparent from these findings that the

more vascular the organ the heavier is the trypanosomes density. The observation of Musgrave and Clegg (1903) that the surra organisms are usually somewhat more numerous in the spleen, liver and lymphatic glands than in the bone marrow is therefore not entirely confirmed.

TABLE 2.—Distribution of trypanosomes in the body of rats at the height of infection

Organs examined	Rat number									
	1	2	3	4	5	6	7	8	9*	10
Bone marrow.....	0	0	0	0	0	+	+	-----	0	+
Brain.....	+	0	0	+	+	+	+	+	3+	+
Heart.....	4+	4+	4+	4+	4+	3+	2+	3+	4+	4+
Kidneys.....	4+	+	+	2+	+	2+	3+	2+	3+	2+
Liver.....	4+	3+	3+	4+	3+	3+	3+	3+	4+	3+
Lungs.....	2+	+	+	0	3+	4+	4+	2+	4+	2+
Spleen.....	+	+	0	0	0	+	+	+	+	+
	0	1	1	1	2	0	0	0	0	0
Days killed after infection										

* Mouse

Since, the animals used in the above experiment were killed by bleeding, the results obtained are to a certain degree questionable. To rule out the possible influence of bleeding in the natural distribution of the parasites in the various organs, another series of rats was infected at various intervals and killed with chloroform inhalation. The impression smears of these animals were made, stained and examined the day they were prepared. The majority of the rats used, were killed at the time the tail blood was swarming with trypanosomes (3+ to 4+ per microscopic field) as shown in Table 3. A perusal of the results presented in the above cited table one will note that the lung, liver, heart and kidneys grouped together bear an almost identical trypanosome burden per microscopic field as that of the tail blood, the range being 3+ to 4+ for both. Comparing the above organs with the rest, there is a decided heavier concentration of the organisms in the lungs, liver, heart and kidney than in the brain, spleen, bone marrow and lymph glands (rats 2 to 5 and 11 to 20). A comparative study of tables 2 and 3 will show that no such decided change in the intensity distribution of the trypanosome has taken place in the lungs, liver, heart and kidneys as a result of bleeding beyond a slight degree in the kidneys and lungs. However, in the case of the bone marrow, brain and spleen the change in the

density is quite marked. In some of the rats that were killed when the tail blood was lightly infected with trypanosomes (Table 3, rats Nos. 1, 2, 8, 9, and 10) the parasite burden of the peripheral blood is almost the same as that in the heart, liver, lungs and kidneys. Indirectly, these five rats serve to bridge the gap between the prepatent period and the patent period of maximum trypanosome density in the peripheral blood. Again the brain, spleen and bone marrow carry a correspondingly lighter trypanosome burden than the peripheral blood.

The above data present an added weight to the statement that the more blood the organ contains the more parasites it harbors. The liver, heart, kidneys and lungs being more vascular than the rest of the organs studied, therefore, presented the heaviest trypanosome density at least in an animal where the resistance is low as in the case of rats. The density of the organisms in the peripheral blood is almost identical with that in the liver, heart, kidneys and lungs but decidedly heavier than the trypanosome density of the spleen, brain, bone marrow and lymph glands. In this case, it is erroneous to subscribe fully to the statement that the parasites are evenly distributed in the various organs of the body. Further, the low density of the trypanosomes in the bone marrow, spleen, and lymph tissues may be attributed to the statement of Martini (1903) who states that these organs, constituting the great bulk of the reticulo-endothelial systems, are quite active in the destruction of the organisms.

TABLE 3.—*Distribution of trypanosomes in the body of rats during the patent period*

Organs examined	Rat number									
	1	2	3	4	5	6	7	8	9	10
Bone marrow	+	0	2+	+	+	2+	0	0	0	0
Brain	0	2+	2+	2+	3+	2+	0	0	+	+
Heart	+	4+	4+	3+	3+	3+	+	2+	2+	2+
Kidneys	+	4+	4+	3+	3+	4+	+	+	2+	2+
Liver	+	4+	4+	3+	3+	4+	+	+	2+	2+
Lungs	+	4+	4+	3+	3+	4+	+	+	2+	2+
Spleen	0	4+	2+	2+	3+	2+	0	0	+	2+
Lymph gland		+	0	0						
Tail blood	+	4+	4+	4+	4+	4+	+	+	2+	2+
	3	4	4	6	6	7	6	8	6	5
	Days killed after infection									

TABLE 3.—*Distribution of trypanosomes in the body of rats during the patent period—Continued*

Organs examined	Rat number									
	11	12	13	14	15	16	17	18	19	20
Bone marrow	+	+	2+	+	+	2+	+	+	+	0
Brain	+	2+	2+	2+	2+	+	2+	2+	+	+
Heart	3+	3+	3+	3+	3+	3+	3+	3+	4+	3+
Kidneys	4+	3+	3+	3+	3+	3+	4+	3+	4+	2+
Liver	4+	3+	4+	3+	3+	3+	4+	4+	4+	3+
Lungs	4+	3+	4+	3+	3+	3+	4+	4+	3+	3+
Spleen	3+	+	2+	+	3+	2+	2+	+	2+	+
Lymph gland		0								
Tail blood	4+	3+	3+	3+	4+	3+	3+	4+	3+	3+
	5	8	6	6	8	9	10	5	6	4
	Days killed after infection									

Subpatent period.—In the subpatent period study, guinea pigs were killed as early as fourteen days and as late as one hundred and eighty-four days after infective inoculation of surra blood (Table 4). The picture of trypanosome distribution is quite different from the rats. Relative to the frequency of the microscopic finding of the trypanosome in the organs examined, the brain, and the lymph glands show the parasites eight times out of the fifteen guinea pigs thus far employed in the investigation. The spinal cord comes next with four positive results out of the numbers used; kidney and liver 3 times and the bone marrow and spleen 2 times; and in the lungs and heart the organism was only noted once. In the adrenals the trypanosome was noted two times in the six cases that this organ was examined. In regards to the density, although quite variable in the same organ of the different animals of the species, the brain tissue demonstrated the heaviest density of trypanosome its maximum being 3+ and the minimum +. Taking the animals as a whole it will be noted that the organism was noted in all organs examined. For comparative study a number of guinea pigs with positive peripheral blood (+) were killed and distribution studied. The brain and lymph glands showed the heaviest density, the former being 3+, the latter 2+. The rest of the organs gave almost the same intensity as the surface blood. In discussing the results of this series, at least in the organs consistently used, the general statement "the more vascular the organ, the heavier is the trypanosome density and that the trypanosome

density of the peripheral blood is directly proportional to the density of the organisms of the vascular organs given in the rats" does not seem to fit in with the results obtained in the guinea pigs. Further, the brain, lymph glands and the spinal cord are certainly less vascular than the heart, liver, kidneys and lungs, yet the burden of trypanosomes is significantly heavier in the former than in the latter. In the guinea pig the organism has the strongest affinity to settle in greater number in the nervous tissue than the rest of the organs both in patent and subpatent periods. To elucidate the different findings between the rats on one hand and the guinea pigs on the other, one has to look into the differences in the resistance of the two animals to surra infection and the course of the disease when the animals were killed. In this particular instance the rat represents a susceptible animal whereas the guinea pig a resistant subject. In fact, Tubangui and Yutuc (1931) stated that a varying degree of resistance is exhibited by different species of surra animals. This is indicated by their ability to keep in abeyance for a shorter or a longer period of time the rapid and permanent proliferation of the surra trypanosomes. Thus, on the one hand the rat possesses a low type of resistance for, in this animal the infection runs an acute progressive course, the parasite undergoing a constant increase in number and death taking place when the number of the parasites in the blood has reached a maximum level. The guinea pig, on the other hand, possesses a high type of resistance, for in this animal the infection follows a chronic relapsing course and death usually occurs when the parasites are scarce in the circulation. *In vitro* study of the sera of rats and guinea pigs infected with surra organisms Kligler (1931) demonstrated trypanolysin in the guinea pigs but not in rats. In the latter no lysin existed at any stage of trypanosome infection. As a result of splenectomy studies in rats, the main defense has been found to be a cellular one in this species. These lytic bodies in the guinea pig and other resistant species have also been repeatedly demonstrated by a number of investigators *in vivo* studies (Diesing, 1908; Kleine and Mollers, 1906; Taliaferro, and Johnson, 1926). It is probable that this resistance in the guinea pig induced the trypanosome to localize in less vascular organs such as the brain, spinal cord and the lymph glands when the peripheral blood was negative in microscopic examination.

TABLE 4.—Distribution of *surra* trypanosomes in the body of guinea pigs during subpatent period

Organs examined	Guinea pig number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Adrenals.....	+	0	---	---	+	---	---	---	---	---	---	---	0	0	0	
Bone marrow.....	+	0	0	0	+	0	0	0	0	0	0	0	0	0	0	
Brain.....	0	3+	0	3+	0	+	0	0	0	+	+	+	0	+	+	
Heart.....	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0	
Kidneys.....	+	0	0	+	+	0	0	0	0	0	0	0	0	0	0	
Liver.....	+	0	+	+	+	0	0	0	0	0	0	0	0	0	0	
Lymph glands.....	+	2+	+	+	+	0	0	0	0	0	+	0	0	+	+	
Lungs.....	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	
Spleen.....	+	0	0	0	+	0	0	0	0	0	0	0	0	0	0	
Spinal cord.....	---	+	+	2+	---	+	0	0	0	0	0	0	0	0	0	
		184	173	87	14	17	14	16	17	17	51	52	18	123	83	
		Days killed after infection														

SUMMARY AND CONCLUSIONS

An inquiry into the distribution of *Trypanosoma evansi* (Steel, 1885) in the body of rats and guinea pigs was performed. It has been found that in rats during the prepatent period the organisms are scarce in the internal organs such as the bone marrow, brain, heart, kidneys, liver, lungs, spleen and lymph glands. No indication tending to suggest that the organisms multiply and accumulate in considerable number in the organs examined during the initial period was found. During the patent period there seems to be a direct relationship between the density of the trypanosomes in the peripheral blood and in the heart, liver, lungs, and kidneys. In the spleen, brain, bone marrow and lymph glands, the distribution intensity is lower than in the peripheral blood. While bleeding has little or no effect on the distribution of the organisms in the liver, heart, lungs and kidneys, a significant decrease in the bone marrow, brain and spleen was recorded. During the subpatent period in guinea pigs the brain, lymph glands and the spinal cord which have light trypanosome burdens during patent period, presented a comparatively heavier trypanosomes density. The resistance of the animal to the infection may possibly be the factor responsible for this finding. The statement that the organisms are evenly distributed in the different organs of the body was not sustained and that the multiplication of the trypanosome takes place in the body fluids seems justified.

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ADVERBS AND PREPOSITIONS IN ILOKO

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CHAPTER I: THE ADVERB

I. GENERAL REMARKS

A great many adverbs are expressed in Iloko by simple adjectives; by substantives, adjectives, and so on, in the oblique; by verbs with an adverbial meaning; and by substantives, verbs, and so on, with adverbial prefixes, infixes or suffixes, or with adverbial reduplications.

Many of these forms are found scattered about in former publications, under different headings. To be more or less complete and to supply as much as possible all omissions, I shall give the following list, which may serve at the same time as a recapitulation. Later on I shall study some of the most used adverbs and adverbial expressions in particular.

I. Adjectives used as adverbs. Examples:

<i>nadarás ti panmagnána</i>	he walks quickly.
<i>naináyad ti panaggunáyyo</i>	you move slowly.
<i>napintás ti panagabélda</i>	they weave nicely.
<i>naalás ti panagsaóda</i>	they speak unbecomingly.
<i>nalainṅ ti panagsarítam</i>	you speak fluently.
<i>nagagét ṅga agsursúro</i>	he studies diligently.
<i>wasadútkayo ṅga agsúrat</i>	you are lazy writers (you write lazily).
<i>naúyoṅ a maṅgisúro</i>	he is a severe teacher (he teaches severely).

II. The oblique taken adverbially. Examples:

<i>mapánkayo iti rumabii</i>	go at nightfall.
<i>mapán iti masansán</i>	he often goes.
<i>immáykami iti rabii</i>	we came in the evening.
<i>agsublikayo iti bigát</i>	come back in the morning.
<i>maṅgán iti mabayág</i>	he eats long.
<i>madúsadanto iti agnanáyon</i>	they will be punished eternally.
<i>simmaṅpet iti ṅgálay ti rabii</i>	he arrived at midnight.
<i>pumánawkami iti apagbiit</i>	we go away for a while.
<i>napán iti sunoén daydí a láwas</i>	he went the following week.
<i>iti naminsán ṅga aldáv</i>	on a certain day.
<i>iti naminsán a pananṅgrabíida</i>	once, while they had supper.

<i>addá iti unég</i>	he is inside.
<i>matúrogkami iti pagbaetánda</i>	we sleep between them.
<i>agnaédkayo iti teñgñgána</i>	you live in its midst.
<i>makisaritada iti ruár</i>	they talk outside.
<i>nagyan iti nagsenñgatánda</i>	he was located between them.
<i>immúli iti ngátona</i>	he climbed above.
<i>napán iti babána</i>	he went below.
<i>addá iti makatigidna</i>	it is at his left.
<i>agsaó iti naalás</i>	he speaks unbecomingly.
<i>magnáka iti nadarás</i>	walk quickly.
<i>nagsakáy iti naminduá</i>	he rode twice.
<i>agsaóda iti adú</i>	they talk much.

III. Verbs with an adverbial meaning. Examples:

<i>sansánem ti agluálo</i>	pray often.
<i>bayagénda ti agsaríta</i>	they talk long.
<i>sinápami ti nagbantáy</i>	we watched early.
<i>agteñgñgá</i>	he is in the middle.
<i>rumuárda</i>	they go out.
<i>ngumáto</i>	it goes up.
<i>bumabá</i>	it goes down.
<i>agdamá a mañgán</i>	he is eating just now.
<i>inináyadmo ti nagná</i>	you walked slowly.
<i>nagináyadda a nagtaráy</i>	they ran slowly.
<i>darasényo</i>	be quick.
<i>in-inútenda ti pumídut</i>	they pick them up little by little.
<i>agsiglátkami</i>	we go fast.
<i>dína met binayág a pinagkot-tónngan</i>	he was not long in getting thin.

IV. Adverbial prefixes, infixes and suffixes:

1. Notion of concomitance:

a. The Prefix *ka* and the combination *ka . . . an*. Cfr. The Substantive, III. Formation of Substantives, III, 4; The Adjectives, III. Special Forms. 1; and The verb, The Adjectival Prefix *maki*. b. II. and so on.¹

b. The Prefix *maki*. Cfr. The Verb, The Adjectival Prefix *maki*.²

c. The Prefix *si*. Cfr. The Adjective, III. Special Forms. 7; The Verb, The Adjectival Prefix *ag*. b. III. A. 4; The Adjectival Prefix *ma*. b. 1. and so on.³

¹ Anthropos 26 (1931) 472-473, 480-481; Philip. Jour. Sci. 69 (1939) 236.

² Philip. Jour. Sci. 69 (1939) 235-237.

³ Anthropos 26 (1931) 484-485; Philip. Jour. Sci. 69 (1939) 231, 239.

d. The Prefix *tagi*. Cfr. The Verb, The Adjectival Prefix *ag*. b. III. B. 1; The Substantial Suffix *en*. b. II. 1. and so on.⁴

e. The Prefixes *sañga* and *sañgka* combined with Prefix *i*. Cfr. The Verb, The Substantial Prefix *i*. b. II. Note 6. B.⁵

2. Notion of similarity:

a. The Prefix *sinan* or *sinin* and *mara*. Cfr. The Adjective, III. Special Forms. 3; and The Verb, The Adjectival Prefix *ag*. b. III. A. 3.⁶

b. The Suffix *en* and the combination *pañg . . . en*. Cfr. The Substantive, III. Formation of Substantives. V.⁷

3. Notion of reciprocity: The infix *inn*. Cfr. The Substantive. III. Formation of Substantives. III. 6; The Verb, The Prefix *ag*. b. III. A. 2; The Prefix *maki*. b. II. 2. and so on.⁸

4. Notion of recency: The prefixes *ka*, *apag* and *kapag*. Cfr. The Adjective, III. Special Forms. 2.⁹

5. Notion of repetition:

a. The Infix *an*. Cfr. The Verb, The Adjectival Infix *an*, and so on,¹⁰

b. The Prefix *kara*. Cfr. The Verb, Prefix *kara*; Suffix *en*; Prefix *i*. B. I. 3.¹¹

6. Notion of possibility: The Prefixes *maka* and *ma*. Cfr. The Verb, Prefix *maka*; Prefix *ma*. (adjectival and substantival), and so on.¹²

7. Notion of instrumentality:

a. The Prefix *pag*, and so on, and the Prefix *pa*. Cfr. The Substantive, III. Formation of Substantives. VI; The Verb, Substantives with Verbal Notions, and so on.¹³

b. The Prefix *i*. Cfr. The Verb, Prefix *i*.¹⁴

8. Notion of being of less importance: The Infix *um*. Cfr. The Verb, The Infix *um*; Verbs Implying Order or Permission, *pa . . . en*¹⁵

⁴ Philip. Jour. Sci. 69 (1939) 231; 71 (1940) 12.

⁵ Philip. Jour. Sci. 71 (1940) 20.

⁶ Anthropos 26 (1931) 482-483; Philip. Jour. Sci. 69 (1939) 231

⁷ Anthropos 26 (1931) 474-475.

⁸ Anthropos 26 (1931) 473-474; Philip. Jour. Sci. 69 (1939) 230-231, 236-237.

⁹ Anthropos 26 (1931) 481-482.

¹⁰ Philip. Jour. Sci. 69 (1939) 241-242.

¹¹ Philip. Jour. Sci. 69 (1939) 240-241; 71 (1940) 12, 17-18.

¹² Philip. Jour. Sci. 69 (1939) 233-235, 239-240; 72 (1940) 429-440.

¹³ Anthropos 26 (1931) 475; Philip. Jour. Sci. 69 (1939) 247-249.

¹⁴ Philip. Jour. Sci. 71 (1940) 15-20.

¹⁵ Philip. Jour. Sci. 69 (1939) 232-233, 71 (1940) 30-31.

9. Notion of quantity or quality: The Prefixes *nag*, *naka*, *suman̄gka*, and the Combinations *nai . . . an* and *nain . . . an*. Cfr. The Adjectives, II. Comparatives and Superlatives, *passim*.¹⁶

10. Pretending to be so: The complex prefix *agin*. Cfr. The Verb, Prefix *ag*. b. III. B. 2. and so on.¹⁷

11. Almost: The combinations of the prefixes *tagi*, *tari*, *ari*, and *arin* with the suffixes *an* and *en*. Cfr. The Verb, The Adjectival Combinations with *tari*, etc.¹⁸

12. Locative:

a. The Suffix *an*, Cfr. The Substantive, III. Formation of Substantives, III. 3; IV; The Verb, Substantive with Verbal Notions; The Substantival Suffix *an*; The Prefix *ma*. II. Note 18. a. and so on.¹⁹

b. The Prefixes *i* and *ipa*. Cfr. The Verb, Prefix *i*; Prefix *ipa*, and so on.²⁰

c. The combination *pakin*. . . . *en*. Cfr. The Verb, Prefix *ipa*. A. 3. Note 7.²¹

d. The terms *addá* and *awán*. Cfr. To have and to be.²²

13. Frequentative: Cfr. The Verb, Frequentative Prefixes.²³

14. How and when, where, why and to whom: Cfr. The Verb, Substantive with Verbal Notions.²⁴

15. Ordinal numbers, multiplicatives, distributives, indefinite numbers, fractional numbers:

a. Cfr. The Number, II, III, IV, and V; The Verb, Suffix *en*. b. II. 3. and so on.²⁵

b. The combination *pi . . . en* or *pin . . . en* and the Prefixes *ipi* or *ipin* and *ikapi* or *ikapin*. Cfr. The Verb Combination *pi . . . en*, and so on.²⁶

16. Reaching a certain part of the body: The Prefixes *aga* and *paga*. Cfr. The Verb, The Adjectival Prefix *aga*.²⁷

¹⁶ *Anthropos* 26 (1931) 477-479.

¹⁷ *Philip. Jour. Sci.* 69 (1939) 231-232.

¹⁸ *Philip. Jour. Sci.* 69 (1939) 245.

¹⁹ *Anthropos* 62 (1931) 472, 474; *Philip. Jour. Sci.* 69 (1939) 247, 250-253; 71 (1940) 12-15; 72 (1940) 439.

²⁰ *Philip. Jour. Sci.* 71 (1940) 15-22.

²¹ *Philip. Jour. Sci.* 71 (1938) 21.

²² *Philip. Jour. Sci.* 66 (1938) 417-431.

²³ *Philip. Jour. Sci.* 69 (1939) 245-247.

²⁴ *Philip. Jour. Sci.* 69 (1939) 247-248, 250-255.

²⁵ *Anthropos* 28 (1933) 714-720; *Philip. Jour. Sci.* 71 (1940) 12.

²⁶ *Philip. Jour. Sci.* 71 (1940) 23-24.

²⁷ *Philip. Jour. Sci.* 69 (1939) 242-243.

V. Adverbial reduplications:

1. Notion of easiness, and so on: reduplication of the first open syllable. Cfr. The Verb, Reduplication of Verbal Stems, *passim*.²⁸

2. Notion of reciprocity, rivalry, repetition, and so on: reduplication of two or more syllables. Cfr. The Substantive, III. Formation of Substantives. III. 6; The Verb, Prefix *ag*. b. III. A. 2, Prefix *maki*. b. II. 2; Reduplication of Verbal Stems, *passim*.²⁹

3. Notion of similarity and so on: reduplication of the first open syllable with the next consonant if there is any. Cfr. The Adjective, Special Forms. 3; The Verb, Prefix *ag*. b. III. A. 3; and so on.³⁰

II. ADVERBS OF TIME

I. 1. The ordinary simple adverbs of time are:

a. For the present: *itá* and *itattá* (reduplication form, the initial *i* being replaced by the ligature *t*). Examples:

<i>addáda itá</i>	this time they are here.
<i>sadín ti papanányo itá</i>	where do you go at this time?
<i>inkayo itattá</i>	go now directly.
<i>inkami mañgáyo itattá</i>	we go to gather wood presently

b. For the past: implying a near past: *itáy* and *itattáy* (reduplicated form); implying a more or less distant past: *idi*. Examples:

<i>immáy itáy</i>	he came just now
<i>nagsañgít itáy</i>	he cried just now.
<i>addáda itattáy</i>	they were here a short while ago.
<i>sañgsañgpétna itattáy</i>	he has just come home a little while ago.
<i>natáy idi</i>	he was dead at the time.
<i>pimmánaw idi</i>	he was gone then.
<i>nagsakítak idít ta</i>	then I got sick there.

NOTE 1. In ordinary conversation, when *itáy* and *idi* follow another word, their initial *i* is very often replaced by the ligature *t*, especially when the other word ends in a vowel. Examples:

<i>Sikát tay</i> (for: <i>Sika itáy</i>)	it was you just now.
<i>isútdi</i> (for: <i>isú idi</i>)	it was he at the time.

²⁸ Philip. Jour. Sci. 75 (1941) 207-211.

²⁹ Anthropos 26 (1931) 473-474; Philip. Jour. Sci. 69 (1939) 230-231, 236-237; 75 (1941) 207-211.

³⁰ Anthropos 26 (1931) 482; Philip. Jour. Sci. 69 (1939) 231; 75 (1941) 207-211.

2. Complex adverbs of time are formed by the addition of a substantive (either alone or accompanied by a qualifying word), an adjective, and so on, to:

a. The demonstrative *itóy* or *itá* (preceding, ligature *a* or *ñga*), for the present. Examples:

<i>itóy ñga aldáw</i>	today.
<i>itóy a bigát</i>	this morning.
<i>itóy a búlan</i>	this month.
<i>itá ñga aldáw</i>	today.
<i>itá a malém</i>	this afternoon.
<i>itá a rabíi</i>	this evening.
<i>itá a nasápa</i>	now as it is early.
<i>itá a naládaw</i>	now as it is late

NOTE 2. *Itóy* may follow immediately, but then the article precedes the substantive, and so on. Examples:

<i>itáy aldáw itóy</i>	today.
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b. The demonstrative *itáy* or *idí*, rarely *idiay* (no ligature), for the past. Examples:

<i>itáy agsápa</i>	early this morning.
<i>itáy malém</i>	this afternoon.
<i>itáy kuá</i>	a while ago.
<i>itáy parbánñgon</i>	this morning very early.
<i>itáy napán a tawén</i>	last year.
<i>itáy kallabés a tawén</i>	last year.
<i>idí kalmán</i>	yesterday.
<i>idí rabíi</i>	last night.
<i>idí malém kalmán</i>	yesterday afternoon.
<i>idí bigát kalmán</i>	yesterday morning.
<i>idí kallabés ti talló a búlan</i>	three months ago.
<i>idí napán a tawén</i>	last year.
<i>idí maikatló a tawén</i>	three years ago.
<i>idí kuá</i>	then.
<i>idí nabayág</i>	long ago.
<i>idí naminsán ñga aldáw</i>	the day before yesterday.
<i>idí (ka) sañgaldáw</i>	the day before last.
<i>idí kasañgatawén</i>	the year before last.
<i>idí katimmawén</i>	three years ago.
<i>idíay nakabutbutéñg ñga aldáw</i>	on that terrible day.

c. The conjunction *intóno*, *no*, *tóno* (ordinary forms), *attóno*, *antóno* (rarely used), for the future. Examples:

<i>intóno bigát</i>	tomorrow.
<i>bigát no bigát</i>	tomorrow morning.
<i>malém no bigát</i>	tomorrow afternoon.
<i>tóno malém</i>	this afternoon.

<i>attóno aldáw</i>	later on in the day.
<i>antóno rabii</i>	this evening.
<i>no rabii</i>	this evening.
<i>(in)tóno kuá</i>	then.
<i>intóno mabayág</i>	much later.
<i>intóno umáy a búlan</i>	next months.
<i>intóno maikapát a búlan</i>	after four month.
<i>intóno malábes ti uppát a bulan</i>	after four months.
<i>intóno arinúnos ti búlan</i>	at the end of the month.
<i>intóno sañgatawén</i>	after two years.
<i>intóno sañgaaldáw</i>	the day after tomorrow.
<i>intóno sañgaaldáw a maysá</i>	after three days.

NOTE 3. When these adverbs of time follow the verb, no ligature connects the two. Examples:

<i>umáyka itóy ñga aldaw</i>	come today
<i>agáladkami itóy ñga aldáw</i>	we make a fence today.
<i>napánda itáy aldáw</i>	they went about midday.
<i>sinurónnakami itáy agsápa</i>	he teased us early this morning.
<i>kasañgsañgpétda itáy malém</i>	they just came home this afternoon.
<i>nagtálawda idi rabii</i>	they escaped last night.
<i>inádalko idi nabayág</i>	I learned it long ago.
<i>immáy idi aldáw kalmán</i>	he came yesterday about midday.
<i>mapánto no bigát</i>	he will go tomorrow
<i>matáyto no mabiit</i>	he will die soon.
<i>mapánkami intóno agsápa</i>	we shall go early tomorrow.
<i>umáyak no kuá</i>	I shall come later.
<i>sumañgpet intóno kuá</i>	he will arrive later.

NOTE 4. The term *agdamá* may be used to indicate the present; when used in the past (*nagdamá*), it indicates concurrence of events. Examples:

<i>agdamá a manñán</i>	he is eating presently.
<i>agdamáda ñga agsursúrat</i>	they are writing just now.
<i>nagdamáda a nagsañgit idi</i>	they were crying at the time.
<i>ití agdamá a búlan</i>	the current month.
<i>ití agdamá a tawén</i>	the current year.
<i>ití tawén ñga agdamá</i>	the current year.

NOTE 5. The combination *ka . . . an* (past *kina . . . an*) adds the notion of "the following" to the substantive which indicate the period of time. Examples:

<i>ití kabigatánna</i>	the next day.
<i>idi karabiúan ti isasañgpetko</i>	the evening after I came home.
<i>intóno kabigatánna</i>	the next day (future).
<i>idi kinabigatán ti daydi aldáw</i>	the next day (past).

II. To indicate that something is done every day, every month, and so on:

1. The infix *in* is joined to the stem. Examples:

<i>inaldáv</i>	every day.
<i>binigát</i>	every morning.
<i>rinabíi</i>	every evening.
<i>umáy ití binulán</i>	he comes every month.
<i>tinawén ti panagsakitko</i>	I am ill every year.

2. The term *patináyon* or (*kan*) *kanáyon* is connected with the noun by *a* or *ñga*. Examples:

<i>patináyon ñga aldáv</i>	every day
<i>patináyon a búlan</i>	every month.
<i>kanáyon a bigát</i>	every morning.
<i>kankanáyon a malém</i>	every afternoon.

NOTE 6. When the infix *in* is joined to the stem and its first two syllables are reduplicated besides, the recurrence of the event is emphasized. Examples:

<i>inaldaw-aldáv</i>	day by day.
<i>binigatbigát</i>	every morning without fail.
<i>rinabirabíi</i>	every evening without fail.
<i>tinawentawén</i>	every year without fail.

III. The prefix *maka* (past: *naka*) joined to the substantive which indicates the period of time, means that something lasts once the duration implied by the substantive. If the duration is longer, the Iloko connect the number with the substantive, followed by a possessive pronoun, by the ligature *a* or *ñga*. Examples:

<i>makabúlan kayonto idiáy</i>	you will stay there a month.
<i>nakatawénda idiáy babá</i>	they stayed a year in the lowlands.
<i>duá ñga aldávmi idiáy</i>	we stayed there two days.
<i>duá púlo ñga aldáwtayo idiáy</i>	we stayed twenty days in the forest.
<i>kabakíran</i>	
<i>sañgapúlo a tawénmi idiáy</i>	we stayed there ten years.

NOTE 7. *Agpatnág* (past: *nagpatnág*), from the complex prefix *agpa* and the stem *tinnág*, means: the whole night; *agmalmalem* (past: *nagmalmalem*) means: the whole day. Examples:

<i>agpatnág ñga agsursúrat</i>	he passes the night writing.
<i>nagpatnágkayo a nagsugsugál</i>	you spent the whole night gambling.
<i>agmalmalémda ñga agsañgsa-ñgít</i>	they weep the whole day.
<i>nagmalmalémkami a nagnagná</i>	we walked the whole day.

NOTE 8. Sometimes the prefixes *maka* and *makanika* (past: *naka* and *nakanika*) are joined to the cardinal numbers in the same way as the prefix *maiká* (of ordinal numbers), to indicate a period of days. The prefix *maka*

may also be joined to the distributives with the same meaning. "One day" is *makaysa* (past: *nakaysa*). The corresponding interrogatives are: *makamanó* and *makasagmamanó*. If the period is not a number of days, but a number of months, and so on, this must be expressed in the sentence. These forms, however, are used very rarely. Examples:

<i>makatlódanto ñga agyán idiáy</i>	they will stay there three days.
<i>makamanókayo ditóy</i>	how many days do you stay here?
<i>makanikatló púlokami ket duá</i>	we shall stay twenty-two days.
<i>makaysádato</i>	they will stay one day.
<i>makapátda idiáy</i>	they stay there four days.
<i>makasagwawalókamto</i>	we shall stay eight days.
<i>makapát a tawén ditóy</i>	he stays here four years.

NOTE 9. *Makamanó* and *makamanmanó* (rarely used) mean: a long time, much time, difficult. Examples:

<i>saán a makamanó daytá ñga</i>	that work is easy.
<i>arámid</i>	
<i>makamanmanóka a baonén</i>	it is very hard to send you somewhere.

IV. A peculiar adverb of time is *en* which is often joined to the last word of the sentence and means: already, now, and so on. We saw one of its many uses when treating the comparatives and superlatives of adjectives,³¹ and we shall see another one in the disintegration of the adverb *manén* "again."³² Cfr. also Phonology, VI Syncopations. II. B. c. and IV. B. 1.³³ Examples:

<i>addán</i>	here he is now.
<i>umáykan</i>	come along now.
<i>simmañgpéten</i>	he has arrived already.
<i>nakadánon ti lakáyen</i>	the old man got there already.
<i>siákon</i>	it is my turn now.
<i>aldemon</i>	all right, take it now.
<i>mayátakon</i>	I am willing now.
<i>kuákon</i>	now it is mine.
<i>kitáem ti bakéten</i>	look at the old woman now.
<i>addá mettén</i>	here he is now though.
<i>madikamin</i>	we don't want it any more.
<i>addá ñga agtaráyen</i>	there he is running now.
<i>nagtálawsa met ti ásomon</i>	your dog escaped already, didn't he?
<i>inayátnan</i>	she loved him already.
<i>madamán</i>	he is at it.
<i>idi kuán</i>	and then at the time.
<i>bumáñgonkayon</i>	arise now.

³¹ *Anthropos* 26 (1931) 479.

³² See below: VI. Adverbs of Quality and Manner, IV. 13.

³³ *Anthropos* 23 (1928) 1936, 1940.

*mañggapón ñga agbannáwag
anián, daytóyen*

isúnan

konák lan nalaklakáda

awánen

*saán ñgaminen ayá ñga agsur-
súrat
anía ketdín ayá*

it begins to dawn already.
what now, what is the matter with
this one?

stop it now; it is enough now.
I thought though that they were
cheaper.

there is no more; he is not here
any more; it is done for.

well, indeed, is he not writing any
more now?

stop it, what is the matter there?
(annoyance)

what can be done? (resignation)

V. Other adverbs of time:

1. *Patináyon*, (*kan*) *kanáyon* and *agnanáyon*: "always".
Examples:

*agluálo a patináyon
patináyonda ñga agsánġit
patináyon ñga agrabrábak
kankanáyon a tumaráy
agbasbása a kankanáyon
kankanyon láeñġ a nagtalinaéd-
da iti kappiá
kanáyon ñga agdđawat
kastá a kanáyon
naragsákda ñga agnanáyon
madúsada iti agnanáyon*

he always prays.
they always weep.
he is always jesting.
he always runs.
he is always reading.

they always remained in peace.
he always asks for things.
it is always so.
they are always full of joy.
they are punished eternally.

2. *Masansán*: (past: *nasansán*), *mamin-adú* (past: *namin-
adú* and *nasarantá*: "often." Examples:

*masansán ñga umáy
masansán a sasaoénna
masansán ti panagkatáwana
agsánġit iti masansán
agladiñġit a masansán
mamin-adú ñga agbarték
namin-adú a naguñġét,
kimmagát iti namin-adú
nasaránta ti panagdđawatna*

he often comes.
he often says so.
he often laughs.
he often weeps.
he often grieves.
he often gets drunk.
he often was angry.
he often bit.
he often asks for things.

3. *No daddúma*: "sometimes" (no ligature). Examples:

*immáy no daddúma
no daddúma agsánġit
mañġánkami no daddúma iti ti-
nápáy
no daddúma napánkami idiáy
Bañġár*

sometimes he came.
sometimes he weeps.
sometimes we eat bread.
sometimes we went to Bangar.

4. *Sagpaminsán*: "now and then." Examples:

<i>mañgálakami iti sagpaminsán</i>	we take some now and then.
<i>umáy no sagpaminsán</i>	he comes now and then.
<i>sagpaminsán ti yaáymi</i>	we come now and then.
<i>sagpaminsán ñga agbarték</i>	he gets drunk now and then.

5. (*Pas*) *pasaráy*: "occasionally" (preceeding). Examples:

<i>paspasaráy umáy</i>	he comes occasionally.
<i>pasaráy nagbarték</i>	he got drunk occasionally.
<i>pasaráyda tumaliáw</i>	they look back occasionally.

6. *Ñganñgáni* and *dandaní*: "nearly, almost", and so on (preceding, no ligature). Examples:

<i>ñganñgánika sapliten</i>	I shall soon whip you.
<i>ñganñgáni rabiien</i>	it is almost evening already.
<i>dandaní pumánaw</i>	he is near going.
<i>dandaní a las dos</i>	it is nearly two o'clock.
<i>dandaní ni ulitégko itán</i>	my uncle is almost here now.

7. *Madamdama*: "soon." Examples:

<i>sumañgpét no madamdamá</i>	he will arrive soon.
<i>no madamdamá umáyak</i>	I shall come soon.
<i>iti madamdamá bassít</i>	a little later.

8. *Bít* and *bassít*: entreating; "literally for a moment" (following, no ligature). Examples:

<i>sumrékka bít</i>	come in for a moment.
<i>ínka bassít idiáy Sánta</i>	go once to Santa.
<i>ínka bassít aláen ti súratko</i>	please, go to take my letters.

III. ADVERBS OF PLACE

I. The three simple adverbs of place, corresponding to the three demonstratives, are:

Complete form		Abbreviated form	Corresponds to
<i>ditóy</i>	(here)	<i>toy</i>	<i>daytóy</i> (this)
<i>ditá</i>	(there)	<i>ta</i>	<i>daytá</i> (that)
<i>idiáy, sadiáy</i>	(there)	<i>diáy</i>	<i>daydiáy</i> (that)

<i>addákam ditóy</i>	we are here.
<i>simmañgpet ditóy</i>	he arrived here.
<i>madí a mañgán ditóy</i>	he won't eat here.
<i>addá masakít ditóy</i>	is there anyone sick here?
<i>nañgasáwa ditóy</i>	he married here.
<i>ditóy nakatayánna</i>	he died here.
<i>adú ti bagás ditóy baláymi</i>	there is much rice in our house here.
<i>ti kúkua ditóy lábónñg</i>	the earthly goods.
<i>umáykat toy</i>	come here.

awán toy ti kayátko
isú ti addát toy
awán ti mayát toy
isú ti nakiasáwa kenkuánat toy
awán ditá
madida ámin ditá
addá nanǵála ditá
ditá ti papanánda
adú ti bagás ditá baláyyo

awán ditá yánmo
ínkat ta
addát ta ti birókek
umáyaktot ta no umimbágak
no umáykamit ta aguñǵétka
nakadánondat ta
nagsakitak idít ta
napánkami idiáy
madida a matúrog idiáy
adú ti bagás idiáy
ínkamto gumátañǵ idiáy
dagiti ubbiñǵ ti napán idiáy
idiáy ti nakasarákami
ínkat diáy
addádat diáy
bassit ti mayát kanót diáy

isúdat diáy
addánsat diáy ni Luis

what I want is not here.
 it is he who is here.
 nobody is willing here.
 she married him here.
 it is not there.
 do they all refuse there?
 someone took it there.
 they go there.
 is there much rice in your house
 there?
 it is not at your place there.
 go there.
 what I look for is there.
 I shall come there when I get well.
 when we come there you are angry.
 they got there.
 then I got ill there.
 we went there.
 they do not want to sleep there.
 there is much rice there.
 we shall go to buy some there.
 the children went there.
 we met him there.
 go there.
 they are there.
 they say that few people there are
 willing.
 there they are.
 Lewis is there, I believe.

NOTE 10. There is no difference between the use of the complete forms and that of the abbreviated ones, and, when these adverbs follow the verb and so on, (except an occasional *t*) no ligature is used to connect them all this may be seen in the above examples.

NOTE 11. *Sadiáy* refers to a place which has been alluded to before. Examples:

ínka diáy simbaán sadak ura- go to the church and wait for me
yen sadiáy there.
napanák idiáy Dinǵrás ket sa- I went to Dingras and met him
diáy ti nakakitáak kenkuána there.

NOTE 12. In some districts the Iloko use *sadí* instead of *idiáy*⁴. Examples:

Sadín ti papanám?—Sadí where do you go?—There.

NOTE 13. Sometimes *nay* is used as an adverb of place, but it is not very polite term. Examples:

nay aláem here, take it.
ditá nay lansáñǵan there in the street.
bumallásiwka ditá nay álad cross that fence there.

⁴ See below: The Preposition, VI.

NOTE 14. *Ni* may be added to words indicating place or location, and sometimes also to other words. It more or less represents the English "see." Examples:

<i>addát toy ni</i>	it is here, see.
<i>kitáem ni</i>	look here.
<i>awán ni</i>	it is not here, see.
<i>kastóy ni</i>	like this, look.

NOTE 15. *Ditóy* may be used as a substantive including the notion of an adverb of place. Examples:

<i>nasakit ti ditóyko</i>	this hurts (showing where).
<i>addá gaddíl ití ditóyna</i>	he has itch here (showing where).

II. The following adverbial expressions sometimes occur:

<i>adtóy</i> or <i>atto'y</i>	Contraction: <i>addá</i> and <i>toy</i>
<i>addaytóy</i> (rarely used)	Contraction: <i>addá</i> and <i>daytóy</i>
<i>addáyta</i>	Contraction: <i>addá</i> and <i>dayta</i>
<i>addaydiáy</i>	Contraction: <i>addá</i> and <i>daydiáy</i>
<i>addagitóy</i>	Contraction: <i>addá</i> and <i>dagitóy</i>
<i>addagítá</i>	Contraction: <i>addá</i> and <i>dagítá</i>
<i>addagidiáy</i>	Contraction: <i>addá</i> and <i>dagidiáy</i>

Examples:

<i>adtóy ti adípenmo</i>	behold thy servant.
<i>adtóy ni apó Juán</i>	here is Mr. John.
<i>adtóy a binaón ti lakáy</i>	here he is whom the old man sent.
<i>adtóy ti yánna</i>	here he is.
<i>addaytóy ti ubiñg</i>	here is the child.
<i>addayta ti birókem</i>	there is what you look for.
<i>addaydiáy ti asinyo</i>	there is your salt.
<i>addagitóy kami</i>	here we are.
<i>addagitádan</i>	there they are now.
<i>addagidiáy ti ásoyo</i>	there are your dogs.

III. To indicate the relative position of two or more objects, the prefixes *akin* or *makin* (past: *nakin*) are joined to the stem implying the position of one of the objects. Cfr. The Adjective, III. Special Forms. 4; The Verb, The Prefix *ipa*. A. II. 2. Note 7.³⁵ Examples:

<i>akindáya daytóy</i>	this is on the east side.
<i>daydiáy ti akinrabáw</i>	that is on the upper side.
<i>makinkanawán ti yánna</i>	he stands at the right.
<i>isú ti nakinkatigid</i>	he was at the left.
<i>ipánmo ití makinláud</i>	carry it to the west side.
<i>ti makin-unég</i>	the inside.
<i>ti makinruár a káyo</i>	the wood at the outside.
<i>addá ití makinñgato</i>	it is uppermost.

³⁵ Anthropos 26 (1931) 485; Philip. Jour. Sci. 71 (1940) 21.

IV. Many adverbs of place are formed by substantives in the oblique and by the preposition *idiáy* followed by a substantive, Examples:

<i>napánda ití ruár</i>	they went outside.
<i>napán ití adayó</i>	he went far.
<i>awánda ití unég</i>	they are not inside.
<i>addá ití malikudák</i>	it is behind me.
<i>addá ití masañgoanak</i>	it is before me.
<i>addáda idiáy sirok</i>	they are below.
<i>ínka idiáy ruár</i>	go outside.
<i>immuli idiáy ñgato</i>	he climbed up; he ascended.
<i>makadánon idiáy babá</i>	he gets down.
<i>nagýán idiáy teñgñgá</i>	he stayed in the middle.
<i>ínkayo idiáy unég</i>	go inside.
<i>naidissó idiáy rabáwna</i>	it was placed on top.

IV. ADVERBS OF NEGATION

I. 1. There are two adverbs of negation: *saán* and *dí*.

a. *Saán* is connected with the word it modifies by the ligature *a* or *ña*. Examples:

<i>saán ñga áso</i>	it is not a dog.
<i>saán a ñi Pédro</i>	not Peter.
<i>saán a nasayáat</i>	it is not good.
<i>saán a nalagdá a baláy daytá</i>	that is not a strong house.
<i>saán ñga ámin</i>	not all.
<i>saánda a talló</i>	they are not three.
<i>saán a daytáy</i>	not this.
<i>saán a napán</i>	he did not go.
<i>saánka ñga immáy</i>	you did not come.
<i>saánda a kayát</i>	they do not like.
<i>saánkonto a dí mapáyat</i>	I shall certainly tread it (go there).

b. *Dí* precedes it immediately without any ligature. The peculiarities connected with the use of the possessives, when *dí* is followed by a substantive or a substantival verb, have been alluded to before. Cfr. The Pronoun, II. Possessives.

2. Peculiarities. I.³⁶ Examples:

<i>dída gayyém</i>	he is not their friend.
<i>díak mapán</i>	I do not go.
<i>díkam kayát</i>	we do not like it.
<i>díkay umáy</i>	don't go.
<i>dídakami ayatén</i>	they do not love us.
<i>dína pay nalpás ti nagsaó</i>	he had not yet finished speaking.

³⁶Anthropos 28 (1933) 691-692.

3. *Saán* is the most extensively used.

Di is rarely used by itself without an accompanying pronoun, except in some expressions and in literature, but it is generally preferred to *saán* when the verb is in the imperative. Examples:

<i>dipay la umáy</i>	doesn't he come yet?
<i>di naimbág daytá</i>	is that not good?
<i>asíno ti di agayát</i>	who won't be glad?
<i>sumúrot kenkuána a di agtantán</i>	he follows him without delay.
<i>dika mamapátay</i>	thou shalt not kill.
<i>dika agtákaw</i>	thou shalt not steal.

NOTE 16. *Ammók pay* and *ammók kadí* or *ammó pay* and *ammó kadí* are strange expressions meaning "I don't know, it cannot be known".

NOTE 17. *Naymán*, "who knows?", has become antiquated.

II. "Never" is translated by adding the adverbial expressions *úray kaanó* (*man*) or *úray anó* (*man*) to a negative sentence. After *úray* may be placed: *no*, *intón* (regular forms) *adtón*, *attón* (rarely used). Examples:

<i>diakto gatanġen úray kaanó</i>	I shall never buy it.
<i>man</i>	
<i>saánna a kayát úray no anó man</i>	he never wants it.
<i>díkamto gayyém úray no anó</i>	he will never be our friend.
<i>úray intón kaanó man</i>	never.
<i>úray anó saának pay a nañgán</i>	I never ate bread.
<i>ití tinápáy</i>	

V. ADVERBS OF INTERROGATION

I. In general, an interrogation, in Iloko, is distinguished from a statement merely by the inflection of the voice.

II. Besides several adverbs of interrogation which have been studied under the Number, the following are the most used interrogatives introducing a sentence in Iloko.

1. *Kaanó ti* (ordinary form) and *ití aniá tí* (rarely used), "when?" Examples:

<i>kaanó ti isasañpétna</i>	when did he arrive?
<i>kaanó ti yaáymo manén</i>	when will you come again?
<i>kaanó ti panagsardéñgda</i>	when did they stop?
<i>kaanó ti pannañganyo ditóy</i>	when do you eat here?
<i>kaanó ñga aldáw ti panañg-</i>	on what day will you bring it?
<i>yeygo</i>	
<i>ití aniá ñga aldáw ti ipapánna</i>	on what day will he go?

2. *Intonanó ti* (most common form), *intón kaanó ti*, *tonanó ti*, *ton kaanó ti*, *attonanó ti*, *adton kaanó ti* or *attón kannó ti*, *antonanó ti*, *anton kaanó ti*, "when?" (future). Examples:

<i>intonanó ti yaáymo</i>	when will you come?
<i>intonanó ti kayátayo a pannaka-</i>	when do you want it made?
<i>arámidná</i>	

<i>intonanó ti kaaddá ti nákemda</i>	when will they have sense?
<i>intón kaanó ti panañgyégda</i>	when will they bring it?
<i>tonanó ti pannakasápulna</i>	when is it needed?
<i>ton kaanó ti pannagnáda</i>	when will they walk?
<i>attonanó ti konáyo</i>	when do you think?
<i>attón kaanó ti panagkayátda</i>	when will they like it?
<i>antonanó ti panagápít</i>	at what time is the harvest?
<i>antón kaanó ti panagbáyadmo</i>	when will you pay?

NOTE 18. Nowadays these forms are very often superseded by *kaanónto*.
Examples:

<i>kaanónto ti panañgiserrékna</i>	when will he bring it in?
<i>kaanónto ti panagódoñgmí</i>	when will we go to town?

3. *Adín (o) ti, sadín (o) ti*, "when?" Examples:

<i>sadín ti papanánna</i>	where does he go?
<i>sadíno ti nakabirókam kada- kuáda</i>	where did you find them?
<i>adín ti nagtarayán ti áso</i>	where did the dog run?
<i>adíno ti paglutoányo</i>	where do you cook?
<i>sadín ti kayátda a pakaikabi- lanna</i>	where do they want it located?

4. *Asín (o) ti, si asíno tí*, "who?" Examples:

<i>asíno ti mayát</i>	who is willing?
<i>asín ti piliém</i>	whom do you choose?
<i>asín ti lakáy ñga immáy idi ka- mán</i>	who was the old man who came yesterday?
<i>si asíno ti napán</i>	who went?
<i>si asínoak tapnó dayáwendak</i>	who am I that you should honor me?

5. *Aniá tí* (ordinary form) *aná tí*, "what?" Examples:

<i>aniá ti konám</i>	what do you say?
<i>aniá ti kayátmo</i>	what do you want?
<i>aniá ti pagságadko</i>	with what can I sweep it?
<i>aniá ti ginátanñgda</i>	what did they buy?
<i>aniá ti ilábasyo</i>	with what do you pass?

6. *Aniá ti gapóna, ápay* (ordinary forms), *apay-ápáy* (mostly used in literature), *apayá* (rarely used), "why?" Examples:

<i>aniá ti gapóna ñga immáyka</i>	why did you come?
<i>aniát gapóna a madída</i>	why do they refuse?
<i>aniát gapóna ñga awán ti mayát</i>	why is nobody willing?
<i>aniá ti gapóna a nabarték manén</i>	why is he drunk again?
<i>aniát gapóna a bimmassít ti áراك</i>	why did the wine diminish?
<i>ápáy a suká ti inkábilyo</i>	why did you put vinegar?

<i>ápaya a didakami kitkitáen</i>	why don't you look at us?
<i>ápaya n̄ga áso ti ginátan̄gda</i>	why did they buy dogs?
<i>ápaya n̄ga awán ti sumangpét</i>	why does nobody arrive?
<i>ápaya a siká ti baonénda</i>	why do they send you?
<i>apayápaya mapánkayo</i>	why do you go?
<i>apayá umáy</i>	why does he come?

7. *Kasanó ti, an-anoén, agan-anó* (past: *nagan-anó*), "how?"

Examples:

<i>kasanó ti pannakaarámidna</i>	how was it made?
<i>kasanó ti panagtaráyko no nasa- kit ti sákak</i>	how can I run if my foot hurts?
<i>kasanó ti panañgbírokko kada- kuáda</i>	how can I look for them?
<i>an-anoén a bayádan ti útan̄g no awán ti pirák</i>	how can one pay one's debts if there is no money?
<i>an-anoék daytá</i>	how can I do that; what must I do with that?
<i>agan-anókam a bumaknañg</i>	how can we get rich?
<i>nagan-anóka a rimuár</i>	how did you get out?

8. *Agpaanó* (past: *nagpaanó*), "in what direction?" Examples:

<i>agpaanó daytá lakáy</i>	in what direction does that old man go?
<i>nagpaanókayo idi kalmán</i>	in what direction did you go yes- terday?

9. *Tagaanó* (ordinary form), *yanó*, "from where?" Examples:

<i>tagaanó dagidiáy</i>	from where are those ones?
<i>tagaanókayo</i>	from where are you?
<i>yanóka</i>	from where are you?

NOTE 19. The same question may be asked this way: *Aniá ti ílim?* "what is your town; from where are you?"

III. Most of these interrogatives may be used either as adverbs of interrogation or as conjunctions introducing an incidental clause, in which latter case they are preceded by the simple conjunction *no*. Examples:

<i>ammók pay no kaanó ti yaáyna</i>	I don't know when he came.
<i>ibagám no intonanó ti panañg- yegmo iti bagás</i>	tell me when you will bring rice.
<i>dinámagko no sadíno ti napa- nána</i>	I asked where he went.
<i>suritáem no adíno ti nañgalaám</i>	tell us where you took it.
<i>saludsúdem no asino ti mayát</i>	ask who is willing.

<i>ammóda no si asino ti nagtákaw</i>	they know who stole.
<i>isúrona no aniá ti dálan</i>	he shows them where the road is.
<i>ipalawáigna no aniá ti gapóna a madída</i>	he explains why they refuse.
<i>inpadámagna no ápay ñga awán ti immáy</i>	he told me why nobody came.
<i>díkayonto panunóten no kasanó wenno aniá ti saóenyonto</i>	take no thought how or what to speak
<i>kitáenyo dagiti ubbing no kasanó ti idadakkélda</i>	look at the children how they grow.

NOTE 20. Formerly the adverb *ñga* was generally used to introduce an interrogative sentence, but actually it has become entirely obsolete, and it only exists in the complex adverb *ñgáman*.

IV. *Ñgay*, *aya* and *ñgamín* are adverbs of interrogation which nearly always follow some other word. *Ñgaman* or *náman*, which is not used very extensively, stands by itself or introduces the sentence.

1. *Ñgay* is a simple interrogative. Examples:

<i>ápay a madíka ñgay</i>	why do you refuse, what is the matter?
<i>ápay ñgay</i>	why, what is the matter?
<i>aniá ti birókem ñgay</i>	what are you looking for?
<i>sadín ti yánmo ñgay idi kalmán</i>	where were you yesterday?
<i>aniá ti kalintegánna ñgay</i>	what right has he?
<i>napanánna ñgay</i>	where did he go?
<i>ni Juán ñgay</i>	and John? (where is he; where is his share?)
<i>ket ti panagádalmo ñgay</i>	and your studies? (when talking to a boy or a girl who wants to marry, for instance)
<i>sa pay awán ñgay</i>	why shouldn't there be any? (answering contradictorily a person who said there wasn't any)

NOTE 21. The form *ay* for *ñgay* has become antiquated.

2. *Ayá* and *ñgamín* are interrogatives implying an additional notion of wonder. Examples:

<i>nápának ayá</i>	did I go? (implying the contrary)
<i>siák ayá ti baonényo</i>	is it I you send? (I thought somebody else)
<i>ínka ayá</i>	do you go? (I thought you wouldn't or not yet)
<i>pudnó komá ayá</i>	it should be true, wouldn't it be nice?
<i>aláem man ayá</i>	all right, take it (why not?)
<i>aniá keddín ayá</i>	stop it (or: what can be done?)
<i>nalukmég ayá</i>	is he really fat?
<i>ápay sakít ayá ñgamín</i>	why, is it sickness indeed?

<i>siák ayá ñgamin</i>	I? (do you suppose I did it, not at all)
<i>saánda ñgamin a sañgápulo, dagiti nadalusán</i>	were not ten made clean? (and why do I see only one?)
<i>addá ñgamin nagkúrañg kada-kayó</i>	were you really in need of something?
<i>bulsékkami met ñgamin</i>	are we blind indeed? (do you consider us as blind?)
<i>mabalinna ñgamin ti agsubli ñgamin komá no addá ások</i>	can he go back? (I think not)
<i>mabalinda ñgamin ti aglidáy</i>	I wish I had a dog.
<i>dakdakkélda ñgamin ñgem ni áma</i>	can they grieve? (I think not)
<i>iti ñgamin Abra ti paggapoán ti káyo</i>	why, indeed, they are taller than my father.
<i>namáti ñgamin kenkuána ti maysá kadakuáda</i>	the timber comes from Abra (who would have thought that?)
<i>saán ñgamin a daytáy ti anak ti allawági</i>	one of them believed in him, isn't it strange?
<i>itédmo ñgamin ti kankanén</i>	was not that the carpenter's son?
<i>kastáy ti nagtutulágantay ñgamin</i>	you are giving sweets (we didn't know that)
<i>agpaysó ñgamin</i>	did we agree to such a course of action? (I thought the contrary)
<i>awán met ñgamin pirák</i>	is it true, really?
<i>apayá ñgamin a ditay ipatpatég ti kukuatayo</i>	well, there is no money (we thought there was)
	why indeed don't we prize our belongings?

3. *Ñgámán* or *náman* means "why?" and so on. Examples:

<i>náman</i>	what is the matter? why?
<i>ñgámán apó ñga awán ti ná-kemko tapno isú ti aramidek</i>	why, Sir, do you think I have no sense that I should do that?
<i>ñgámán itá a di met naipákat itóy dagátayo</i>	why is it now that it was not given to this country of ours?
<i>ñgámán pay ñga ikkánnak ngatá ti pagduaduaák kenkuana</i>	why do you seem to make me doubt him?
<i>ñgámán pay a mariknák daytá</i>	why do I feel that?
<i>ñgámansa no gumátanñg ditóy ti págay</i>	what if I buy rice here?

NOTE 22. The interrogative *man*, "why?" which follows the word it modifies, is very little used nowadays, except in the expression *saán man*, "why not?," "certainly," when answering affirmatively a negative question or its equivalent, and in the complex adverb *ñgámán* or *namán*.

Examples:

<i>dika man mamáti</i>	why don't you believe?
<i>saánka a napán ayá?—Saán man</i>	didn't you go really?—I went though.
<i>saánkansa a napán?—Saán man</i>	you didn't go I believe?—I went though.

VI. ADVERBS OF QUALITY AND MANNER

I. To indicate continual repetition of an action, the word expressing the action is twice repeated and the adverb *la* from *láeñg* followed by the ligature *a* or *ñga* connects the two. Examples:

<i>sarita la a sarita daytá lakáy</i>	that old man does not stop talking.
<i>saóka la a saó</i>	you are talking all the time.
<i>bumassít la a bumassít ti bagás</i>	the rice becomes less and less.
<i>lumukmég la a lumukmég ti ubíñg</i>	the child grows fatter and fatter.
<i>umadú la ñga umadú ti dódon</i>	the locusts increase in number all the time.
<i>sánñgítla la a sánñgít</i>	they are always weeping.
<i>pumúdawda la a pumúdaw</i>	they become whiter and whiter.
<i>ñgumísít la a ñgumísít ti rúpam</i>	your face becomes blacker every day.
<i>taráy la a taráy</i>	running all the time.
<i>lumálo met a lumálo</i>	it becomes worse and worse.
<i>siák la a siák ti baonényo.</i>	you always send me.

II. The concept of completeness, purity, and so on, is expressed by the following words, which are connected with the word they modify by the ligature *a* or *ñga*: *Pasig*, *büig*, *bin-ig* (preceding) and *pulos* (following or preceding). Examples:

<i>pásig a tuláñg</i>	all bones.
<i>büig ñga allid</i>	pure wax.
<i>bin-ig a balitók</i>	pure gold.
<i>pulós a sinamáy</i>	all of it sinamay.
<i>awán a pulós</i>	there is nothing at all.

III. 1. "So" is rendered into Iloko by the indefinite adjectives in *kas*, *kastóy*, *kastá*, and so on. Examples:

<i>aramidem a kastá</i>	do it so.
<i>kastóy latta</i>	like this all the time.
<i>kastíay a natáyag</i>	as tall as that; so tall.
<i>kastóy ñga adú</i>	as much as that; so much.
<i>kastí a bassít</i>	as little as that; so little.
<i>kastóy a dakkél</i>	as great as this; so great.

2. "Equally" is expressed by *páda* or *agpáda* (past: *nagpáda*) with ligature *a* or *ñga* following. Examples.

<i>ti pádana a natañgsít</i>	his equal in pride.
<i>nagpadpádada a nadagsén</i>	they were equally heavy.
<i>agpadpádada a nalag-án</i>	they are equally light.
<i>dagiti pádami a napañgláw</i>	our equals in poverty.

NOTE 23. The latter is an expression the Iloko generally use, instead of saying "the poor" and so on, whenever they refer to a quality which is humiliating to their neighbor. It would be rather bad taste to say that a man is poor, without referring to him as one's equal in poverty, even though one be as rich as Croesus.

<i>dagiti pádami a nanenñnéñg</i>	our equals in stupidity.
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IV. Other adverbs of quality and manner are:

1. *Únay*, "very much" (following, no ligature). Examples:

<i>dakkél únay</i>	it is very great.
<i>bassít únay</i>	very little.
<i>kayátko únay</i>	I like it very much.
<i>ipapilitna únay</i>	he insists much.
<i>magná ití nadarás únay</i>	he walks very fast.

NOTE 24. *Bassít* means "a little" and so on. Examples:

<i>dakkél bassít</i>	rather great.
<i>adú bassít</i>	rather much.
<i>nadagsén bassít</i>	rather heavy.
<i>adayó bassít</i>	a little far; rather far.

2. *Amañgán* (ordinary form), *amamañgan*, *allek* (rarely used), "how great" (preceding). Examples:

<i>amañgán a nagadú ti táo</i>	how many men.
<i>amañgán a nagrikút únay</i>	how very difficult it is.
<i>amañgan a salditmo ñgatá a buybuyáek</i>	looking at you I think you must be exceedingly well-favored.
<i>amañgán imbág ti baláyyo</i>	how good is your house.

3. (*Nañg*) *nañgróna*, *sañgkañgrona*, "especially." Examples:

<i>daytáy ti nañgróna a dákes</i>	this is especially bad.
<i>nañgróna únay ití bigát</i>	especially in the morning.
<i>isú ti ñañgnangrona a bassít</i>	he is especially small.
<i>sañgkañgrónada a napintás</i>	they excel in beauty.

NOTE 25. This adverb has a form of relative superlative: *kañgronáan*. Examples:

<i>ti kañgronáan a túleñg</i>	the deafest of all.
<i>ti kañgronáanda a dákes</i>	the worst of them all.

4. *Istáy*, *nagistáy*, *nagistayán*, "nearly" (preceding, no ligature). Examples:

<i>istáy natnág</i>	he nearly fell down.
<i>nagistáy naitibkúl</i>	he nearly stumbled.
<i>nagistáyak natáy</i>	I nearly died.
<i>nagistayán pimmánaw</i>	he was nearly gone.

5. *Ñganñgáni di*, *ñganñgáni saán*, *apáman* (ordinary forms), *apagapáman*, *apaganamá*, "scarcely" and so on. Examples:

<i>ñganñgáni di agúni</i>	it scarcely sounds.
<i>ñganñgáni saán a mañgñgeg</i>	it is scarcely audible.
<i>apáman a nañgtéd</i>	he barely gave.
<i>apáman a nagságadda</i>	they hardly swept it.
<i>apáman addá</i>	there is just a little.
<i>apáman ta mayát</i>	he is but just willing.

6. *No maminsán*, "in a way" and so on (no ligature). Examples:

<i>no maminsán nasayáat</i>	it is good in a way.
<i>no maminsán kayátko</i>	I more or less like it.
<i>napintás no maminsán</i>	it is beautiful in a way.

7. *Sigud*, "originally" and so on ligature *a* or *ñga*. Examples:

<i>sigud a dákes</i>	it is intrinsically bad.
<i>sigud a bulsék</i>	he was born blind.
<i>nabaknúng a sigud</i>	he has always been rich.
<i>sigud ñga awán ti kúkuana</i>	he never had any property.
<i>sigud a nakasúrat</i>	he had always been able to write.

8. *Ūray (no) kasanó, uray (no) ipapaanó*, "anyhow, anyway" (no ligature). Cfr. VIII. Other Adverbs. I. 3.

9. *Mabayág* (past: *nabayág*), *kalkalá* (*pay*) (ordinary forms), *makamanó, makamanmanó* (rarely used), "a long time" and so on. Cfr. II. Adverbs of Time. III. Note 9. Examples:

<i>mabayág ti pananñgpatitda</i>	they ring the bells for a long time.
<i>addá a nabayágen</i>	he is here a long time already.
<i>nabayágak a nanñgálan</i>	I took some a long time ago.
<i>kalkalá pay ti isasanñpétko</i>	I arrived a long time ago.
<i>kalkalá pay ket dika pay nalpás</i>	such a long time and you have not yet finished it.

10. *Apagbalikás, apagdarikmát apagkanitó, apagkigmát, apagdípás, saán a kakigmátan*, "in a short time" and so on. Examples:

<i>maláto ití apagbalikás</i>	it can be cooked in a very short time (the time of pronouncing a word)
<i>rimmuár ití apagdarikmát</i>	he came out in a moment.
<i>sumanñpétto ití apagkanitó</i>	he will be here in a moment.
<i>nakarubbuát ití apagkigmát</i>	he was ready in the twinkling of an eye.
<i>apagdípás a naibús ti sabá</i>	the bananas were consumed in a very short time.
<i>saán a kakigmátan addán</i>	one moment and here he is already (before the eye twinkles)

11. *Pagamoán*, "at once" and so on (preceding, no ligature). Examples:

<i>pagamoán addá</i>	it appears at once.
<i>pagamoún nagtálawen</i>	he was gone unawares.

12. *Darás* "quickly" and so on (following, no ligature).

Examples:

<i>maibús darás</i>	it is used quickly.
<i>agsublí darás</i>	he returns quickly.
<i>umálogkat darás</i>	go down quickly.
<i>makalípat darás</i>	he forgets easily.
<i>aramídem darás</i>	do it quickly.

13. *Manén*, "again". This adverb either stands by itself or follows immediately some other word. *En* may be separated from *man* and joined to some other word further down in the sentence, and then it follows the rules of the simple adverb *en*. Cfr. II. Adverbs of Time. IV.

II. Adverbs of Time. IV. Examples:

<i>napán manén</i>	he went again.
<i>ápáy a nabartékka manén</i>	why are you drunk again?
<i>siká manén</i>	you again?
<i>addá man daytá lakáyen</i>	that old man is there again.
<i>nagsakit man idi kalmánen</i>	he got sick again yesterday.
<i>kasdi man met láengen</i>	just like that again.
<i>napán man nagtákarawen</i>	he went again to steal.
<i>addátay man áminen</i>	we are here again all of us.
<i>awán man ti makitamon</i>	don't you see anything again?
<i>nagsublí man kaniákon</i>	he came back again to me.
<i>addá man iti biánngmin</i>	he is again under our care.

14. *Pili*, with the meaning of "what should not be", is rarely used (preceding, no ligature). Examples:

<i>pili ket dida sapliten ti nasúbeg únay</i>	why don't they rather whip the very disobedient one?
<i>pili natáy ti baknáñg ditóy íli-tayo</i>	the rich man of our town died, why he?
<i>pili nabóonñgda ti kapintásan a burnáy</i>	they must break just the nicest jar.

VII. ADVERBS OF QUANTITY

I. The concept of excess is expressed in Iloko by:

1. The term *napálalo* or *nalabés*. Examples:

<i>napalálo a dakkél</i>	too big.
<i>napalaló a nasadút</i>	too lazy.
<i>dákes a napalálo</i>	too bad.
<i>nabannógka a napalálo</i>	you are too tired.
<i>uminúm iti napalálo</i>	he drinks too much.
<i>manñgánda iti napalpalálo</i>	they eat too much.
<i>nalabés ti ñgínana</i>	it is too expensive.

2. The adverb *únay* following immediately the word it modifies and the conjunction *tápno* introducing an incidental clause. Examples:

<i>naimbág únay a táo tapnó mapanúnotna a balsén</i>	he is too good a man to think about revenge.
<i>ay-ayaténka únay tapnó mabalínka a buybuyáen a di arakúpen</i>	I love you too much to be able to look at you without embracing you.

II. "Only" is expressed in Iloko by:

1. The adverb *láeng*, which always immediately follows some preceding word without connection by ligature. When another word follows, it is often abbreviated into *la*. Examples:

<i>siák láeñg</i>	I only.
<i>úrày ti láeng panangságidko</i>	even only my touching him.
<i>isúda láeñg ti pangikkánna</i>	he gives only to them.
<i>daytáy a ragsák sa láeñg maragpát ití kalpasán ti adú a panagleddáañg</i>	this joy will only be obtained after much sorrowing.
<i>táo la ti addá</i>	only men are there.
<i>agbídañg latta</i>	she just wears a tapis and that's all.
<i>sáñgit la ti ammóna</i>	he knows only weeping.

NOTE 26. This adverb is extensively used in Iloko. We have seen some instances before and we shall see more of them in due time. Sometimes the change it effects in the meaning of the sentence is very slight and often practically nil; therefore we shall give some examples of its use here. Examples:

<i>siák láeñgen</i>	let me do it.
<i>awán la ti umáy</i>	nobody has come yet.
<i>matúrogka láeñg</i>	go on sleeping.
<i>úràyka láeñg</i>	it depends on you.
<i>napúdot pay láeñg</i>	it is still warm.
<i>makitam la no addá idiáy</i>	you will see it if he is there (that it is worse than what you thought).
<i>di pay la pimmánaw ití baláyna</i>	he has not left his house yet.
<i>konák lan nalaklakáda</i>	I thought though that they were cheaper.
<i>diák la idá napagraém</i>	I was wholly unable to have them respect him.
<i>masápulmi la únay</i>	we need it very badly.
<i>ínka láeñg</i>	all right, you can go.
<i>addá pay láeñg</i>	he is still here; there is still some left.
<i>awán pay láeñg</i>	he is not here yet.
<i>adú pay láeñg</i>	there is still much left.

2. The reduplication of the initial, open syllable of the stem with the next consonant, if there is any, of the personal pronouns

of the first series, of the complete forms of the demonstratives, of some numbers (cardinal numbers, distributives, and so on), of the prefix *sañga* and so on. Examples:

<i>sisiak</i>	I only.
<i>dakdakami</i>	we only.
<i>daydaytóy</i>	only this one.
<i>dagdagitóy</i>	only these ones.
<i>up-uppát</i>	four only.
<i>walwaló</i>	only eight.
<i>is-isú</i>	he is alone.
<i>sagsaglilimáda</i>	they have only five each.
<i>sagsagsasasañgapúlo</i>	only ten each.
<i>sañgsañgaburnáy</i>	only one jarful.
<i>dúdua láeñg a dálan</i>	only two roads.
<i>banbannógda ti mamagbagá</i>	it is useless for them to give advice. (literally: only their labor in giving advice.)

NOTE 27. The forms *datdaytóy*, *datdaytá*, and so on, instead of *daydaytóy*, *daydaytá*, and so on, sometimes occur.

3. The reduplication of the first or of the second part of the complex prefix of the multiplicatives; in the latter case *mami* and *mamin* become *maminpi* and *maminpin* respectively. Examples:

<i>namnaminsán</i>	only once.
<i>nammaminpúlo</i>	only ten times.
<i>maminpinsán</i>	only once.
<i>maminpitló</i>	only three times.
<i>maminpinsiam</i>	only nine times.

NOTE. 28. *Maminpisán* may also mean "completely". Example:

parútekte a maminpinsán I shall grub it up completely.

III. "A little" is rendered into Iloko by:

1. The term *bassít* following the word immediately without any ligature. Examples:

<i>naturéd bassít</i>	he is rather bold.
<i>addá bassít</i>	there are just a few.
<i>manñán bassít</i>	he eats a little.
<i>yadayóna bassít iti dagá</i>	he puts it a little distance from the earth.

2. The term *addá* or *awán* followed by the principal word in which the initial, open syllable is reduplicated together with the next consonant if there is any. Examples:

<i>addá tultúleñgna</i>	he is a little deaf.
<i>awán ti taktakrótda</i>	they are not timid at all.

addá pañgpañgkismo
addá samsam-itna

you have a cast in the eye.
it has a tinge of sweetness.

NOTE 29. The prefix *kanika* adds the meaning of "less than" to a number. Cfr. The Number, I. Cardinal Numbers. IV. Note 1.⁸⁷ Example:

kanikapát

less than four.

IV. The multiplicatives and the distributives, which were studied under the numbers, are connected with the word they modify:

1. By the ligature *a* or *ñga*, when they precede;
2. By the article in the oblique, when they follow. Examples:

naminduá a napán
mamimpátkami a mañgán
namitlóda a nagayáb
naminwalóda ñga agtaráy
saggaysáda ñga agsublí
sappapátda a napán
nagtaráyak ití naminsán
gumátañgkaminto ití mamitló
nagikkisda ití naminduá
agulbódda ití maminribu
nagsángit ití kapamitlóna
nañgálada ití sagduduá

he went twice.
we eat four times.
they called three times.
they run eight times.
they come back one by one.
they went four by four.
I ran once.
we shall buy three times.
they shouted twice.
they lie a thousand times.
he wept for the third time.
they took each two.

1. Adverbs implying affirmation, confirmation, and so on: Examples:

1. *Wen*, "yes" (used by itself).
2. *Pay*, "yet, also" and so on (following, no ligature). Examples:

adú pay
addá pay
agsaó pay láeñg
ni pay Ana
naúyoñg pay
dakkél pay
bumúlodak pay
ikkánnak pay
bagás pay
siák pay
diak pay nañgán
saán pay a napán
awán pay
di pay dimtéñg
mañgánka pay sáka mapán
di pay nasayádat

there is much left.
there is some more left.
he still talks.
Ann also.
he is also severe.
it is also big.
I want to borrow more.
give me some more.
rice also.
I also.
I didn't eat yet.
he did not go yet.
he is not here yet.
he didn't arrive yet.
eat first and then go.
is that not good? it is really good.

⁸⁷ Anthropos 28 (1933) 711-712.

nakigtótak pay I was startled (*pay* corroborates the statement).
aramidekto pay no ammók a dákes would I do it if I knew it were bad?

3. *Agpapán pay, úray*, “even, whatever” and so on (preceding, no ligature). Cfr. Conjunction “Although”.³⁸ Examples:

agpapán pay san̄galubóñgan even the whole world.
diak kiníta agpapán pay ti rúpa I did not see even your father's face.
ni amám even he, he went also.
úray isú napán met there is nothing, not even a dog.
úray áso awán I also.
úray siák nobody died, not even one.
awán natáy ñga úray maysá whenever you say so.
úray no kaanó ti konám it is always good.
nasayáat úray kaanó come any time.
umáykayo úray no anó even those dogs of them, they also.
úray dagitá ásoda met I don't like it at all.
úray no sadín ti yánda mabiró- wherever they are we shall find
kanminto them.
addá ití úray sadíno a yan ti it is all over the world.
lúboñg
úray no si asino whosoever.
ayatén ti úray si asino a maka- whoever sees it loves it.
kíta
úray si asino ti addá ayabám call whomsoever is there.
úray no aniá ti konána whatever he says.
úray aniát kita a tagiláko any kind of merchandise.
úray aniá a sakít ñga addá ken- whatever is his ailment.
kuána
madiak úray no kasanó I won't anyhow.
úray ipapaanó ti umiggém howsoever we can take hold of it.
úray kasanó ti panañgay-áyona howsoever he coaxes me.
kaniák

4. *Ñgarud*: confirmatory (ordinarily following, no ligature).
 Examples:

inka ñgarúd go now (your reasons convinced me; do as you told me).
mapának ñgarúden I am going now (as I told you; as you told me).
inbagák ñgarúden I said it (why do you say I did not; why didn't you believe me; I told you so, as it had to be so).
ti ñgarúd kinonána kastóy now, what he said was like this.

³⁸ Unpublished.

<i>siák ñgarúden ket addá pay saóyo</i>	it is I, and still you have something to say.
<i>umáy ñgarúd</i>	he is here now (stop your mouth); of course he comes.
<i>aniá ñgarúd ti kayátyo</i>	what do you want (why don't you speak?)
<i>awán ñgarúd</i>	of course he is not there; he is not there indeed.
<i>siká ñgarúden</i>	now you (I can't; you do it as you pretend that you can).
<i>ni Juán ñgarúd ti ayabám</i>	then call John (if you cannot find another one).
<i>uminanáka ñgarúd</i>	take a rest now (as you are tired).
<i>puórak ñgarúd daytá káyo</i>	if so I shall burn that wood.
<i>saányo ñgarúd a kayát</i>	why, you don't like it (why do you object to my taking it?)
<i>ápáy ñgarúd a makítam</i>	why, do you see it? (you said you were blind).
<i>intó ñgarúd no umáy matari-máanto ámin</i>	consequently, when he comes, everything will be settled.
<i>ti ñgarúd lakáy ti nanñgarámid</i>	of course the old man made it; it was the old man who made it (nobody else).
<i>aniá ñgarúd ti addánto no bigát ámin ñgarúd a ñimngég nasdá-awda</i>	then what will happen tomorrow? whosoever heard it was astonished (it couldn't be otherwise).
<i>wen ñgarúd</i>	all right (stop asking me for it); yes, isn't it strange?

5. *Ñgad*: abbreviation of the preceding, mostly used in literature (following), no ligature. Examples:

<i>ta nadalús ñgad ámin</i>	because everything was clean of course.
<i>aniá ñgad ti gapóna</i>	then why?
<i>dika ñgad tuláden</i>	thus, don't imitate him.
<i>ti ñgad agturáy ti rebbéngtay ñga annugóten</i>	thus, we have to obey rulers (no others).

6. *Píman*: confirmatory, ordinarily implying commiseration (ordinarily following, no ligature). Examples:

<i>ta awán pínam ti nakapanúnót</i>	as there was nobody who thought (it's too bad).
<i>anáknaka píman ti okóm ket isút gapóna a kastá ti arámidmo</i>	because you are the son of the judge, is that a reason to behave as you do?
<i>ta babbái ket píman dagiti ub-bíng</i>	as the poor children were girls (what could they do?)
<i>ta isú píman awán pay inararámidna</i>	because he hadn't done anything yet, poor man.

<i>maduaduá píman no addá ken panagtagtagainép</i>	he is really in doubt if he is dreaming or not (the news is so very bad).
<i>píman ni María kásnak la anák píman</i>	poor Mary. she treated me as a son, poor girl.
<i>dína kayát ti mañgpabáin píman</i>	he doesn't want to make her feel ashamed.
<i>mabáin mettén píman a mañgúlit</i>	he is ashamed now to repeat it, poor boy.
<i>ni anákna a sísem, píman sísem ta dína pay la am mó ti napa-sámak ti amána</i>	his son who was smiling, smiling indeed, as he did not yet know what happened to his father.

7. *Da*: confirmatory (no ligature). Examples:

<i>da ikkának da</i>	now, give me some, quick.
<i>innak da</i>	I go now.
<i>da man dínak kikién</i>	leave me, don't tickle me.

8. *A*: confirmatory (at the end of a sentence). Examples:

<i>inkayo a</i>	go now (why do you wait, I don't keep you back).
<i>mañgtédka a</i>	give me some now, won't you?
<i>isú a</i>	that is he of course; all right then, if you say so.
<i>awán a</i>	there isn't any of course.
<i>madí a</i>	of course he won't.
<i>makaammóka a</i>	that is your business of course.
<i>addá a</i>	he is there of course.
<i>kastán a</i>	so long.
<i>wen a</i>	yes, of course.
<i>adú a</i>	there is much of course.
<i>birókem a</i>	well, look for it.
<i>isúda ti pagdamágam a</i>	ask them (why do you bother me?)
<i>no mapánda ámin úray siák mapánakto met a</i>	if they all go, I also shall go, shouldn't I?

II. Adverbs implying opposition:

1. *Ket*, *ketdí*, "rather" and so on (following, no ligature).

Examples:

<i>addá ket</i>	there is some (why do you say there isn't any?)
<i>sabáli ket ti malagípko</i>	now I am remembering something else.
<i>isú, saán ket a sabáli</i>	he it is and not somebody else.
<i>awán pay met ket ti nasasaóna</i>	he had not said anything yet though.
<i>kas ket bassit ti patégna</i>	as if it were of little value.
<i>ñgem kinonána ket kenkuána</i>	but he said to him though.

<i>a kas ket sakitén ti nákemda</i>	they seem to be sorry about it though.
<i>ñgem kanénda ket ti tinápáy</i>	but they eat the bread though.
<i>inarámidda ket kenkuána dágup</i>	but they treated him howsoever they liked.
<i>ti kinayátda</i>	
<i>naálana a di ket naslép</i>	he took it without getting wet at all.
<i>dína ket maíbbatán</i>	he doesn't let it go though.
<i>awán ket a pulós ti linabásanna</i>	he didn't skip anything at all though.
<i>awán ket kenkuána ti úray aniá</i>	there isn't anything bad in him though.
<i>a dákes</i>	
<i>awán ketdí</i>	there isn't any (why do you deceive me; why don't you believe me).
<i>siká ketdí</i>	you better do it.
<i>nagdaksangásatak ketdín</i>	what bad luck is mine (complaining).
<i>konám ketdí apó, makítam la no</i>	that is what you think, sir, but if he is there, you'll see.
<i>addá idiáy</i>	
<i>wen ketdí ñgem nanñínansa</i>	all right, but isn't it expensive?
<i>dída la ketdí mabaín</i>	why, they should be ashamed.
<i>wen ketdí no mayát ti bakétko</i>	all right, if my wife agrees.
<i>isúnsa ketdí daytáy ti birbirókem</i>	isn't this what you are looking for?
<i>addánsa ketdí nanñyég kenkuána ití pirák</i>	hasn't somebody given him money?
<i>kayátjonsa met ketdí ti agbalín</i>	don't you act as if you wanted to become chiefs?
<i>a pañgoló</i>	

NOTE 30. *Get* has become antiquated.

2. *Met, met láenñg, met la* "also, though" (following, no ligature). Examples:

<i>addá met ni kabsátko</i>	my brother is here also (he might not have been, but he is).
<i>awán met</i>	but he is not there (didn't you say he was?)
<i>addá met</i>	he is there though.
<i>madí met</i>	he refuses though.
<i>dagúsenna mettén</i>	now he does it at once.
<i>di únay adayó met</i>	it is not very far though.
<i>siák met</i>	I also (don't leave me out).
<i>dagití áso pay met</i>	also the dogs (don't exclude them).
<i>awán met ñgamín pirák</i>	well, there is no money (we thought there was).
<i>ni met Luís</i>	Lewis also.
<i>bulsékkami met ñgamín</i>	we are blind indeed (do you think so?)
<i>ti asáwak au ñn pay met</i>	my wife isn't here yet (I thought she was).

<i>simmañgpét mettén</i>	he has arrived already (don't think he hasn't).
<i>asidég met</i>	it isn't so far.
<i>siká pay met</i>	why, you also?
<i>awán pay met ti mayát</i>	nobody is willing yet (although you said otherwise; although the salary is very high).
<i>awán met la ti mayát</i>	nobody is willing though.
<i>awán met láeñg</i>	he isn't there though.
<i>addá met láeñg</i>	he is here though.
<i>madí met láeñg</i>	he refuses though.
<i>inagawáanna met la ñga inliw- liwag darás</i>	he did his best though to get rid of it (sorrow, and so on) quick.
<i>kas met la idi</i>	just as formerly.
<i>daydí met láeñg ti yánna</i>	he is in that same place.
<i>isú met láeñg</i>	it is the same.
<i>daytá met láeñg</i>	that same thing.
<i>ti pugót isú met la ti táo</i>	what we call <i>pugot</i> (black one) is just a man.
<i>idi met la kanitó nakakitada</i>	they were able to see on that exact moment.

NOTE 31. "Self," as applied to persons, may be expressed either by the adverb *met laeñg* or by the term *bagí* or *bagí met láeñg*. Examples:

<i>ti bagína komá ti panunótenna</i>	he should think of himself.
<i>pinatáyna ti bagína met láeñg</i>	he committed suicide.
<i>ayaténtayo ti bagitayo met lá- eñg</i>	let us love ourselves.
<i>siák met láeñg</i>	I myself.
<i>ni áma met láeñg</i>	my father himself.
<i>ni met la Ana ti napán</i>	Ann herself went.
<i>isúda met la ti agbúsor</i>	they themselves are enemies.

III. Adverbs implying doubt:

1. *Ñgatá*, "perhaps" (following, no ligature). Examples:

<i>addá ñgatá ni apó lakáy</i>	is the old gentleman there perchance?
<i>awán ñgatá</i>	maybe he is not there.
<i>siká ñgatá ti nanǵála</i>	did you take it perchance?
<i>umáyakto ñgatá</i>	perhaps I'll come.
<i>nayad-addána ñgatá ti nanǵán</i>	maybe he only came to eat.
<i>siák la ñgatán ken siká ti addán a sipupáot</i>	maybe you and I were the only ones who noticed it at the time.
<i>agan-anóak ñgatá no sumañgpét ditóy</i>	what can I possibly do if he arrives here?
<i>no kastá komá amañǵán ñgatá, ti taknéñg dagiti agturáy</i>	if it were so how virtuous the rulers would be.
<i>amañǵán a gagétmo ñgatá ti paliíwek</i>	isn't the diligence I notice in you very great?

idiáy baláy ñgatá ti yánna
nalukmég ñgatá la únay itán
ammó ñgatá ti kabsátko

maybe he is in the house.
 maybe he is very fat by this time.
 maybe my brother knows.

2. *Sa*, "probably" (always joined to a preceding word; the ligature *n* connects the two if the preceding word ends a vowel).

Examples:

addánsa apó
addánsa pay annákda
awánsa
kayátnansa ti sumrék
wénsa
nínsa Pédro (ni Pedrónsa)
isánsa ti nagtákaw kadagiti bá-
buymi
uppátsa ti nabáti
matúrogdansa

I think he is there, sir.
 haven't they also children?
 I don't think there is any.
 he probably wants to enter.
 I think so.
 Peter probably.
 I think that is the one who stole
 our pigs.
 I think there are four left.
 they are asleep probably.

3. *Nalábit*, "probably" (preceding, ligature *a* or *ñga*).
 Examples:

nalábit a simmanñgpéten
nalábit ñga awán
nalábit a kastá
nalábit ñga ayaténnaka
nalábit ñga addá pirákman
nalábit a dué púloda mettén

he probably arrived already.
 it is probable that there isn't any.
 that is very likely.
 he probably loves you.
 you very likely have money now.
 in all probability they must be
 twenty by this time.

4. *Agarúp*, "seemingly" (preceding, no ligature). Examples:

agarúp mayát
agarúp madí
agarúp napigsá
agarúp naimbág
agarúp masakít

he seems to be willing.
 he seems to be unwilling
 he seems to be strong.
 he seems to be good.
 she seems to be ill.

5. *Komá*: used for the conditional, the subjunctive and the optative (following, no ligature). Cfr. The Verb, Moods and Tenses. V, VI and VII.³⁹

6. *Mán*, *kadí*, *kad*: entreating (ordinarily following, no ligature). Examples:

siká man
manñgtédka man
siák man
umáyka man
napúdot man

you now (inviting).
 please, give me some.
 let me do it.
 come here, please.
 isn't it hot?

³⁹ Philip. Jour. Sci. 75 (1941) 200-202.

<i>kas man la díka makagun-ód ití kayátmo</i>	you seem not to obtain what you want.
<i>pagarupémsa man a diák mabalín ti agdáwat</i>	do you think perhaps I can't ask for things?
<i>kasdí man met láeñg ti inará-midna</i>	he behaved in exactly the same way.
<i>díkansa man marikná</i>	you don't seem to feel it.
<i>dákes man ti partáañgna</i>	he probably foresees bad news.
<i>man met láeñg</i>	wait a moment (I'll get you).
<i>manǵálaka man ití danúm</i>	please, get water.
<i>kitáem kad a siayát toy ílimi</i>	please, look with favor upon our town.
<i>diká kad láeñg mapán</i>	don't you go? (you certainly should)
<i>kaasiánnak kadí</i>	please, have mercy on me.
<i>tulonǵanyo kadí</i>	you should help him.
<i>pakawanem kadí</i>	please, forgive it.
<i>ipaáymo kadí a kalak-ámanmi</i>	please, allow us to partake of them.
<i>idawátannakam kad ití amám</i>	please, ask your father for us.
<i>innak kad indeñgán</i>	let me go and pay attention to it.
<i>úray kadí ket ti biág ababá úmay</i>	never mind, life is very short.
<i>dí kadí manmanó ti táo a maka-panúnót</i>	isn't it a shame how few people have sense?
<i>dí kad met la síká ti pañgíku-míták</i>	isn't it you to whom I entrust it?
<i>aniá kad daytóy a maipaáy ití adú a táo</i>	what is this for a great number of people?
<i>aniá kad ti konák idi</i>	what did I tell you some time ago?
<i>dakámto kad ket ñga addaún makán</i>	how could we have food? (richer people haven't).
<i>námakto kad a liwliwáda</i>	great will be their consolation.
<i>indakto kad pay patién</i>	will they believe me? (I doubt it).
<i>madaydáyaw kadí ti amám</i>	your father should be honored.
<i>saán kadí apó</i>	no, sir, please.
<i>umikkátka kadí</i>	go away, please.
<i>aniánto kad ketdí kenkán a bassit ti pammátina</i>	what is the matter with you having so little faith.

NOTE 32. *Man* is extensively used in Iloko and is very often placed between two parts of a complex conjunction, instead of following the said conjunction at it stands. Cfr. The Conjunction, passim.⁴⁰

IV. Adverbs implying wonder:

1. *Gáyam* (following, no ligature). Examples:

<i>ni áma gáyam</i>	it's my father (I didn't expect him).
<i>kastáka gáyam</i>	that is the kind of man you are (I shouldn't have thought it).

⁴⁰ Unpublished.

<i>addá ayá gáyam</i>	is there any, really?
<i>simmanǎpét gáyam ti anákmo</i>	your son came home (I didn't know that).
<i>isú gáyam</i>	it's he (I thought it was somebody else).
<i>awán gáyam</i>	there isn't any (I thought there was).
<i>ni gáyam Ana ditóy</i>	well, this is Ann (isn't it strange?)
<i>addáka gáyam ditóy</i>	you are here now (I didn't know that).

2. *Giém* (following, no ligature; often pronounced *diem*).

<i>awán pay giém</i>	there isn't any yet (I thought the contrary).
<i>duá pay ti ginátañgko giém</i>	I bought two (and still you don't mind).
<i>awán met giém ti aramídek</i>	I don't do anything to you (why are you angry?)
<i>konána idi gímonǎg apó giém</i>	he said it in the assembly, sir (yes, really).
<i>isú ti saóna giém</i>	that is what he said.
<i>adú giém ti kúkuana ket di pay mañgtéd</i>	he has so much and nevertheless he does not give.
<i>saán met giém</i>	no, not at all.
<i>ti komá árak giém apó</i>	better the wine, sir (we prefer the wine).
<i>maysá pay ti gatáñgek komá giém</i>	I should like to buy one more.
<i>sagwawaló komá giém</i>	it should be eight each.
<i>innak komá kumíta giém no addáda</i>	well, let me go and see if they are there.
<i>no addá met kúkuak giém</i>	well, I also have some (and still you leave me out).
<i>suktám man iti nainǎngpís giém</i>	change it, please, into a thinner one.

V. Adverbs implying resignation:

1. *Aniá ñgay, aniá pay, aniá ñgarúd*, "what can be done?"

Examples:

<i>aniá ñgay no nákem ti naganák</i>	what can be done if it is the will of the parents.
<i>aniá pay no sigud a dákes</i>	what can be done, he has always been bad.
<i>aniá kad pay no napañgláw met datáo</i>	what can be done, really, as one is poor.
<i>aniá ñgarúd awán met sabáli a pamuspúsan</i>	what can be done, there is no other remedy.

2. *An-anoen (kadi)*, "what can be done?" Examples:

<i>an-anoén no awán met ti pirák</i>	what can be done if there is no money.
<i>an-anoén kadi no isú ti konána</i>	what can be done if that is what he says.

CHAPTER II: THE PREPOSITION

I. Most prepositions are rendered into Iloko by adverbial expressions followed by the genitive, and by articles or pronouns in the oblique. Examples:

<i>iti tenḡḡá ti rabii</i>	at midnight.
<i>iti ḡálay ti dálan</i>	halfway.
<i>iti sakláḡ ti okóm</i>	before the judge.
<i>iti sírok ti káyo</i>	under the tree.
<i>iti rabáw ti alsónḡ</i>	on the mortar.
<i>iti unég ti burnáy</i>	in the jar.
<i>iti áway ti ili</i>	outside the town.
<i>iti ruár ti baláy</i>	outside the house.
<i>iti tenḡḡá ti dálan</i>	in the middle of the road.
<i>iti ígid ti karayán</i>	along the river.
<i>iti bánḡir ti karayán</i>	at the other side of the river.
<i>iti dáya ti adigi</i>	east of the post.
<i>iti nagbaetán ti baláy ken ti agámaḡ</i>	between the house and the granary.
<i>iti bátug dagiti bakét</i>	on a line with the old women.
<i>iti ḡáto ti agdán</i>	above the stairs.
<i>iti babá ti túrod</i>	beneath the hill; at the foot of the hill.
<i>iti likudán ti táo</i>	behind the man.
<i>iti masaḡoánan ti lakáy</i>	in front of the old man.
<i>ipakánmo iti áso</i>	feed it to the dog.
<i>ikábilmo iti ólona</i>	put it on his head.
<i>iserrékmo iti abút</i>	put it in the hole.
<i>ilákom kadagiti balásaḡ</i>	sell it to the girls.
<i>gataḡgem ken Ana</i>	buy it from Ann.
<i>ibagám ken amám</i>	tell it to your father.
<i>itédmo kenkuána</i>	give it to him.
<i>yégmo kaniák</i>	bring it to me.
<i>aláem kadakamí</i>	take it from us.
<i>ikkaték itóy ubiḡ</i>	I take it away from this child.
<i>ibítinmo itá káyo</i>	hang it on that tree.

II. 1. "From", indicating the place, is expressed by:

a. *Aggapó* (past: *naggapó*), literally: it comes from; followed either by the oblique or by a preposition or an adverb of place. Examples:

<i>aggapó idiáy Bontók</i>	from Bontoc.
<i>aggapó sadi láḡgit</i>	from heaven.
<i>naggapó ditóy</i>	from here.

<i>naggapó idiáy</i>	from there.
<i>aggapó ken áma</i>	from my father.
<i>naggapó ití atép</i>	from the roof.
<i>aggapó itá baláy</i>	from that house.
<i>naggapó itáy lakáy</i>	from that old man.

b. The prefixes *i* or *taga* joined to the name of the place.
Cfr. The Adjective. II. Special Forms. 5.⁴¹ Examples:

<i>tagasolsóna</i>	he is from Solsona.
<i>ibintár</i>	he is from Bintar.

2. "From", indicating the place or the time, is expressed by:

a. *Mañgrugí* (past: *nañgrugí*) literally: it begins at; followed either by the oblique or by a conjunction, a preposition or an adverb. Examples:

<i>mañgrugí ken Ana</i>	from Ann.
<i>mañgrugí itóy káyo</i>	from this tree.
<i>mañgrugí idiáy karayán</i>	from the river.
<i>mañgrugí idiáy</i>	from there.
<i>mañgrugí ití bigát</i>	from morning.
<i>mañgrugí idi kalmán</i>	since yesterday.
<i>mañgrugí no rabíi</i>	from this evening.
<i>mañgrugí itá</i>	from now.

b. *Manipud* (past: *nanipud*), literally: it begins at; *sipud*, literally: beginning. Both are either followed or not by the same terms as the preceding. Examples:

<i>manipud ití karayán</i>	from the river.
<i>manipud kadagiti il-ili</i>	from the towns.
<i>manipud ken António</i>	from Anthony.
<i>nanipud idiáy baláymi</i>	from our house.
<i>manipud ditá</i>	from there.
<i>manipud Lawág</i>	from Lawag.
<i>sipud ditóy</i>	from here.
<i>sipud ken Juána</i>	from Joan.
<i>manipud ití parbañgon</i>	from early in the morning.
<i>manipud no bigát</i>	from tomorrow.
<i>nanipud itáy bigát</i>	since this morning.
<i>manipud itá</i>	from now on.
<i>nanipud kinaubíñgna</i>	since his babyhood.
<i>manipud siám ti biláñgen</i>	from the ninth of this month.
<i>sipud idi napán a tawén</i>	since last year.
<i>sipud no bigát</i>	from tomorrow.
<i>sipud itá</i>	from now.
<i>sipud kinaubíñgna</i>	since his babyhood.

⁴¹ Anthropos 26 (1931) 483-484.

III. "To" or "till", indicating the place or the time, are expressed by:

1. *Agpapán*, from the prefix *agpa* indicating direction and the stem *pan*, "going." Examples:

<i>agpapán itá</i>	until now.
<i>agpapán malém</i>	until afternoon.
<i>agpapán bigát</i>	till morning.

2. *Agtuñǵpal* or *manuñǵpal*, literally: it finishes at: followed either by the oblique or by a conjunction, a preposition or an adverb. Examples:

<i>agtuñǵpál ken Ana</i>	to Ann.
<i>agtuñǵpál ditóy</i>	to here.
<i>manuñǵpál idiáy baláyyo</i>	to your house.
<i>manuñǵpál no agsápa</i>	till early tomorrow morning.

3. *Inǵgá*, literally: end. *Inǵganá*, literally: its end, *agiñǵá*, literally: it ends; *agiñǵána* (the same as *agiñǵgá* with an incorrect addition of the pronoun *na*). These prepositions are followed or not by the same terms as the preceding. Examples:

<i>inǵgá itá</i>	till now.
<i>inǵgát malém</i>	till afternoon.
<i>inǵgána ití agdán</i>	to the ladder.
<i>inǵgána ditóy</i>	to here.
<i>inǵgánat ití inǵgána</i>	eternally (literally: till its end).
<i>inǵgána ken patáy</i>	till death.
<i>iggánat ití tuñǵpál ti lúbonǵ.</i>	until the end of the world.
<i>inǵgána ití maikapitó</i>	to the seventh.
<i>inǵgánat no bigát</i>	until tomorrow.
<i>inǵgána itá</i>	till now.
<i>inǵgánat tuñǵpál biágko</i>	till the end of my life.
<i>agiñǵgá ken Juán</i>	to John.
<i>agiñǵgá ití maikatló a búlan</i>	till the third month.
<i>agiñǵgát masañgoánan</i>	till later; until the future.
<i>agiñǵgánat itá</i>	till now.

IV. 1. "With" is ordinarily included in the prefixes *maki*, *tagi* and *ka*, in the combination *ka . . . an*, and in the prefix *i* combined with the prefixes *sañga* or *sañgka*. Cfr. The substantive, III. Formation of Substantives. III. 4; and The Verb, The Adjectival Prefix *maki*; The Adjectival Prefix *ag*. b. III B. 1; The Substantival Prefix *i*. b. II. Note 6. B. and so on.⁴²

⁴² Anthropos 26 (1931) 472-473; Philip. Jour. Sci. 69 (1939) 231, 235-237; 71 (1940) 20.

2. Sometimes "with" is expressed by the preposition *agráman*, followed or not by the oblique, or by the preposition *patí*, followed by the nominative. Examples:

<i>agráman kadagiti kakabsátna</i>	with his brothers.
<i>agráman kadagiti adálanna</i>	with his disciples.
<i>agráman kaniák</i>	with me.
<i>agráman baláy</i>	and also the house.
<i>agráman annákna</i>	with his children.
<i>agráman ámin</i>	with all.
<i>dagiti gayyémmo pati ni Ana</i>	my friends and also Ann.
<i>inálana ti baláy pati dagiti alí-kámenna</i>	he took the house and also its furniture.
<i>ti pirákmi pati ti pagan-anáymi</i>	our money and also our clothes.

V. "Toward" is included in the prefixes *agpa* and *ipa*. Cfr. The Verb, The Substantival Prefix *ipa*; Verbs Implying Order or Permission. II A. 1.⁴³

VI. Other prepositions are:

1. *Idiáy*, "at, in, to, into" and so on (in general). Examples:

<i>addá idiáy Lawág</i>	he is at Lawag.
<i>addá idiáy baláy</i>	he is in the house.
<i>simmanǵpét idiáy pagdigúsan</i>	he arrived at the bathing place.
<i>mapán idiáy babá</i>	he goes to the lowlands.
<i>simrék idiáy agámanǵ</i>	he entered the granary.
<i>agyán idiáy tálon</i>	it stays in the rice fields.
<i>immúli idiáy atépna</i>	he climbed on its roof.

2. *Sadí* "in, to," and so on (exclusively with geographical names and terms). Examples:

<i>adú ti magátanǵ sadí Manila</i>	much can be bought in Manila.
<i>agnaéd sadí Bulakán</i>	he dwells in Bulacan.
<i>nagádal sadí Amérika</i>	he studied in America.
<i>inka sadí abagátan</i>	go south.
<i>napán sadí amiánan</i>	he went north.
<i>immúli sadí lánǵit</i>	he ascended to heaven.

NOTE 33. Sometimes the name of the place follows another word immediately without any preposition or article. Examples:

<i>mapán Manila</i>	he goes to Manila.
<i>napán lánǵit</i>	he went to heaven.

3. *Babaen*, "through," and so on, followed by the genitive. Examples:

<i>babaén ti palábos dagiti agturáy</i>	with permission of the authorities.
<i>babaén ti panaǵibábaetna</i>	through his mediation.
<i>babaén ti pannakaibelléǵ ti dárana</i>	through the shedding of his blood.
<i>babaén ti panagsublida</i>	through their coming back.

⁴³ Philip. Jour. Sci. 71 (1940) 20-22, 26-27.

4. *Malaksid*, "except," followed by the oblique. Examples:

<i>malaksid iti púsayo</i>	except your cat.
<i>malaksid ken gayyémko</i>	except my friend.
<i>malaksid kadagiti áso</i>	except the dogs.
<i>malaksid kadakayó</i>	except you.

NOTE 34. Other prepositions, which at the same time may be used as conjunctions, will be studied under the Conjunction.

ASPLENIACEÆ AND BLECHNACEÆ OF
NEW GUINEA *

By EDWIN BINGHAM COPELAND
Of the University of California

SIX PLATES

ASPLENIACEÆ

Genus *ASPLENIUM* Linnaeus

Brause, Engler's Jahrb. 56 (1920) 144-152, nearly three decades ago, listed 49 species in this genus. Two of these are *Athyrium*. One or two others are probably included because of wrong identification. He overlooked one published species; five have been published in subsequent years; two known elsewhere have been found here; and three are here described as new. The number to be accounted for would seem to be about 56, of which I can distinguish, by comparison or description, about 45. In support of the reductions, except as to my own species, the isotypes available for comparison are mentioned.

Fronds simple and entire.

Nest-forming, with marginal vein.

Sori broad, long, approaching margin.

Base gradually narrowed 2. *A. Phyllitidis*

Base broad, sessile 3. *A. cymbifolium*

Sori shorter, narrow, close in full fruit..... 1. *A. Nidus*

Not nest-forming, veins free.

Sori paired, facing one another.

Fronds uniform, oblanceolate 46. *A. schizocarpum*

Linear-lanceolate; juvenile fronds com-
pound 47. *A. scolopendropsis*

Sori not paired.

Fronnd coriaceous or subcoriaceous.

Fronds over 25 cm long.

Apex acute or acuminate.

Surface squamuliferous 4. *A. vittaeforme*

Surface naked.

Costa prominent 5a. *A. acrobryum*

Costa depressed 5. *A. comosum*

Apex cuspidate 6. *A. Wernerii*

Fronnd under 25 cm long

Rigidly coriaceous 7. *A. durum*

Subcoriaceous 4a. *A. morobense*

* Report on the Third Archbold Expedition, etc.

- Fronde herbaceous.
- Rhizome slender, green..... 8. *A. papuanum*
 Rhizome stouter, brown..... 9. *A. amboinense*
- Fronde pinnate to bipinnatifid.
- Small ferns with axes dark and polished.
- Pinnae rounded at apex.
- Fronde under 1 cm wide..... 10. *A. Trichomanes*
 Fronde broader 11. *A. normale*
- Pinnae more or less acute.
- Apex of pinnae nearly equal-sided 12. *A. unilaterale*
 Lower side of pinnae almost wanting..... 12a. *A. filipes*
- Mostly larger, axes not dark and polished.
- Lamina herbaceous, green.
- Pinnae large, not very oblique
- Rachis not winged 13. *A. subemarginatum*
 Rachis winged upward 13a. *A. Regis*
- Lower or all pinnae conspicuously oblique.
- Proliferous by slender rhizomes..... 14. *A. bipinnatifidum*
 Not proliferous by rhizomes.
- Pinnae under 5 cm long.
- Lower pinnae distant, reduced..... 15. *A. monotis*
 Fronde truncate at base.
- Pinnae merely toothed 16. *A. tenerum*
 Pinnae pinnatifid..... 16a. *A. decorum*
- Pinnae longer.
- Surface naked 17. *A. remotum*
 Surface squamulose 18. *A. persicifolium*
- Lamina more firm, usually brownish.
- Fronde up to about 5 cm wide.
- Larger pinnae incised.
- Fronde up to 2.5 cm wide 19. *A. gracile Fée*
 Fronde about 5 cm wide 20. *A. planicaule*
- Pinnae not lobed.
- Fronde compact 21. *A. pellucidum*
 Fronde long and lax 22. *A. keysserianum*
- Well developed fronds larger.
- Rachis proliferous 23. *A. cromwellianum*
 Not proliferous.
- Pinnae excised on lower side.
- Rachis more or less scaly 24. *A. acutiusculum*
 Rachis glabrescent 25. *A. falcatum*
- Base incompletely excised.
- Pinnae distinctly stalked..... 26. *A. macrophyllum*
 Pinnae almost sessile..... 27. *A. Sancti-Christofori*
- Fronde bipinnate or more compound.
- Sori dorsal (not marginal).
- Segments linear-cuneiform, 1 mm wide..... 28. *A. insititium*
 Segments distinctly wider.
- Rachis bulbiferous.
- Pinnules toothed 31. *A. hapalophyllum*

- Larger pinnules subpinnate 29. *A. Foersteri*
 Tripinnate 30. *A. paedigens*
 Not proliferous.
 Indusia with parallel sides.
 Pinnules not deeply cut.
 Fronds clustered, thin 40. *A. kelelense*
 Fronds remote, firm 35. *A. setisectum*
 Pinnules incised or pinnate.
 Segments cuneate, 2-3 mm wide.
 Rhizome scandent..... 36. *A. Brassii*
 Rhizome short.
 Rachis fibrillose 32. *A. lanceolatum*
 Rachis glabrescent.
 Frond lax 33. *A. laxifolium*
 Frond compact 34. *A. tafanum*
 Segments broad.
 Fronds firm to coriaceous.
 Pinnules rounded 37. *A. cuneatum*
 Pinnules subacute 37a. *A. affine*
 Fronds thin.
 Bright-green 38. *A. laserpitiifolium*
 Black-green 39. *A. Shawii*
 Indusia boat-shaped, ends acute 40. *A. nutans*
 Sori elongate, straight, free side marginal.
 Frond pinnate or subbipinnate, small..... 41. *A. subpinnatifidum*
 Fronds decompound, large 42. *A. scandens*
 Sori short, marginal to apical (*Loxoscaphe*).
 Fronds up to 10 cm long 43. *A. Bakeri*
 Fronds much larger.
 Fertile segments mostly entire 44. *A. novo-guineense*
 Fertile segments mostly furcate 45. *A. Schultzei*

1. *A. NIDUS* L.

A. Nidus L., Sp. Plant. (1753) 1079.

Brass 8966, 11320, 12903, 12951, alt. 20-2,200 m; *Carr* 12040; *King* 425.

Old-World Tropics.

Questionably distinct from *A. Nidus* is *A. ellipticum* (Feé) Copel., *Elmer's Leaflets* 3 (1910) 819. Referable to it are *Brass* 11373, 12335, 13742, 13863, 12903; *King* 424; and *Clemens* s. n. *Brass* 8974 is intermediate between these and what I suppose to be typical *A. Nidus*. *Brass* 13742 seems to be exactly *A. nidiforme* v.A.v.R.; and *Carr* 11898 is like it.

Philippine; Borneo; Java.

2. *A. PHYLLITIDIS* Don

A. Phyllitidis Don, Prod. H. Nepab (1825) 7.

Brass 14047, 13800, Idenburg River, alt. 50 m; *King* 422, 423, 286.

These are unlike typical *A. Phyllitidis* of India in having a veinlet which runs under the free edge of the indusium, and, as the latter curls back after maturity, gives superficially the same appearance as *A. scolopendrioides* J. Sm., in the case of which this appearance is not due to a vein. There is no such vein in typical (?) *A. Phyllitidis*, and only a suggestion of it in *A. simonsianum*. I suppose that all reports of *A. Phyllitidis* in New Guinea are based on this atypical form. The same peculiar vein is found in many collections from the central and southern Philippines, including *Cuming 319*, from Samar.

3. **A. CYMBIFOLIUM** Christ.

A. cymbifolium Christ, Bull. Boiss. II 6 (1906) 999.

Brass 12076.

Philippines.

The preceding three species represent Presl's section *Thamnopteris*. Because all have been construed as forms of *A. Nidus*, and even mixed in collection, their distribution and synonymy are uncertain.

4. **A. VITTAIFORME** Cav.

A. vittaeforme Cav., Descr. (1802) 255.

Brass 11500, Bele River, alt. 2,200 m.

Both *A. vittaeforme* and *A. squamulatum* Blume have been reported from New Guinea. As to their probable identity, see Christensen, Dansk Bot. Arkiv 9 (1937) 18. To his observations, it may be added that I have complete specimens from the type region, identified as *A. squamulatum*, which are certainly Cavanilles' species. All Philippine "*A. squamulatum*" is this species, which is also in Borneo and Sumatra. My Java specimens so named are distinct, but I suspect wrong identification.

4a. **ASPLENIUM MOROBENSE** Copel., sp. nov.

Plate 1.

Micropodium, rhizomate adscendente, 5 mm crasso, paleis ovatis acuminatis brunneis usque ad 6 mm longis vestito; stipitibus confertis, 10-23 cm longis, gracilibus, paleis parvis dense, sed sursum decidue, vestitis; lamina simplice, 15-25 cm longa, 3.5-4.5 cm lata, acuminata, haud prolifera, basi cuneata vix decurrente, integra, subcoriacea, costa paleis paucis minutis deciduis praedita, alibi glabra, inferne pallida; venis liberis, late patentibus; soris ca $\frac{3}{4}$ marginem versus elongatis, indusiis 0.8 mm latis, sporangiis longissime pedicellatis, annulo 20-cellulare, sporis oblongo-reniformibus, episporio hyalino, haud spinosis.

New Guinea: Morobe, Boana, alt. 800–1,300 m. *Mary Strong Clemens No. 41541*.

In the same group and from the same region is *A. Werneri* Ros., which I have not seen. It is described as larger throughout, which might well not be a real difference. But it is said to be abruptly acuminate, and rounded at the base, while the eight fronds of *A. morobense* in hand are all gradually narrowed to both ends. The lamina of *A. Werneri* is described as scaly; the immature frond of *A. morobense* bears sparse, minute, amorphous, ferruginous squamulae on the upper surface, and is promptly glabrescent. The nether surface, even as the frond grows, is practically glabrous.

5. *A. COMOSUM* Christ.

A. comosum Christ, in Schum. & Lauterb., Fl. dent. Südsee (1901) 127.

I do not know the type. *Schlechter 16609* might be authentic, but its costa is prominent, even carinate on some fronds. Endemic.

5a. *A. ACROBRYUM* Christ.

A. acrobryum Christ, Nova Guinea 8 (1909) 150.

Brass 12198, with long, winged stipe; *13711*, with long (10 cm) terete stipe; *13813*, attenuate downward and subsessile; *King 120 A, 393* and *s. n.*

There was considerable confusion in the numbering of King's specimens, and, understanding that I had a complete set of his later collections (some earlier ones went to Bailey only), I suppose that one of these just cited is the plant sent to Buitenzorg and reported as *No. 320*, the type of *A. paucidens* v.A.v.R. This is a very variable plant, but I believe that all specimens cited above are one species. *Brass 13183* is identical with *Schlechter 16609*; if that specimen is correctly named, all are *A. comosum*. It is noted that Christ closed his comment on *A. acrobryum* with "Conf. *Asplenium comosum* Christ de la Nouvelle Guinée orientale."

6. *A. WERNERI* Ros.

A. Werneri Ros., Fedde's Repert. 5 (1908) 39.

Not seen. The type is *Werner No. 3*, from Mt. Gelu. Reported also as *Ledermann 12516*. Reported as with rhizome 5 cm. thick, short-creeping and then suberect; frond long-stipitate, subrounded at base, obtuse and abruptly acuminate. Probably near *A. vittaeforme*.

7. **A. DURUM** Copel.

Plate 2.

A. durum Copel., Univ. Calif. Publ. Bot. 18 (1942) 222.

Rhizomate breve, valido, paleis ovatis acutis brunneis circa 3 mm longis vestito; foliis confertissimis, sessilibus, integris, lineari-oblongeolatis, usque ad 23 cm longis et 17 mm latis, acutis, deorsum longe attenuatis, prope basin inferne parce paleatis aliter nudis, rigide coriaceis, costa applanata, venis immersis furcatis in marginem cartilagineum plus minus deflexum terminantibus; soris ad costam et marginem fere attinentibus, angulo 45° seriatis, indusio lato brunneo crasso.

Dutch New Guinea: Balim River, alt. 1,600 m, *Brass 11639*; "occasional on bare limestone on deforested slopes; leaves fleshy." The description is of the larger of the two individuals. The larger fronds of the smaller one are 7.5 by 1 cm, but fruiting freely.

Distinguished from *A. apoense* and *A. ensiforme* by sessile fronds; from *A. simplicifrons* by the position of the sori; more rigid and naked than any of these. Such plants as this must be supposed to be reduced relatives or forms of species of normal size for the group, the reduced stature and the texture being functions of exposure. Some features of resemblance to another local species suggest *A. cymbifolium*, which in full development has fronds a meter by 20 cm; but the paleae are different.

8. **A. PAPUANUM** Copel.

A. papuanum Copel., Philip. Jour. Sci. 6 (1911) 79.

Known only by the type, *King 287*. Possibly a juvenile *A. amboinense*, but not to be reduced on the evidence in hand.

9. **A. AMBOINENSE** Willd.

A. amboinense Willd., Sp. Plant. 5 (1910) 303.

Brass 11258, 12436, 12897, 13623, 13657, 13858, 13663, alt. 700 to 1,100 m. *No. 13657* is aberrant, with sessile fronds, minutely but rather freely squamulose surfaces, and remote marginal teeth.

Malaya.

10. **A. TRICHOMANES** L.

A. Trichomanes L., Sp. Plant. (1753) 1080.

A specimen collected by Mrs. Clemens is this species, broadly construed.

Cosmopolitan New to New Guinea.

11. **A. NORMALE** Don

A. normale Don, Prod. Fl. Nepal. (1825) 7.

Brass 12212, 12437, alt. 1,750 m. For first New Guinea report, see Christensen, *Brittonia* 2 (1937) 290, *Brass 5451* and 5549.

Asia, Africa, Malaya; reported from Queensland.

12. *A. UNILATERALE* Lam.

A. unilaterale Lam., Enc. 2 (1786) 305.

This comprehensive species is reported from New Guinea, but all specimens I have seen are referable to *A. filipes*.

Africa; Asia; Polynesia.

12a. *A. FILIPES* Copel.

A. filipes Copel., Philip. Jour. Sci. 3 (1908) 34.

Brass 13850, alt. 130 m. Collected also by King and by Mrs. Clemens. A segregate of *A. unilaterale*.

Philippines.

13. *A. SUBEMARGINATUM* Ros.

A. submarginatum Ros., Fedde's Repert. 5 (1908) 372.

A. Kingii Copel., Philip. Jour. Sci. Bot. 6 C (1911) 79.

A. pseudovolcanicum v.A.v.R., Nova Guinea 14 (1924) 8.

Brass 13859, 13900, alt. 55 and 120 m; Damun, *Wernes 68*.

13a. *A. REGIS* Copel., sp. nov.

Plate 3.

A. rhizomatis apice solummodo viso valido; stipitibus fasciculatis, 15–20 cm longis, brunneis, paleis lineari-lanceolatis 2–4 mm longis, interdum ramis lateralibus ornatis, persistentibus vestitis; lamina 30 cm longa, non prolifera, pinnata foliola apicale pinnis lateralibus simile, rhachi minute et sparse paleata, sursum alata ala 1 mm lata; pinnis utroque latere circa 6, infimis vix diminutis, medialibus 8 cm longis 2 cm latis, acutis, alatopedicellatis basi suboblique late cuneatis, grosse serratis, herbaceis, viridibus, inferne sparse squamuliferis; venis erectopatentibus, furcatis; soris linearibus nec costam nec marginem attingentibus. Plantae juvenilis stipitibus 6 cm longis, lamina jam fertile 12–15 cm longa deorsum bipinnata, rhachi ubique alata.

Papua: *King 380*.

Probably related to *A. remotum*, as indicated by the bipinnate fronds of the juvenile plant. I do not feel altogether sure that this is not *A. cesatianum* Baker, known only by Baker's description and by Christensen's reduction to *A. persicifolium*, which this certainly is not. Juvenile plants might have been unknown; but Baker could hardly have overlooked the alate rachis; the pinnae are coarsely serrate, not crenulate; and I find no large paleae at the bases of the stipes.

Isotype in Herb. Univ. Calif.; Lakekamu, *King 357* (type of *A. Kingii*), 300. The isotype of *A. subs emarginatum* and the Brass specimens are proliferous at the apex; the apex of King's fronds is wanting. The lowest pinnae of *King 357*, but not of *No. 300* nor the Brass specimens, are forked; we have not the base of *Werner 68*. The type of *A. pseudovulcanicum* is *Lam 671*, with *Lam 674* and *742* also cited, from the Mamberamo River, about sea-level. I have not seen them, but the description shows no distinctive feature.

Endemic.

14. **A. BIPINNATIFIDUM** Baker

A. bipinnatifidum Baker, Synopsis (1867) 221.

Brass 12381, 12889, alt. 1,200 and 1,500 m. Apparently common. The pinnae vary from entire through lobed to subpinnate. For synonymy, see Christensen, Dansk Bot. Arkiv 9 (3) (1937) 47.

To Fiji, and reported in Celebes.

15. **A. MONOTIS** Christ

A. monotis Christ, in Schum. & Lauterb., Nachtr. (1905) 43.

Known only by the type collection. Described as with small sterile and much larger fertile fronds.

16. **A. TENERUM** Forster

A. tenerum Forster, Prod. (1786) 80.

Brass 8930, Cyclops mountains; 13757, 14120. Common throughout New Guinea.

Asia to Tahiti.

16a. **A. DECORUM** Kunze

A. decorum Kunze, Bot. Zeit. 6 (1848) 176.

Darea Belangeri Bory, Bél. Voy. Bot. 2 (1833) 51.

Asplenium tenerum var. *Belangeri* of authors.

Reported from New Guinea as var. *acuminata* Ros., on the basis of *Werner 13*, also as *Ledermann 9293*. Pinnae said to be up to 12 cm long. Described from the upper part only of a frond; very likely not this species.

17. **A. REMOTUM** Moore

A. remotum Moore, Index (1859) 160.

A. ludens Baker, Jour. Linn. Soc. 19 (1882) 294.

Reported from New Guinea are *A. dubium* Brack., and *A. multilineatum* Hooker, respectively *A. remotum* Moore and *A. ludens* Baker, all as var. *dareoides* Ros.

First as to the name: Brackenridge described *A. dubium* and *A. distans*, both applying to the same common Fiji species, both names pre-occupied, *A. dubium* applying to a sterile juvenile form with dissected leaves, the fronds of the adult plant being simply pinnate. Moore substituted *A. remotum* for *A. distans*. Then Hooker substituted *A. multilineatum* because he found Moore's name inappropriate. *A. ludens* was described from the Solomons, supposed to be distinguished by short sori, perhaps really distinguishable by minute squamules instead of narrow paleae of some size on the creeping or eventually scandent rhizome; it, also, has dissected fronds on juvenile plants.

Following the description of *A. multilineatum* var. *dareoides*, Rosenstock, Fedde's Repert. 10 (1912) 327, proceeds: "Das wir es bei ihm mit einer dareoiden Form von *A. multilineatum* Hk. zu tun haben, ergibt sich einmal aus dem charakteristischen braunen, kletternden Rhizom mit seinen kleinen, braunen Schüppchen, das bei beiden genau übereinstimmt, sowie zweifellos aus einem in meinem Herbar befindlichen Wedel des *A. multilineatum* (l. Bamler, Neu-Guinea), der neben den typischen ungeteilten Fiedern andere von der Form der var. *dareoides* trägt." We have such a specimen from Rosenstock, l. Werner, bearing three fertile, strictly pinnate fronds, and a number of manifestly juvenile dissected fronds. From Alston, we have Carr 11677, wholly sterile, but with both dissected and simply pinnate fronds, the latter clearly representing a transition from juvenile to adult. I have also King 496, l. Rev. P. C. Shaw from mountains behind Taupotu, to which I gave but did not publish a new name, distinguishing it from *A. remotum* by the minutely squamulose rhizome, and from *A. ludens* by sori extending to the margin. The latter distinction will probably not hold, and the former deserves more observation. These three specimens represent one species, almost certainly *A. ludens*, probably also *A. remotum*. Its dissected fronds are juvenile; adult plants bear pinnate fertile fronds. As to the variety *dareoides*, see also No. 42, *A. scandens*.

Solomon Islands; Fiji.

18 A. PERSICIFOLIUM J. Smith

A. persicifolium J. Smith: Mett., *Asplenium* (1859) 97.

A. cesatianum Baker. Cf. Christensen, *Dansk Bot. Arkiv* 9 No. 3 (1937) 46.

Collected by Beccari, *teste* Christensen.
Philippines; Celebes.

19. A. CLEMENSIAE Copel., sp. nov.

Plate 2

A. rhizomate breve, paleis fuscis nigrescentibus lanceolatis attenuatis vix 1 mm longis vestito; stipitibus approximatis, 2–3.5 cm longis, brunneis decidue paleolatis; lamina 10–15 cm longa, 2–2.5 cm lata, acuminata, basi aut truncata aut paulo angustata, subbipinnata, papyracea, brunnescente, glabra, rhachi in parte superiore prolem gerente; pinnis brevi-pedicellatis, valde obliquis, majoribus cum pinnula una acroscopica late cuneata sessile, parte apicale pinnulae aut incisa aut tantum dentata dentibus paucis; soris secus venas fere omnes elongatis, indusio integro persistente.

New Guinea: Morobe, Boana, alt. 1,000 m. *Mary Strong Clemens No. 41740.*

This is a reduced member of the group of *A. insititium* Brack.

A series of one collection, *Copeland 1886*, from Mt. Data, Luzon, the smallest individual of which matches Fée's description and figure perfectly, enables me to identify *A. gracile* Fée as *A. planicaule* Wall. *non* Lowe. Similar in appearance as are the reduced Luzon and New Guinea specimens, they are not immediately related.

Similar to this, but not identical, is *Brass 641*,—see *Journal Arnold Arboretum* 10 (1929) 178. It is more and more finely dissected, with less salient venation, about the same size, lamina 12 by 2.5 cm, and with tiny buds on some rachises. So far as the resemblance is due to reduction, it does not prove nor even indicate affinity.

20. A. PLANICAULE Wall.

A. planicaule Wall., *List.* (1828) n. 189 *nomen*: Mett., *asplenium* (1859) n. 158 *non* Lowe.

Reported from New Guinea, but I have no specimen.
India to Japan and Luzon.

21. A. PELLUCIDUM Lam.

A. pellucidum Lam., *Enc. 2* (1786) 305.

Probably common at moderate altitudes.
African Islands to Polynesia.

22. A. KEYSSERIANUM Ros.

A. Keysserianum Ros., *Fedde's Report.* 10 (1912) 328.

Known only by the type collection, *Keysser 26*, from Sattelberg; isotype in Herb. Univ. Calif.

23. A. CROMWELLIANUM Ros.

A. cromwellianum Ros. Feddie's Report **10** (1912) 327.

A. Ledermanni Hieron, Engler's Jahrb. **56** (1920) 150.

Brass 11243, 11244, 11598, 12220, 12865, 13383, alt. 850 to 2,200 m. variable; pinnae obscurely or sharply toothed, or with a basal lobe, but none of this collection is as incised throughout as is one frond of *Keysser 19*, the type collection. I have not seen *A. Ledermanni*, but its description does not show that it is without the range of these specimens. Moreover, if these were Philippine specimens, they would be *A. Steerei* Harr.; and I mistrust identity with *A. lobulatum* Mett. These belong to a natural group, within which distinction of species is difficult or impossible.

24. A. ACUTIUSCULUM Blume

A. acutiusculum Blume, Enum. (1828) 178.

Not seen from New Guinea.

Malaya; Philippines; reported from Samoa.

25. A. FALCATUM Lam.

A. falcatum Lam., Enc. 2 (1786) 306.

Common.

Old-World tropics and subtropics.

26. A. MACROPHYLLUM Swartz

A. macrophyllum Swartz, Schroder's Journal "1800" (1801) 52.

While distinct enough in typical forms, both this and *A. falcatum* are very variable in New Guinea and Malaya, and the assignment of intermediate forms to one or the other is uncertain. Bakker and Posthumus, *Varenflora voor Java* 139, treat them as one species, and I am now so doing in the Philippines. *Brass 11638*, a dwarf growing on bare limestone, alt. 1,600 m. may represent *A. macrophyllum*. And I would give this name to *Hollrung 789*, distinguished by Hieronymus as *A. toyayanum* Wall.

African islands to Polynesia.

27. A. SANCTI-CHRISTOFORI Christ

A. Sancti-Christofori Christ, in Schum. & Lauterb., Fl. dent. Südsee (1901) 128.

A. Goadyi Copel. & Shaw, Philip. Journ. Sci. **26** (1926) 330.

Brass 13956, 14125, alt. 50 m. Apparently common.

Endemic in New Guinea and neighboring islands. *Goadby 1*, the type of *A. Goadbyi*, is from New Britain.

A. Gjellerupii v.A.v.R., Bull. Jardin Bot. Buit. II No. 7 (1912) 7, was maintained by its author, Malayan Ferns Suppl. I 293, as being *A. Sancti-Christofori* Ros. non Christ; but I find nothing in the more complete description given there by which to distinguish it from the real *A. Sancti-Christofori*.

28. A. INSITICUM Brack.

A. insiticum Barck; U. S. Expl. XVI (1854) 161, pl. 22, f. 2

Brass 12054, alt, 1,800 m; *12037* (?). *Carr 11989* is received as *A. spathulinum* J. Smith, and may be correctly named; but I cannot distinguish it from *A. insiticium*. The two were included in the first description of *A. spathulinum* by Hooker, Sp. Fil. III (1860) 170.

New Caledonia; Fiji; Hawaii; and if *A. spathulinum* be included, the Philippines.

29. A. FOERSTERI Ros.

A. Foersteri Ros., Fedde's Repert. 12 (1913) 168.

Brass 10285, 10543, 10629, 10286, 11242, 11407, alt. 2,300 to 2,800 m. The type is *Keyesr B 51*, isotype in Herb. Univ. Calif. Of Brass' collections, the first three are even more slender than the type, the lamina up to 50 by 5 cm. The last three are much more ample, up to 90 by 27 cm. The first three have more promptly glabrous axes; and are without buds on the rachises of the pinnae, as is also our isotype.

Endemic.

A. cromwellianum, *A. insiticium* and *A. Foersteri* are closely related species, a group characterized by somewhat fleshy texture and the production of gemmae, at least at some of the upper axils of the rachis. If *A. cromwellianum* is *A. lobulatum* and *A. insiticium* includes *A. spathulinum*, both species range from New Guinea to Luzon (and probably Formosa) and to Hawaii. Whether they are one or two species, or a group of related species, can only be decided with more ample collections than have ever been made.

30. A. PAEDIGENS Copel.

Plate 4.

A. paedigens Copel., Univ. Calif. Publ. Bot. 18 (1942) 222.

Euasplenium, rhizomate breve, valido, paleis castaneis aciculari-lanceolatis integris rigidis circa 3 mm longis vestito; stipite 25 cm alto 2 mm crasso, griseo-fusco, rhachique sparse fibrillosis

mox denudatis; lamina usque ad 60 cm longa et 25 cm lata, ovata, tri-quadri-pinnata, tenuiter papyracea, glabra, apice flagelliforme cum pinnis remotis vix 2 mm longis linearibus rhachi gemmifera; pinnis fere sessilibus, apice frondis simile sed brevius protractis, infimis paulo brevioribus, inframedialibus usque ad 17 cm longis et 6 cm latis; pinnulis usque ad 4 cm latis, basi oblique truncatis 14 mm latis, apice protractis; pinnulisii maximis 8 mm longis 4 mm latis, ad costam anguste alatum sectis, segmentis 1-3 cuneiformibus 1 mm latis subacutis vel apice fassis; venulis plerumque 2, soris 1 vel 2, linearibus, indusiis laete castaneis integris.

Dutch New Guinea: *Brass 12896*, type, 6 kilometers southwest of Bernhard Camp, Idenburg River, alt. 1,100 m. "Low epiphyte in a rain-forest gully," also, *Nos. 12817, 13330, 13752*, alt. 850 to 1,200 m.

Because of its fine dissection, this has the aspect of a *Loxoscaphe* or *Darea*, but the sori are attached on the side nearest the margin. In spite of the gemmate rachis, this is not very close to *A. Foersteri*, being different in texture as well as in dissection. It is not in the group of *A. lanceolatum* (*A. furcatum*, *A. praemorsum*), in spite of some similarity in dissection.

31. A. HAPALOPHYLLUM Ros.

A. hapalophyllum Ros., Fedde's Repert. 12 (1913) 167.

Brass 9220, 9295 Lake Habbema, alt. 3,225 m; *Brass & Myer-Dress, 10029*, Mt. Wilhelmina, alt. 3,560 m; Morobe, alt. 8,000-9,000 feet, *Clemens s.n. 12384 bis* and the type is *Keysser II 38*, and our specimen is marked "unicum." Brass' specimens are larger, with a few more residual paleae on the fronds, but I am confident of the specific identity. *No. 9296*, the largest, has stipes 20-25 cm long, lamina up to 36 cm long and 15 cm wide, tripinnate in the lower part, pinnules with few (2-4) secondary pinnules, the lowest sometimes forked. Note on the *Clemens s.n.* specimen reads "pendulous, 4-5 feet."

Endemic.

32. A. LANCEOLATUM Forsk.

A. lanceolatum Forsk.: C. Chr., Suppl. III (1934) 36.

A. praemorsum Swartz, Prod. (1788) 130.

Bamler 29 (1913), from Rook Island, received as "Aspl. furcati Thbg. var. an sp. n.", is approximately this "species."

Cosmopolitan.

33. **A. LAXIFOLIUM** v.A.v.R.

A. laxifolium v.A.v.R., Nova Guinea 14 (1924) 8.

Dutch New Guinea: Doorman-top, alt. 2,500 m, *Lam* 1976.
Not seen or not recognized.

Endemic.

34. **A. TAFANUM** C. Chr.

A. tafanum C. Chr., Brittonia 2 (1937) 291.

Mt. Tafa, alt. 2,400 m, *Brass* 4839, 4840. Not seen.

Endemic.

This and *A. laxifolium* as described are unlike *A. paedigenis* in having stalked pinnae.

35. **A. SETISECTUM** Blume

A. setisectum Blume, Enum. (1828) 187.

A. inciso-dentatum Ros., Fedde's Repert. 12 (1913) 167.

Brass 9297, Lake Habbema, alt. 3,225 m; *Clemens* 10154, Mt. Sarawaket, alt. 11,000 feet; *Keysser B* 12, Bolan mountains, alt. 3,400–3,800 m, isotype of *A. inciso-dentatum* in Herb. Univ. Calif. The reduction of *A. inciso-dentatum* is by Backer and Posthumus, Varenflora voor Java 339; and the fact is not overlooked that Christensen, Brittonia 2 (1937) 290, 291, has listed them as distinct.

Malaya; Luzon.

36. **A. BRASSII** C. Chr.

A. Brassii C. Chr., Brittonia 2 (1937) 291.

Brass 9854, Wilhelmina-top, alt. 3,560 m, epiphytic in large masses in subalpine forest. The rhizome, like that of *A. setisectum*, is wide-creeping, with remote fronds.

Endemic.

37. **A. CUNEATUM** Lam.

A. cuneatum Lam., Enc. 2 (1786) 309.

A. affine Swartz, Schroder's Journal "1800" (1801) 56.

37a. **A. AFFINE** Swartz

These names have been applied rather indiscriminately to specimens from Malaya, New Guinea and Polynesia. The original distinction between *A. cuneatum*, from Jamaica, and *A. affine*, from Mauritius, is that the former has rounded, the latter, subacute pinnules.

Brass 13797, 13957, alt. 50 m. Ample, with board, rounded pinnules, *A. cuneatum* by definition. *King* 239, 365, smaller fronds of the same species. *Werner* 69, *Rosenstock Fil. Novog.*

Exsicc. n. 1 is smaller and more harsh,—*A. cuneatum* var. *oceanicum* Kuhn. *King 365* and *Bamler, Rosenstock Fil. Novog. Exsicc. 157* can be *A. affine* by definition; both rounded and subacute pinnules are on both. I am of course not proposing the reduction of *A. affine*.

Pantropic, as a group.

38. A. LASERPITHIFOLIUM Lam.

A. laserpithifolium Lam., Enc. 2 (1786) 310.

Brass 13969, 14046, alt. 50 m. Common near sea-level. Malaya; Polynesia.

39. A. SHAWII Copel.

A. Shawii Copel., Philip. Jour. Sci. 30 (1926) 330.

Known only by the original collection, *1 Shaw, King 494*.

40. A. KELELENSE Brause

A. kelelense Brause, Engler's Jahrb. 49 (1912) 29, f. 2 A.

The original collection, *Schlechter 16302*, isotype in Herb. Univ. Calif., is correctly described as having a short, erect rhizome, the fronds fascicled. It looks to me like a juvenile plant, possibly of *A. cuneatum*. *Rosenstock Fil. Novog. Exsicc. n. 183*, distributed with this name, with a slender, scandent rhizome, is no near relative. Six collections by Ledermann, det. Brause, Engler's Jahrb. 56 (1920) 146, are unknown to me. Endemic.

41. A. NUTANS Ros.

A. nutans Ros., Fedde's Repert. 12 (1913) 168.

The type collection, *Keysser B 51 A*, Bolan mountain, alt. 2,400–3,000 m, isotype in Herb. Univ. Calif. The indusia look like those of a *Loxoscaphe*, to which it has no other resemblance. *Carr 14072*, Alola, alt. 6,000 feet, is a more ample specimen, with longer and more acute pinnules, more scaly rachis, and longer sori, but probably of the same species.

Endemic.

42. A. SCANDENS J. Smith

A. scandens J. Smith: Mett., Asplenium (1859) 108.

A. multilineatum var. *dareoides* Ros., Fedde's Repert. 10 (1912) 326.

A. remotum var. *dareoides*, Engler's Jahrb. 56 (1920) 146.

A. ludens var. *dareoides* Alston, Jour. Bot. (1939) 289.

A. impressivenium v.A.v.R., Bull. Jardin Bot. Buit. II No. XX (1915) 8.

As to the variety *dareoides*, whatever the specific name, I have already pointed out in discussing *A. remotum*, No. 17 of this enumeration, that the dissected fronds of that species represent juvenile stages and are sterile. The variety *dareoides* is a plant with dissected fertile fronds of mature plants. Its type was collected by Bamler in the Cromwell mountains in 1910. We may not have it, but do have a specimen collected by Bamler in the same place, dated 1912, *Rosenstock Fil. Novog. Exsicc. n. 152*, "*Asplenium multilineatum* Hk. v. *dareoides* Ros., n. v." It bears two fronds: one sterile, *A. scandens*, with short, rounded pinnules; the other larger, fertile, with longer subacute pinnules. Similar specimens are *Schlechter 16428*, received as *A. dubium*; *Lam 1384*, received as *A. scandens*, and *Carr 14790, 15399*, received as *A. ludens* var. *dareoides*.

A. scandens of the southern Philippines,—I have 11 collections from Mindanao and Palawan,—has rather narrow, lanceolate pinnae with short pinnules rounded at the apex. My isotype, *Cuming 297* from Leyte, has longer and more pointed pinnules. In New Guinea, the form with narrow pinnae is apparently common, represented by *Brass 13667, 13846* and *13847*. The variety *dareoides* has distinctly longer, more pointed pinnules. *Brass 12265, 12379* and *12892* are of this form. The extremes look distinct, but the type of the species is intermediate. Juvenile plants, identical from Palawan and New Guinea (*1. Mrs. Clemens*), with fronds down to 5 cm long, are dissected like the adults except as necessarily simplified in mechanical correlation with stature.

Philippines; Solomon Islands.

43. **A. BAKERI** C. Chr.

Known only by the type collection, from Vanapa Valley, alt. 2,000–4,000 feet.

44. **A. NOVO-GUINEENSE** Ros.

A. novo-guineense Ros., Fedde's Repert. 5 (1908) 40.

Mt. Gelu, alt. 1,000, *Werner 16* isotype in Herb. Univ. Calif.; Kani mountains, alt. 1,000 m, *Schlechter 17191*.

Endemic.

45. **A. SCHULTZEI** Brause

A. Schultzei Brause, Engler's Jahrb. 49 (1912) 30.

Brass 12022, 12706, alt. 1,800 and 2,000 m; Sattelberg, alt. 1,500 m, *Keysser 196*. The type, not seen, is *Schultze (33) 77*.

Endemic.

Brause, Engler's Jahrb. 56 (1920) 146, lists *A. achilleifolium* (Lam.) C. Chr. as a New Guinea species. Its presence is improbable.

46. **A. SCHIZOCARPUM** Copel.

A. schizocarpum Copel., Genera (1947) 165.

Scolopendrium schizocarpum Copel., Philip. Jour. Sci. 1 Suppl. (1906) 152.

Diplora schizocarpa C. Chr., Suppl. III (1934) 78.

Schlechter 10229; Bamler, *Rosenstock Fil. Novoy. Exsicc. n. 96*; *Keysser 26*; all from Kaiser-Wilhelmsland, alt. 900 to 1,600 m.

Mindanao; very nearly the same form from the Solomon Ids.

47. **A. SCOLOPENDROPSIS** F. v. M.

Asplenium scolopendropsis F. v. M., Papuan Plants III (1876) 48.

Scolopendrium d'Urvillaei Bory, Dup. Voy. Bot. I (1828) 273.

Diplora d'Urvillaei C. Chr., Suppl. III (1934) 78.

A. Linza Cesati, Rend. Ac. Napoli 16 (1877) 29.

Triphlebia dimorphophylla Baker, Malesia 3 (1886) 42.

Scolopendrium Mambare Bailey, Queensland Agric. Journal (1898) 9.

Phyllitis intermedia v.A.v.R., Bull. Dept. Agric. Ind. Néerl. No. XXI (1908) 6.

It is unnecessary to authenticate this synonymy by citation of the many specimens. I am not now in doubt about *A. scolopendropsis*; but the Solomon Islands plant to which I gave that name, Philip. Jour. Sci. 60 (1936) 114, is nearer to *A. schizocarpum*.

Melanesia; Micronesia; Borneo (?).

BLECHNACEÆ

Genus **BLECHNUM** Linnaeus

Fronds alike, sori not covering nether surface.

- Margin entire 1. *B. orientale*
- Margin serrate 2. *B. nigropaleaceum*

Fronds dimorphic: Lomaria.

Fronds pinnatifid or pinnate.

All sterile pinnae confluent or adnate.

Dwarfed basal pinnae remote.

- Sterile pinnae over 10 cm long..... 3. *B. saxatile* and
- 4. *B. Ledermanni*
- Sterile pinnae up to 8 cm long 5. *B. deorso-lobatum*
- Dwarfed basal pinnae contiguous, wide.... 6. *B. Keysseri*
- Only lowest pinnae free, not adnate..... 7. *B. dentatum*

Most pinnae free.

- Dwarfed basal pinnae present 8. *B. papuanum*

Dwarfed basal pinnae absent.

Pinnae subacute to acuminate.

Pinnae entire unless near apex.

Pinnae rounded at base.

Pinnae 12 cm long 9. *B. pendulum*

Pinnae 6 cm long 10. *B. Brassii*

Pinnae cordate.

Apical leaflet like others 11. *B. decorum*

Apical pinnae confluent 12. *B. Archboldii*

Margin not entire.

Pinnae cordate 11. *B. decorum var.*

Pinnae rounded at base.

Costae densely scaly 13. *B. Hieronymi*

Costae sparingly squamulose 14. *B. acutiusculum*

Pinnae obtuse, linear 15. *B. revolutum*

Pinnae rounded, oblong 16. *B. nudius*

Fronds bipinnatifid bipinnate..... 17. *B. Fraseri*

1. *B. ORIENTALE* L.

B. orientale L., Sp. Plant. (1753) 1077 (as *B. occidentale*).

Brass 8959, 13485, alt. 850 m. No. 13486, with pinna 37 cm long and 2.5 cm wide, might be *B. finlaysonianum* Wall. Common.

To India, and across Polynesia.

2. *B. NIGROPALEACEUM* Alston

B. nigropaleaceum Alston, Jour. Bot. 78 (1840) 225; Nova Guinea N. S. 4 (1940) 109, Pl. 4, f. 1.

Carr 14363, 13336, Boridi, Papua, alt. 5,000 feet; otherwise unknown.

3. *B. SAXATILE* Brause

B. saxatile Brause, Engler's Jahrb. 56 (1920) 152.

Ledermann 11046, Hunstein Peak, alt. 1,350 m. Not seen.

4. *B. LEDERMANNI* Brause

B. Ledermanni Brause, Engler's Jahrb. 56 (1920) 153.

Ledermann 11595, 12062, Schraderberg, alt. 2,070 m; not seen.

The seven species (out of eleven credited by him to New Guinea) described as new by Brause are presumably distinct, and seem to be well described until one undertakes to distinguish them by description.

5. *B. DEORSO-LOBATUM* Brause

B. deorso-lobatum Brause, Engler's Jahrb. 56 (1920) 154.

Described from *Ledermann* 11905, 11932a, Schraderberg, alt. 2,070 m. To this I refer *Brass* 10815, alt. 2,750 m; and, less confidently, No. 12353, alt. 1,700 m. These are one species, but No. 12353 might be *B. saxatile*.

Endemic.

6. B. KEYSSERI Ros.

B. Keysseri Ros., Fedde's Repert. 12 (1913) 153.

Keysser 220, Sattelberg Hinterland, alt. 1,400–1,500 m; isotype in Herb. Univ. Calif. Well distinguished by the dwarfed basal segments, 2–3 mm long by 10–17 mm wide.

Endemic.

7. B. DENTATUM (Kuhn) Diels

B. dentatum (Kuhn) Diels, in Schum. & Lauterb., Fl. dent. Südsee (1901) 130.

B. bamlerianum Ros., Fedde's Report. 10 (1912) 325.

Bamber L. 39, Logaueng, type of *B. bamlerianum*, not seen. *Bamber, Rosenstock Fil. Novog. Exsicc. n. 115*, Wareo, alt. 600 m; *King 104*, Goodenough Bay, alt. 300–600 m. Related to the Philippine *B. egregium*, intermediate between *Eublechnum* and *Lomaria*.

New Hanover, the type.

8. B. PAPUANUM Brause

B. papuanum Brause, Engler's Jahrb. 56 (1920) 158.

Ledermann 11978, Schraderberg, alt. 2,070 m. Not seen.

9. B. PENDULUM Brause

B. pendulum Brause, Engler's Jahrb. 56 (1920) 157.

Ledermann 11922 Schraderberg, alt. 2,070 m. Not seen.

10. B. BRASSII Copel.

Plate 5.

B. Brassii Copel., Univ. Calif. Publ. Bot. 18 (1942) 222.

Lomaria, rhizomate scandente, 4 mm crasso, basi que stipitis paleis brunneis nonnullis nigrescentibus circa 7 mm longis basi 2 mm latis incurvis acuminatis vestitis; stipitibus remotis (8 cm), primo stramineis, vetustate nigrescentibus, sursum paleis stramineis plus minus deciduis vestitis, frondis sterilis 13 cm, fertilis circa 30 cm altis; lamina circa 30 cm longa, 12 cm lata, basi truncata, foliola apicale maxima usque ad 10 cm longa; frondis sterilis pinnis inferioribus vix reductis, medialibus 6 cm longis 11 mm latis, acutis apice obscure serrulatis, subsessilibus basi rotundatis, coriaceis, costa inferne decidue squamulata excepta glabris; venis gracilibus simplicibus et furcatis obscuris; pinnis fertilibus circa 8 cm longis, 2–3 mm latis, superioribus brevioribus adnatis vix decurrentibus, infimis brevissime pedicellatis.

Dutch New Guinea: Idenburg River, alt., 1,800 m, *Brass 12287*. One plant, climbing on dead trunk, in mossy forest.

Characterized by the long-scandent rhizome and remote fronds, pale-scaly rachis, and complete absence of dwarfed basal pinnae.

11. B. DECORUM Brause

B. decorum Brause, Engler's Jahrb. 56 (1920) 156.

Ledermann 12459a, Sepik region, alt. 1,400–1,500 m; also var. *dilatata*, *Ledermann 11168*; neither seen. To this I refer *Brass 12439*, alt. 1,800 m; roughly, the distal half of each pinna is serrulate.

Endemic.

12. B. ARCHBOLDII C. Chr.

B. Archboldii C. Chr., Brittonia 2 (1937) 288.

Brass 4318, Mt. Albert Edward, alt. 3,680 m, isotype in Herb. N. Y. Bot. Garden; *Brass 4590*, Murray Pass, alt. 2,840 m. Pinnae obtuse to acute; costae clothed beneath with large ovate paleae.

Endemic.

13. B. HIERONYMI Brause

B. Hieronymi Brause, Engler's Jahrb. 56 (1920) 155.

Ledermann 12217b, Schraderberg, alt. 2,000 m. Not seen. *Carr 15132*, smaller than described.

Endemic.

14. B. LATIUSCULUM (v.A.v.R.) C. Chr.

B. latiusculum (v.A.v.R.) C. Chr., Suppl. III (1934) 45.

Lomaria latiuscula v.A.v.R., Nova Guinea 14 (1924) 31.

Lam 1543 Doorman Top, alt. 1,420 m. Not seen.

15. B. REVOLUTUM (v.A.v.R.) C. Chr.

B. revolutum (v.A.v.R.) C. Chr., Suppl. III (1934) 46.

Lomaria revoluta v.A.v.R., Nova Guinea 14 (1924) 31.

Lam 1708, Doorman Top, alt. 3,250 m; not seen. *Brass 9442* and *9600*, Lake Habbema, alt. 3,225 m, seem to represent this species.

Endemic.

16. B. NUDIUS Copel.

Plate 6.

B. nudius Copel., Univ. Calif. Publ. Bot. 18 (1942) 222.

B. fluviatile affine eocumque confusum, rhachi sparsissime paleacea vel nuda et textura firmiore distinguendum.

Dutch New Guinea: 7 kilometers north-east of Wilhelmina-top, alt. 3,560 m, *Brass & Myer-Drees 9966*, type, "Sides of moist sinkholes and chasms in limestone, common;" also, *Brass 9328*,

Lake Habbema, alt. 3,225 m, "Under wet banks of grassland streams; sterile fronds flat-spreading, fertile fronds erect;" *Brass 4733*, Murray Pass, alt. 2,840 m; *Mrs. Clemens s.n.* near and on Mt. Sarawaket, 9,000 to 13,200 feet.

Borneo: Mt. Kinabalu, alt. 11,000 feet, *Clemens 51450*. Other Kinabalu specimens, which I have not, but which are likely to be this species, are *Clemens 27044, 27047 and 38727*. These and *Brass 4733* are determined by Christensen, *Gardens' Bull.* 7 (1934) 283, and *Brittonia* 2 (1937) 288 as *B. fluviatile* (R. Br.) Lowe. He states that his Kinabalu specimens (those I do not have) conform with those of New Zealand in scaliness of stipe and rachis. All which I cite from personal observation have the rachis conspicuously more naked or wholly so. The affinity, however, is to *B. fluviatile* rather than to the related New Zealand species, *B. membranaceum* (Col.) Mett., with naked rachis.

The specimens vary greatly in stature, as conditioned by the local environment. The type has stipes 15 cm long, laminae even 30 cm, the fertile and sterile fronds alike nearly erect. *Brass 4733* and *Mrs. Clemens'* collections from Mt. Sarawaket are rosette-forming dwarfs growing in open grass. *Brass 9328* and *Clemens 51450* are intermediate.

17. **B. FRASERI (A. Cunn.) Luerssen**

B. Fraseri (A. Cunn.) Luerssen, *Flora* 59 (1876) 292.

Brass 10814, near Lake Habbema, alt. 2,700 m.

This is var. *novoguineensis* Brause, *Engler's Jahrb.* 56 (1920) 159, distinguished from the New Guinea species by larger size, leaves narrowed downward, and strongly toothed segments of the sterile pinnae. Only the last feature distinguishes it at all from Christ's var. *philippinensis*, and large specimens of the latter are hardly less coarsely toothed, small specimens having the subentire segments of the New Zealand type.

Genus **WOODWARDIA** J. E. Smith

W. RADICANS (L.) Smith

W. radicans (L.) Smith, *Mém. Ac. Turin* 5 (1793) 412.

Brass 11053, Bele River, alt. probably 2,200 m. "Forest undergrowth; common on steep limestone slopes; fronds few, in weak spreading clumps."

The genus seems to be new to New Guinea. The extension of range is significant, because *Woodwardia*, always regarded as a relative of *Blechnum*, is a genus of distinctly northern

distribution, previously known south of the equator in Java only, while its relatives are of evident antarctic origin. The new collection carries the genus back along the track along which the great mass of oriental ferns seems to have immigrated.

As to the specific name, the recent tendency,—see Christensen, Suppl. III 196,—is to distinguish specific segregates long regarded as forms of *W. radicans*, among these, *W. orientalis*, *W. auriculata* and *W. unigemmata*. It is possible to distinguish *W. orientalis* and *W. unigemmata*; but I am not so sure that the latter is not *W. auriculata*, and so prefer for the present to use the most inclusive name. *Woodwardia* is common in the mountains of northern Luzon, and unknown between those mountains and New Guinea. With the material in hand, it is impossible to distinguish the plants of the two regions.

Genus STENOCHLAENA. J. Smith

Fertile pinnae rolled back	1. <i>S. areolaris</i>
Fertile pinnae flat.	
Fertile pinnae 2-3 mm wide.....	2. <i>S. palustris</i>
Fertile pinnae at least 5 mm wide.....	3. <i>S. juglandifolia</i>

1. *S. AREOLARIS* (Harr.) Copel.

S. areolaris (Harr.) Copel., Philip. Jour. Sci. 2 C (1908) 406.

Brass 13417, alt. 850 m, on *Pandanus*; *Clemens s. n.* Morobe, alt. 1,300 m, on banana and betel. The latter is the first record of the species as growing elsewhere than on *Pandanus*. Other New Guinea records by Holttum are *Versteeg 1102* and *Docters van Leeuwen 9909*.

Luzon.

2. *S. PALUSTRIS* (Burm.) Bedd.

S. palustris (Burm.) Bedd., Ferns Brit. India Suppl. (1876) 26.

Brass 13938, alt. 50 m; *Brass 936*, *Carr 11323*, Papua, sea level.

To India and Samoa.

3. *S. JUGLANDIFOLIA* Presl

S. juglandifolia Presl, Epim. (1849) 164.

Bamber 112p, Sattelberg; *King 167*, Papua; *Bamber R. 1*, from Ins. Rook.

Philippines; Solomon Islands.

As to the distinctness of this species, see Holttum, Gardens' Bull. 9 (1937) 139. Recognized as a species, *S. juglandifolia* is the type-species of the genus.

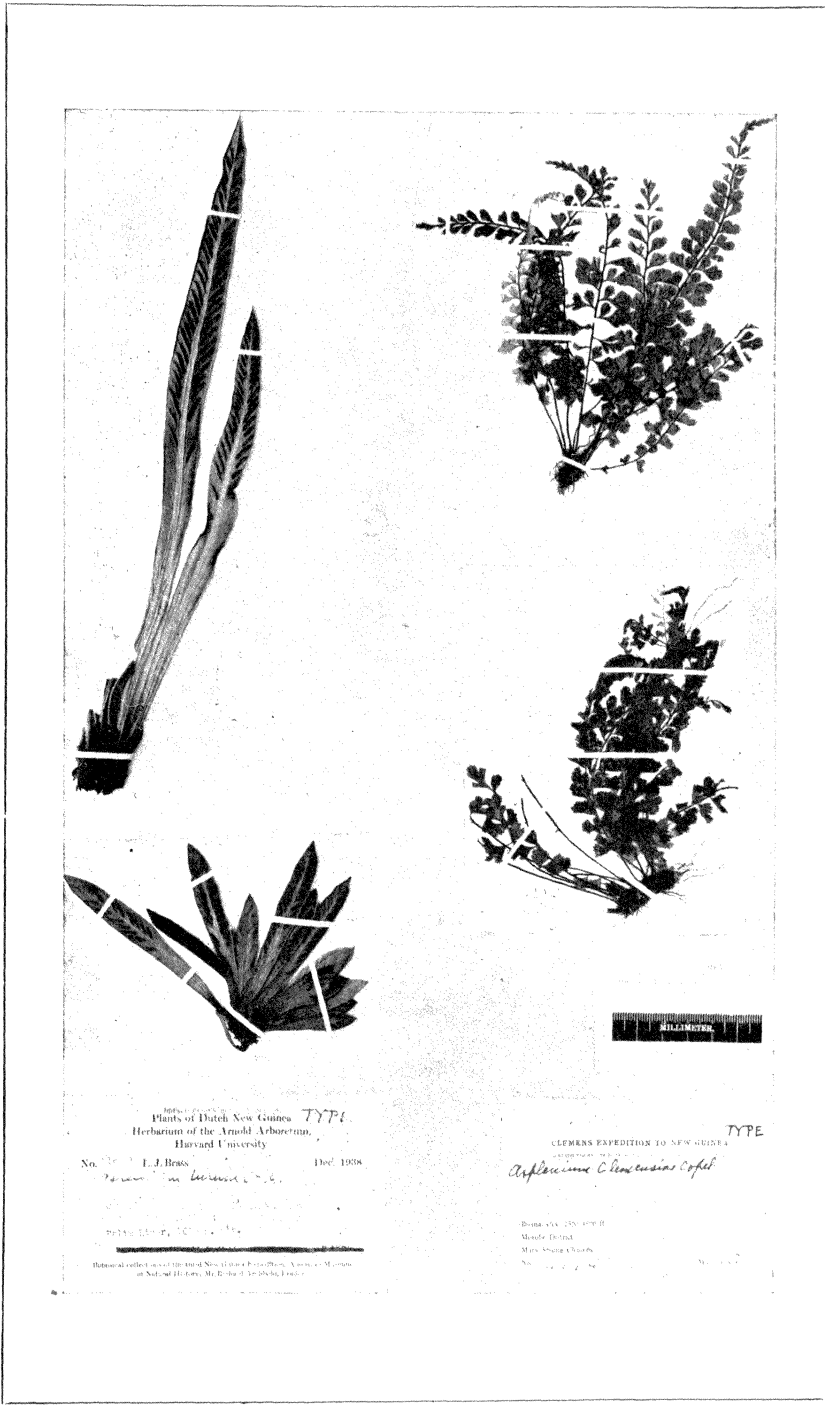
ILLUSTRATIONS

[All are Photographs of the Types]

- PLATE 1. *Asplenium morobense* Copel.
2. *A. durum* Copel.
 A. Clemensiae Copel.
3. *A. Regis* Copel.
4. *A. paedigens* Copel.
5. *Blechnum Brassii* Copel.
6. *B. nudius* Copel.



PLATE 1.



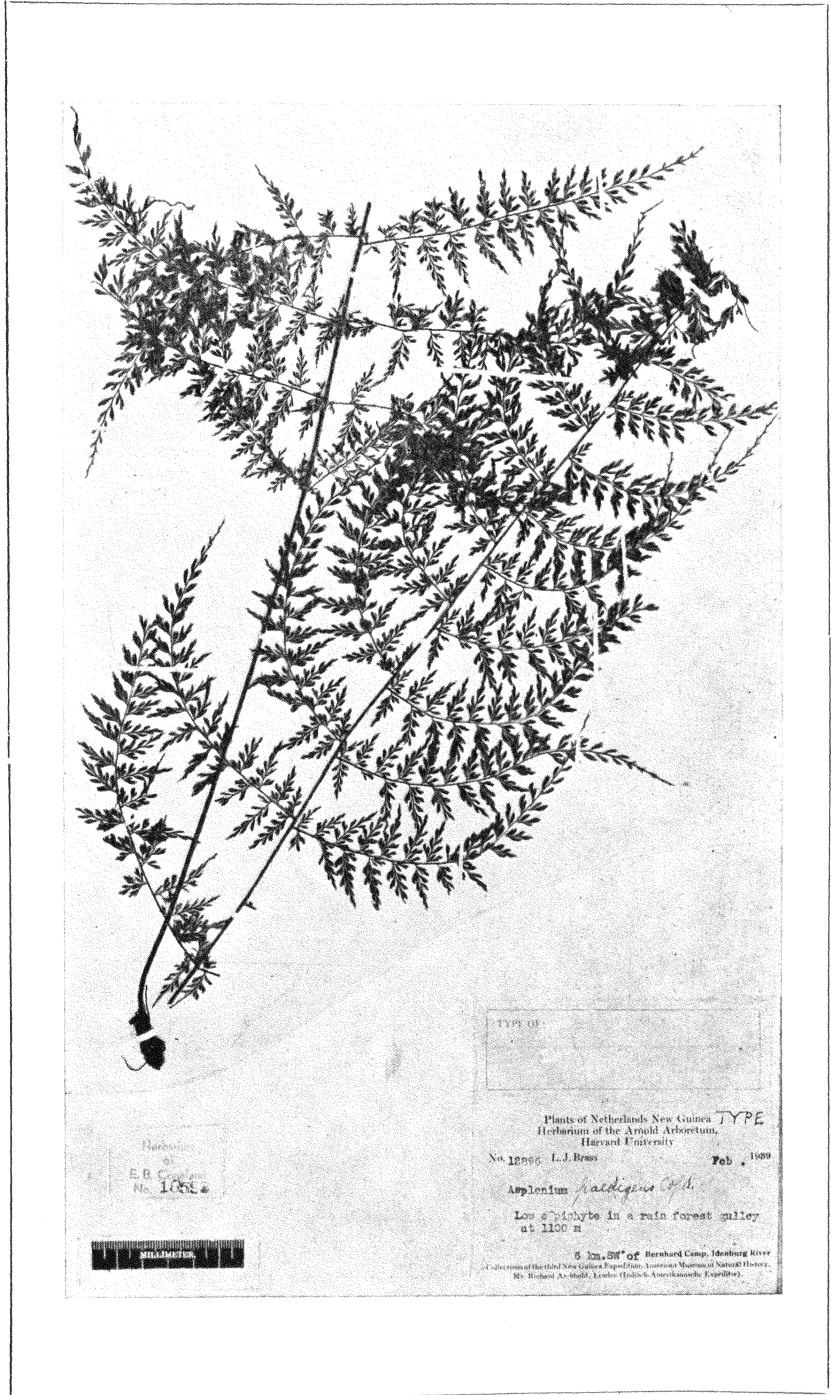
Plants of Dutch New Guinea *TYPE*
 Herbarium of the Arnold Arboretum,
 Harvard University
 No. 1000 L.J. Brong. Dec. 1908
Pteris *...*

TYPE
 CLEMENS EXPEDITION TO NEW GUINEA
Asplenium Clemensii Copel.

PLATE 2.



PLATE 3.



Herbarium
of
E. B. Copeland
No. 1058

SHAW-WALKER

TYPE OF

Plants of Netherlands New Guinea TYPE
Herbarium of the Arnold Arboretum,
Harvard University

No. 1262. L. J. Brass Feb. 1939

Asplenium radiatum J. D. D.

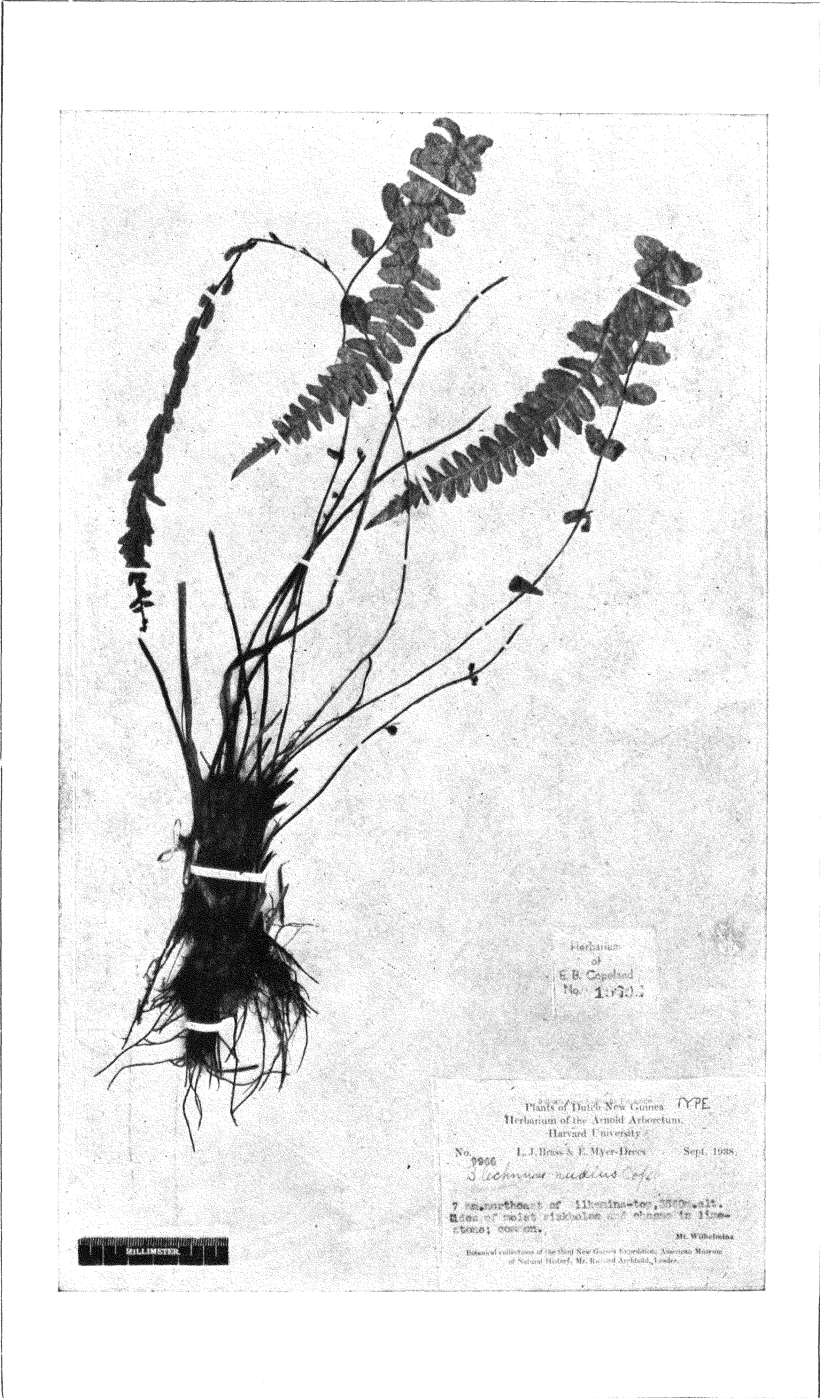
Low epiphyte in a rain forest gully
at 1100 m

5 km. SW of Bernhard Camp, Idenburg River
Collected in the field New Guinea by E. B. Copeland, American Museum of Natural History,
Dr. Richard A. Smith, London (Public Americanische Papieren).

PLATE 4.



PLATE 5.



Herbarium
of
E. B. Copeland
No. 11711

Plants of Dutch New Guinea TYPE
Herbarium of the Arnold Arboretum,
Harvard University
No. 996 L. J. Hens & E. Meyer-Dress Sept. 1928
Selaginium nudius Cope

7 cm. high at 11000 ft. alt.
Rise of moist siltstone and change to lime-
stone; common.
Mt. Wilhelm
Botanical collection of the Dutch New Guinea Expedition, American Museum
of Natural History, Mr. R. and Mrs. A. S. Peck, London.

MILLIMETER

PLATE 6.

BOOKS

Books reviewed here have been received by the Philippine Journal of Science from time to time and acknowledged in this section.

REVIEW

Radio Aids to Navigation. By R. A. Smith. Cambridge, At the University Press, New York, The Macmillan Company, 1948. 114 pp. Price, \$2.50.

The material for this book was originally prepared as a contribution to the British Ministry of Supply (Air) Scientific War Records, but by permission of that ministry, it was later revised for publication.

This book traces the remarkable development in the application of electronics to navigation during the war and shows how the limitations of prewar radio navigation systems were overcome by the introduction of new techniques particularly by the development of radar. These electronic devices are now widely adapted for air and sea navigation and other works requiring quick and accurate determination of position under any weather condition. Other devices find application in the field of surveying, triangulation and aerial photography.

The book is a good reading matter for the layman interested in the sciences, and to those possessing the basic knowledge of radio this book ushers them into the relatively new field of electronics.—L. G. A.

Analytic Geometry. Revised edition. By Roscoe Woods. New York, The Macmillan Company, 1948. 322 pp. Price, \$3.50.

Beginners on analytic geometry will find this book neither too technical nor too elementary because the author introduced each new principle with illustrating examples completely worked out in the text. Of course, there is the usual dose of exercises which are carefully graded at the end of each chapter. All the materials needed in the usual short course in analytic geometry are presented in the first ten chapters; the last five chapters make it fuller and rounder, aside from thoroughly introducing the student to solid geometry and the concepts needed in the study of calculus. The author stepped farther from the usual run of freehand drawings when he

utilized pictures of wire models to represent quadric surfaces in chapter XV. Answers to the odd numbered exercises only are given at the back of the book but the author will furnish upon request an answer-book with answers to even-numbered exercises.—L. G. A.

Strength of Materials. By Joseph Marin. New York, The Macmillan Company, 1948. 464 pp. illus. Price, \$4.75.

The designing of structure and machine members is the object of this book. It emphasizes that materials for construction must be simple and cheap yet strong enough to resist the different kinds of stresses be it bending, compression, twist, stretch or shear. It calculates to the minutest detail the kind of stress that is required in the different parts of the structure and machine. The materials that are to compose the structure and machines are to be selected and their strength, calculated in order to enable them to withstand the shock or stresses from within as well as from without.

This book is a good text and reference material. It is highly recommended for engineering students, engineering professors and practicing engineers.—R. R. O.

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No. 3

JOSE KABIGTING SANTOS

Of the one-hundred fourteen charter members originally appointed by the Governor-General of the Philippines in 1934 following the enactment by the Philippine Legislature of Act No. 4120 creating the National Research Council of the Philippines, only eighty-one remained at the time of the death on August 6, 1949 of the late José Kabigting Santos, former Professor and Head of the Department of Botany of the University of the Philippines. This irreparable loss of one of the outstanding Filipino scientists was keenly felt by his many friends and associates. The National Research Council of the Philippines, the consulting and advisory body to the Republic on matters pertaining to science and scientific research, has been directly affected by the death of Doctor Santos, not only because of the passing of the charter member who was responsible for the idea of holding the first Philippine Science Convention in 1932 during his incumbency as President of the Philippine Scientific Society, but also because of the marked decrease in the ranks of its members devoted to botanical research. Thus Dr. Bienvenido M. Gonzalez, President of the University of the Philippines, Charter Member and for more than ten years, Chairman of the National Research Council of the Philippines, fittingly eulogized the late José Kabigting Santos both in the obituary prepared by the Executive Board of the National Research Council of the Philippines and in the announcement of the passing of José Kabigting Santos transmitted to every member and associate of the National Research Council on August 11, 1949.

José Kabigting Santos was born in Arayat, Pampanga, on February 4, 1889. The son of Lucio de los Santos and Natalia Kabigting, he was at the time of his death a little over 60 years

of age. His early education was obtained in the *Liceo de Manila*, one of the first private schools founded and supported by Filipino educators from whom a number of undergraduate and advanced students were selected to become members of the first group of Filipino pensionados who were sent by the Philippine Government to various colleges and universities of the United States to pursue advanced professional, scientific and technical studies. At the beginning of the academic year 1911-1912, José Kabigtíng Santos enrolled in the Course in Pharmacy offered in the College of Liberal Arts, which was to become the College of Pharmacy of the University of the Philippines with the late Dean Andrew Grover DuMez of the College of Pharmacy of the University of Maryland as its first director. Even during his residence as a student in the University of the Philippines, he displayed a keen interest in botany and an exceptional ability in scientific illustrations especially in the different courses he took in the Department of Botany of the University. He also showed enthusiasm in other activities that the state's highest institution of learning was promoting among her students. For his ability and leadership, the student body of the School elected him President of the University of the Philippines Pharmaceutical Association. This organization included among its members every student enrolled in the School of Pharmacy and was undertaking activities designed to promote the welfare of pharmacy students and the success of the School of Pharmacy in its avowed mission.

Serving as Student Assistant in the Department of Botany of the University of the Philippines, he graduated in 1916 with the degree of Graduate in Pharmacy. Immediately after his graduation, he was appointed Assistant Instructor in Botany in the College of Liberal Arts. In 1918, he was promoted to the position of Instructor in Botany. During the early years of his connection with the Department of Botany of the College of Liberal Arts, he had the opportunity of associating himself with well-known botanists who had spent the greater part of their lives undertaking botanical research in the Philippines, such as Dr. Elmer D. Merrill, former professor of botany in the University of the Philippines and Director of the former Bureau of Science, now with Harvard University; and the late Dr. William H. Brown, former professor of botany in the University of the Philippines and Director of the former Bureau of Science.

Realizing his bright prospects, the University authorities appointed him Fellow of the University of the Philippines

abroad. He left Manila in August, 1919, together with other pensionados of the Philippine Government. Upon his arrival in the United States, he enrolled in the University of Chicago. Notwithstanding his handicaps for not having completed a bachelor's degree, he was allowed to enroll in the University of Chicago in courses that would prepare him for graduate work. The excellent work he performed enabled him to obtain in 1921 the degree of Bachelor of Science *with honors* from the University of Chicago. He then enrolled in the Graduate School of the same university, majoring in botany. At the end of the academic year of 1922, the same university conferred upon him the degree of Master of Science. He continued his graduate work leading to the doctorate degree. At the commencement exercises of the University of Chicago in 1923, he was conferred the coveted degree of Doctor of Philosophy *magna cum laude*. His main research work, the results of which he used for his doctoral dissertation, dealt mainly with his studies on the differentiation of chromosomes and determination of sex in *Elodea*. These two papers were published in the *Botanical Gazette*.

While in the United States, José Kabigting Santos and Dr. Joaquin M. Marañon were appointed official delegates of the College of Pharmacy of the University of the Philippines to the 1921 Annual Meeting of the American Association of Colleges of Pharmacy, formerly American Conference of Pharmaceutical Faculties held in Cleveland, Ohio. They also represented the Philippines in the 1921 Annual Meeting and National Convention of the American Pharmaceutical Association held also in Cleveland, Ohio. On his way home in 1923, he had occasion to visit leading botanical laboratories in renowned universities in London, Vienna, Paris, Belgium, and Switzerland.

Upon his return to the University of the Philippines, he was appointed Assistant Professor of Botany in 1924 in the College of Liberal Arts. He devoted his time to teaching different botanical courses in the University of the Philippines. There was not a single year when he did not conduct and supervise the botanical excursions that the Department of Botany organized regularly for the purpose of instilling in the minds of students of botany the importance of systematic botany and the indispensable corollary of this work, mainly the actual work in the field that enable systematic botanists to learn plant characteristics. He also began studies in the pharmacognosy of Philippine medicinal plants as early as the first year after

his arrival in the Philippines from his trip abroad. His first contribution to the pharmacognosy of Philippine plants was a paper on *Chenopodium ambrosioides* L. published in the *Philippine Journal of Science* in 1925. In 1925 he was appointed Acting Head of the Department of Botany of the University of the Philippines. In 1926 he was promoted to Associate Professor of Botany.

During all the years of his teaching of both undergraduate and graduate courses in botany, he was actively engaged in undertaking research on cytology and the pharmacognosy of Philippine medicinal plants. It was especially his appointment as part-time Botanist of the former Bureau of Science in 1924 (a position which he held continuously for ten years until 1934) that enabled him to devote a great deal of his time to botanical research. He was also invited to contribute a paper on cytology in a special jubilee number of *Cytologia* issued by the International Cytological Association with headquarters in Japan. Not only was he an active research worker but he also spared no efforts in attracting many of his young associates to study advanced courses in botany and to undertake original botanical investigations. He did this work so well that he was instrumental in sending many young members of the faculty to pursue advanced studies in the United States. Several of those students have returned to the Philippines to serve their country and people after obtaining their advanced training in various phases of botanical work.

In 1934, he became permanent Head of the Department of Botany of the College of Liberal Arts of the University of the Philippines. When an exchange of professors between the University of Michigan in Ann Arbor and the University of the Philippines was established in 1934, Professor H. H. Bartlett, Chairman of the Department of Botany of the University of Michigan, came to the University of the Philippines as Exchange Professor. At the same time the late José Kabigtíng Santos was appointed Exchange Professor of Botany in the University of Michigan. There he spent the academic year 1934-1935 teaching botany. During this second trip abroad, he attended the Sixth International Botanical Congress held in Amsterdam, Holland, as an official delegate of the University of the Philippines. On his way home from Europe, he and his family visited London, Berlin, Brussels, Belgium, and France. They also spent three months in Spain, partly because they were stranded in

Europe as a result of the Italo-Ethiopian War. From Spain they went to Italy and then to Marseilles, France, where they finally took passage for Manila.

As president of the Philippine Scientific Society, then a very active instrument for the dissemination of scientific knowledge, he was mainly responsible for the idea of holding the First Philippine Science Convention in 1932. Under his leadership, this national science convention took shape.

Scientists from different branches of the Government, the University of the Philippines, and other universities, colleges and professional organizations cooperated wholeheartedly to make that memorable convention a huge success. It was during that convention when at the behest of Filipino scientists, the late President Manuel L. Quezon publicly announced his support for the establishment of a National Research Council of the Philippines. Thus José Kabigtíng Santos contributed his share in more ways than one to the progress of science in our country.

The full appreciation of the value of research by José Kabigtíng Santos is well illustrated by the following excerpts from his presidential address entitled "Science and the Country" delivered during the Opening Session of the First Philippine Science Convention: *

As I have stated before, scientific mindedness is necessary for the advancement and prosperity of this country; but scientific mindedness alone without its necessary tool—research—is meaningless—an empty phrase! And I need not tell you that for the development of our natural resources, research in pure and applied sciences is indispensable; nor do I need to tell you that our country is economically poorer, though potentially richer, than many countries of its size in the world because we are behind in scientific research. It is high time, therefore, that we give our most serious attention to this vital question. We must solve it now; further delay may prove disastrous to our economic future and fatal to our political aspirations. Our government must establish more experimental stations, and improve upon and enlarge its existing laboratories, or authorize the establishment of new ones. Our colleges and universities must within the limit of their ability and resources, do their full share in furthering scientific research. In fact, they should be made responsible for the scientific progress of the country inasmuch as they are responsible for the scientific education of our youth.

* Proceedings of the First Philippine Science Convention held under the auspices of the Philippine Scientific Society, March 15, 16, 17 inclusive, 1932, Manila. *University of the Philippines Natural and Applied Science Bulletin*, v. 2:165-308.

We, who have had the fortune of being trained in the ways of science, who live in intimate contact with it, who labor under its lure and influence, have a duty to perform and a responsibility to discharge towards our country and people. We do not, we cannot, dodge this duty and this responsibility; but to faithfully fulfill them we need help and encouragement. We have faith in our ability to build the scientific structure of our country provided adequate means are given to us. As the framework of this structure it would perhaps be necessary to organize an institution like the National Research Councils or the National Academy of Sciences of various progressive countries.

With the ever living, ever growing desire in our hearts to serve this Pearl of the Orient Seas—the one spot in the whole creation which God, in His infinite wisdom, has given us to dwell in happily, to own, to develop for our benefit and contentment, to love and to defend—let us exert our best effort to make her self-sufficient and promote her general welfare by leading her along upon the charted highway of science and by inculcating in her youth the love of research for the sake of truth and for the material blessings that research affords.

Speaking of Doctor Santos, the President of the University of the Philippines, Dr. Bienvenido M. Gonzalez, Chairman of the National Research Council of the Philippines, said:

As President of the Philippine Scientific Society, he was mainly responsible during his incumbency of introducing the idea of holding a Philippine Science Convention in 1932. It was such a success that when the National Research Council of the Philippines was created, the Philippine Science Convention was held regularly under the joint auspices of the National Research Council of the Philippines and the Philippine Scientific Society until the war broke out.

As an author, he published a manual entitled, *Experimental Botany* (Manila, Educational Supply, 1934, pages XIV, 235). This manual is at present used by the University of the Philippines in the classes of botany in Quezon City, Cebu and Iloilo and by other universities and colleges in the Philippines. He was contributing editor of *The Philippine Journal of Science* and the *University of the Philippines Natural and Applied Science Bulletin*.

He held membership in professional and learned societies, namely, the Philippine Pharmaceutical Association, the Philippine Scientific Society, the *Colegio Médico-Farmacéutico de Filipinas*, the American Association for the Advancement of Science, of which he was a Fellow, the Sigma Xi and the Society for Advancement of Research. In the National Research Council of the Philippines he held membership in the Sections of Pharmacology, Organic and Plant Chemistry, Pharmacopoeia, Genetics, Botany, and Chemical and Biological Defense. He is listed in the American Men of Science, 4th edition, 1927, New

York, the Science Press, p. 854, in the World Biography, 1948, published by the Institute for Research in Biography, 296 Broadway, New York 7, New York; and also in Bulletin No. 7 issued in February, 1934, of the National Research Council of the Philippines, wherein biographical data and a bibliography of his works are given (pages 734-736).

On September 30, 1925, he married Felisa de la Peña, a holder of the degree of Pharmaceutical Chemist from the College of Pharmacy of the University of the Philippines with whom he had three children.

His love of pharmacy manifested itself again when during the latter part of his life he and his wife engaged in the manufacture in their own laboratory of the well known Jofel's * preparations, namely Jofel's medicinal cigarette, Jofel's asthma relief powder and Jofel's asthma paper. These preparations were made chiefly from the flowering tops of *Datura alba* Nees, or *Datura fastuosa* Linnæus and from the entire herb of *Euphorbia hirta* Linnæus.

The appended bibliography represents the results of the painstaking research work that he pursued during his life.

PUBLICATIONS OF DR. JOSÉ KABIGTÍNG SANTOS

1. Differentiation among Chromosomes in *Elodea*. Botanical Gazette 75 (1923) 42-59.
2. Determination of Sex in *Elodea*. Botanical Gazette 77 (1924) 353-376.
3. A Pharmacognostical Study of *Chenopodium ambrosioides* Linnæus from the Philippines. Philip. Jour. Sci. 28 (1925) 529-547.
4. Histological Study of the Bark of *Alstonia scholaris* R. Brown from the Philippines. Philip. Jour. Sci. 31 (1926) 415-429.
5. Pharmacognostical Study of *Datura alba* Nees and *Datura fastuosa* Linnæus from the Philippines. Philip. Jour. Sci. 32 (1927) 267-296.
6. Stem and Leaf Structures of *Tinospora rumphii* Boerlage and *Tinospora reticulata* Miers. Philip. Jour. Sci. 35 (1928) 187-208.
7. A Cytological Study of *Cocos nucifera* Linnæus. Philip. Jour. Sci. 37 (1928) 417-437.
8. Histological and Microchemical Studies on the Bark and Leaf of *Artabotrys suaveolens* Blume from the Philippines. Philip. Jour. Sci. 38 (1929) 269-282.
9. Leaf and Bark Structure of Some Cinnamon Trees with Special Reference to the Philippine Species. Philip. Jour. Sci. 43 (1930) 305-365.
10. A Critical Morphological Study of *Thalassia hemprichii* (Ehrenb.) Aschers from the Philippines. Univ. Philippines Nat. and Appl. Sci. Bull. 1 (1930) 1-19.

* The word was coined from the first syllable of Jose and Felisa, his first name and that of his wife.

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A REVISION OF THE GENUS *ECTENUS* DALLAS, WITH
DESCRIPTION OF A NEW SPECIES
(HEMIPTERA, PENTATOMIDÆ)¹

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Ectenus Dallas is a small genus, which so far has been recorded almost exclusively from the Philippines, with the exception of a single species from New Guinea (Waigiu and Mysol). Hence, although the group is considered a Papuan derivative (Breddin, *Abhandl. Naturf. Ges., Halle* 24 [1901] 164), its headquarters apparently lie in the Philippines, wherein each species exhibits a strong local endemism. The known forms may be differentiated with the aid of the key included in the present paper, although in some cases separation is rather difficult, owing to the tendency of certain species to merge. The habits of none of the species are known. Unfortunately, because there was no material of *pubicus* and *brevirostris* on hand, sole reliance had to be made on published descriptions for their apparent diagnostic characters. All the specimens referred to herein, which formed part of the collections of the Bureau of Science and of the College of Agriculture, were destroyed by enemy action in February, 1945. It will probably take years to reconstitute the collection. However, it is deemed that the present diagnostic treatment will help in the recognition of the various forms, so that, although a restudy is indicated based on new material, release of this report obviously has its justification. Moreover, the specific collection localities given for each form serve to supply these distributional data for papers by Stål and other earlier authors, who merely reported "Philippines" or "Manila" for material studied by them from any of the islands of the Philippine group.

The species included in the present paper are:

1. *Ectenus generosus* Stål
Sulu Archipelago
2. *E. mesoleucus* Bergroth
Luzon and Polillo

¹ Experiment Station, College of Agriculture, Contribution No. 1543.
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3. *E. spinosus* sp. nov.
Negros
4. *E. pudicus* Stål
Mysol and Waigiu
5. *E. spectabilis* (Burmeister)
Luzon
6. *E. æreus* Stål
Biliran, Bohol, and Mindanao
7. *E. brevirostris* Stål
Philippines; specific locality unknown

Genus **ECTENUS** Dallas (1851)

Genotype: *Cimex spectabilis* Burmeister (Philippines)

Close to *Dalpada* Amyot et Serville (tribe Halyiini), differing therefrom principally in that the first antennal segment in *Ectenus* is longer than the marginal space on the head between the eye and the insertion of the antenna, the first rostral segment extends markedly beyond the bucculæ, the part of the scutellum bounded by the frena is much longer than broad at the base, and the postfrenal part is narrower.

Key to the known species of Ectenus

1. Bucculæ not prominently produced anteroventrad, anteriorly describing a right or subacute angle. Postfrenal part of scutellum broader, more or less broadly rounded apically, almost entirely stramineous, sublævigate, sparsely punctured; basal angles each with a stramineous, sublævigate spot, which is as large as apical spot or smaller. Robust species; width of body about one-half length 2
- Bucculæ prominently produced anteroventrad into an acute or subacute process. Postfrenal part of scutellum narrower, roundly subacute at apex; stramineous, lævigate spot only thinly bordering apical and lateral areas; stramineous, lævigate spot at each basal angle diffuse or wanting. More slender species; width of body slightly or considerably less than one-half length 5
2. Head subequal in length to pronotum. First antennal segment not extending beyond apex of head. Lævigate spot on postfrenal projection of scutellum generally impunctate; lævigate spots at basal angles usually as large as apical spot. An obsolescent sulcus barely extending to caudal margin of third abdominal sternite. *generosus* Stål
- Head markedly shorter than pronotum. First antennal segment extending by about one-third its length beyond apex of head. Lævigate spot on postfrenal part of scutellum conspicuously punctured; lævigate spots at basal angles much smaller than apical. A well-defined median sulcus extending to apex of fourth or to about middle of fifth abdominal sternite 3

3. Lateral angles of terminal abdominal segments only moderately dentate, those of sixth armed with a short spine. External genitalia of female broadly rounded at apices. Lateral halves of propleura very deeply and thickly punctate *mesoleucus* Bergroth
- Lateral angles of terminal abdominal segments very prominently dentate and armed with rather long spines. External genitalia of female acute. Propleura very sparsely and shallowly punctate, except for a small irregular patch near lateral margin 4
4. Second antennal segment slightly shorter than basal *pudivus* Stål
- Second antennal segment about one-half longer than basal..... *spinusus* sp. nov.
5. Anterior angle of pronotum with a conspicuous ectally directed denticle; humeral angle more prominent, subacute; anterior area of pronotum broadly subconfluent with posterior. Second antennal segment somewhat longer than third 6
- Anterior angle of pronotum without prominent denticle; humeral angle of pronotum less salient, somewhat rounded; anterior area of pronotum more strongly gibbous, between lateral one-fourth distinctly delimited from posterior by a transverse uniseriately punctate impression. Second and third antennal segments usually subequal in length *spectabilis* (Burmeister)
6. Rostrum extending to about middle of fifth abdominal sternite. Median sulcus extending to base of, or midway into, fifth abdominal sternite *xreus* Stål
- Rostrum extending to, or only a little beyond, caudal margin of third abdominal sternite. Median ventral sulcus on abdomen shorter or posteriorly more obsolescent *brevirostris* Stål

ECTENUS GENEROSUS Stål

Stål. Ann. Soc. Ent. France, Ser. 4 (1865) 167;
Öfv. Vetensk.-Akad. Förhandlingar (1870) 622.

This species is apparently quite rare. There are available to me only three specimens. All of these were collected from the coral islands of the Sulu Archipelago, wherein the species is probably endemic.

JOLO ISLAND, Bud Dajo (*A. Duyag*), 1 ♀, (*A. Lopez*), ♀; BANARAN ISLAND, Tawi-Tawi Group (*A. Duyag*), 1 ♂.

ECTENUS MESOLEUCUS Bergroth

Bergroth, Ann. Soc. Ent. Belgique 57 (1913) 150-151.

Closely resembling *E. generosus* in size, body conformation, and general color pattern, but the two species are readily separable with the aid of the key. In addition, the male anal segment is deeply sinuate in *generosus*, while in *mesoleucus* it is only broadly so.

POLILLO, October, 1909, B. S. Acc. No. 13031 (*McGregor*), 1 ♂, 1 ♀ (paratypes); LUZON, Mt. Maquiling, elevation 350 meters, September 23, 1932 (*P. Obien*), 1 ♀; elevation 900 meters, September 4, 1932 (*J. Alhama*), 1 ♀; Mt. Banahao, March 23, 1907 (*Banks*), 1 ♀; 1914 (*J. Valdez*), 2 ♀; Nueva Vizcaya (*Alzapan and Ramos*), 1 ♂.

Three males and 4 females (one female bearing identification label in Dean C. F. Baker's handwriting), collected from Los Baños, Laguna, by various collectors, May, September and October, 1914 to 1925. Up to about the latter year, "Los Baños" was used in a broad sense in the insect labels of the College of Agriculture collection, and was often made to include material from Mt. Maquiling at different elevations.

ECTENUS SPINOSUS sp. nov.

Length of body 17 millimeters, width between humeral angles 7. Ground color above dark green, with light brownish olivaceous. Other characters as given in key above.

Closest apparently to *Ectenus pudicus* Stål from Mysol and Waigiu, but differing from this principally by the second antennal segment being considerably longer than basal, in color characters and in the more densely and deeply punctate body above.

NEGROS ISLAND, Negros Oriental, near Lake Dako (collector?), in the Bureau of Science collection, 1 ♀ (type, burnt in 1945).

ECTENUS SPECTABILIS Burmeister

Burmeister, *Nova Acta Acad. Leopold.* 16, Suppl. 1 (1834) 291, Pl. 51, fig. 5 (*Cimex*); Dallas, List of the specimens of hemipterous insects 1 (1851) 174, Pl. 5, fig. 5; Stål, *Öfversigt Vetensk.-Akad. Förhandlingar* (1870) 621.

Two specimens in the lot before me have antennal segment 2 somewhat longer than 3 and a third specimen has the humeral angles subacute, as in *æreus* Stål; but the sum of the other characteristics makes their identity as *spectabilis* beyond question.

LUZON, Laguna, Mt. Maquiling, mainly at and near summit, 1070 meters, occasionally at lower elevations, 13 ♂♂, 40 ♀♀ (various student collectors), mostly during rainy season, from June to October; Tayabas, Quezon National Park, near Atimanan, April, 1931 (*José Campo*), 3 ♂♂, 5 ♀♀; Mt. Bulusan, elev. 350-800 m. (*F. A. Maclang*), 2 ♀♀. Apparently endemic in southern Luzon, where it is fairly common on Mounts Maquiling and Banahao.

ECTENUS AEREUS Stål

Stål, *Öfversigt Kongl. Vetenskaps.-Akad. Förhandlingar* (1870) 621.

BOHOL, May 1906 (A. Celestino) ♀. Card says "Cerambycidae". MINDANAO, Agusan River, Dec. 27, 1909 (A. Celestino), 1 ♀, October 1, 1910 (Schultze), ♀ ♀; Davao; November, 1911 (C. M. Weber, 1 ♂; September, 1911 (C. M. Weber); ♂ BILIRAN, North of Leyte, Naval, 1914 (McGregor), 1 ♀.

ECTENUS BREVIROSTRIS Stål

Stål Öfversigt. Kongl. Vetenskaps. Akad. Förh. (1870) 622.

This species was not included in the collection before me. It is known only from Stål's type specimen, which, according to Prof. Dr. O. Lundblad (*in lit.*, October 18, 1948), is extant in the Royal Natural History Museum of Stockholm. According to the same informant, the type locality is Manila. "Manila" in Stål's time was loosely used by European authors to denote the Philippines; not necessarily any definite collecting locality. No authentic capture of any species of *Ectenus* has ever been made in Manila.

Because my pertinent references were destroyed in 1945, I have been unable to recheck the literature on this species. I am, therefore, indebted to my friend, Prof. Robert L. Usinger, the well-known hemipterologist of the University of California at Berkeley, who very kindly transmitted to me from London (September 14, 1948), the following helpful information:

"Curiously enough, *brevirostris* Stål is not mentioned, even in synonymy, with other species treated by Stål in *Enumeratio Hemipterorum*, part V, p. 43. This is quite surprising, since he mentions *æreus* which was described in the same publication [*supra*] on a previous page in 1870. . . Unfortunately, the species is not represented in the British Museum collection. . . .

"Stål does not number *brevirostris*—but treats it after '2. *E. æreus* Stål. . . .' Following the description of *æreus* he says, 'Specimen unum divergit rostro brevius, apicem segmenti tertii ventris haud vel paullo superante, articulo tertio quarto dimidio longiore, sulco ventris brevius vel posterioribus obsoletioribus. An species distincta, *E. brevis* Stål' "

Since the completion of the present manuscript, a set of Stål's *Enumeratio Hemipterorum* and also Stål's *Hemiptera insularum philippinarum* were received in the library of the College of Agriculture through the courtesy of the Kungl. Vetenskapsakademien Bibliotek, Stockholm.

ANOMALOUS SECONDARY GROWTH IN SOME ROOTS OF *HYDROCOTYLE ASIATICA* LINNÆUS

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TWO PLATES

INTRODUCTION

In the present paper the writer records the result of detailed investigation of anomalous secondary growth in some roots of *Hydrocotyle asiatica* L. (the Asiatic Pennywort) of the family *Umbelliferae*, a preliminary account of which was published some time back.² The anomaly consists in the fission of the vascular cylinder into numerous discrete vascular bundles at the base of some roots of this plant. This stoloniferous herb is common in Bengal and is found in all parts of India at altitudes up to 2,000 feet, its distribution being tropical and subtropical (Hooker).⁷

Naked eye observations of the roots do not, as a rule, show any indication of the fission of the vascular cylinder inside the same but in some cases the cleavage may be inferred from a slight wavy outline or a little flattening of the root itself.

MATERIAL AND METHODS

For microtome sections the selected roots were cut into bits from the base to the tip and fixed in three lots: the first in stock chromo-acetic solution, the second in 'CrAF,' named by Randolph¹³ and the third in formalin-water (40 per cent formalin 10 cc and distilled water 90 cc) at 60° C. for 2 hours. Specimens killed and fixed in the first fixative were treated in the usual way; those of the second lot were directly immersed in 75 per cent alcohol, then passed through the alcohol grades, dehydrated, cleared in cedar-wood oil and embedded as usual; and the last lot, fixed in formalin-water, was treated directly with 95 per cent alcohol for 1 hour, then passed through pure dioxan, 2 changes of 1 hour each, dioxan-paraffin (1:1) 1 hour, paraffin 2 changes of 15 to 20 minutes each, and finally embedded according to Chapman's¹ review of T. Garvin. All the fixatives proved equally successful. Serial microtome sections were cut

in transverse plane 8 to μ to 19 μ thick from the base of the root towards its apical part and some longitudinal sections were also made for comparison. Delafield's haematoxylin and (rapid) safranin as suggested by Dean,⁴ safranin and light green dissolved in clove oil and Bismarck brown and light green were used. The first combination gave the best result.

For the microscopical examination of the cleft xylem-mass *in situ*, a few roots were decolorised after Debenham⁶ in 60 per cent lactic acid for some days, washed in 75 per cent glycerine for 2 to 3 days, then treated with 50 per cent alcohol to ensure complete washing out of the acid and glycerine used. The materials were afterwards bleached in Eau-de-javelle at 40° C. for about 15 to 20 minutes followed by a thorough washing in water for 12 hours with several changes and then treated with 10 per cent alcohol; the roots were then stained as a whole without any sectioning. The writer, however, got equally good results by gently boiling the materials in 60 per cent to 80 per cent lactic acid solution over water-bath for 2 to 4 hours according to the thickness of the roots. After the first hour's boiling some more lactic acid solution was added at intervals to maintain the uniform strength of the boiling solution. This hastened the preliminary decolorization without any perceptible injury of the materials and was a time-saving modification, at least in these materials. Free-hand sections from the base, middle and apical regions of many of these roots were also examined mostly mounted in dactic acid.

OBSERVATIONS

The fission of the xylem-mass is found confined to the base of some roots of 1 to 3 mm in diameter, within a space of about 3 cm from the point of their origin; beyond this the nature and arrangement of the xylem-masses are normal up to the tip. The fission occurs, generally, only once in the root but very rarely, a second fission is also noticed in the same root. On examining the serial microtome sections from the neighborhood of the tip region the apical region shows radial arrangement of the vascular bundles, which may be three, four (Pl. 2, fig. 1) or five in number in different specimens. The pith is distinct, parenchymatous and thin-walled. In the apical region of some young roots the pericycle has been found to be 2 to 3 layers thick (Pl. 2, fig. 1) but in other older roots the pericycle has become 3 to 4 layers in thickness. The major portion of the root shows

secondary growth and thickening of the dicotyledonous type. In adult roots, in many cases, the center is occupied by meta-xylem elements (Pl. 2, fig. 2).

In the middle portion of the root, the cambium approximates a circular ring which towards the basal region becomes progressively invaginated towards the center between the consecutive xylem bundles (Pl. 2, figs. 2, 3, 3a and Pl. 1, fig. 2). Ultimately, it breaks up into as many separate arcs as there are primary xylem bundles. Each of these separate cambial arcs then extends round and encloses the primary xylem with some amount of secondary wood in an annular manner (Pl. 2, figs. 4 and 4a). The smaller ring of cambium, thus formed, then produces at its sides and towards its center, a large amount of parenchymatous cells, arranged in regularly widening circles which push apart the original xylem-masses laterally from one another and force them away from the center, thereby causing the cleavage or fission of the original xylem-mass (Pl. 1, figs. 1 and 2). In the absence of such cambial growth the xylem-masses would have formed a continuous cylinder. This fission causes a slight flattening or wavy outline of these roots as already mentioned earlier. The xylem parenchyma is found abundantly between the cleft xylem-masses and also in the secondary wood.

The old roots in general show copious development of parenchyma. The primary medullary rays at the back of the proto-xylem widen gradually towards the cortex to form somewhat funnel-shaped medullary rays (Pl. 1, figs. 1 and 2). The primary phloem bundles, composed of thick-walled cells, are situated at the outer end of the broad radially elongated medullary rays alternating with the primary xylem bundles (Pl. 1, fig. 2). The secondary phloem bundles are collateral, often truncated, conical in shape and are separated from one another by the widening medullary rays. Sometimes, the walls of these secondary phloem bundles are thickened but they give cellulose reaction. Starch grains are found deposited in abundance in all the parenchymatous elements within the stele (Pl. 1, fig. 2); calcium oxalate occurs very rarely as sphaeraphides in some parenchymatous cells (Pl. 2, fig. 5.)

The cortex is gradually exfoliated from the old roots (Pl. 1, fig. 2), but in the younger ones the cortical cells are found very loosely arranged with broad air-spaces (Pl. 1, fig. 1). Phellogen appears in the pericycle after secondary growth (Pl. 1,

fig. 2, and Pl. 2, fig. 5) and the continuity of the endodermal layer is interrupted, its cells becoming flattened in the meantime (Pl. 1, fig. 5). Glandular ducts are found opposite the xylem and the phloem groups of the primary vascular strands (Pl. 2, fig. 1) as noted by Solereder.¹⁴ After the secondary growth such ducts are also seen external to the secondary phloem (Pl. 1, figs. 1 and 2; and Pl. 2, fig. 5).

A somewhat similar fission of the xylem-mass was reported by Koch¹¹ in the mature napiform roots of *Sedum maximum* Sut. of the family *Crassulaceae* and its allies, the difference being that in this case the fission occurred in the middle portion instead of the basal region of our roots and the bundles were hadro-centric instead of the collateral ones as are found in the roots of *Hydrocotyle asiatica* L.

The fission of the xylem-mass in the root of *Hydrocotyle asiatica* L. differs in many ways from that of *Azorella selago* Hook. f. as noted by Ternetz,¹⁵ although the two genera belong to the same sub-family *Hydrocotyloideae* under the family *Umbelliferae*. In *Azorella* disorganization of the ground tissues of the secondary cortex takes place and is followed by the cleavage of the xylem-mass. Here a meristematic tissue originates secondarily in the parenchyma bordering the cleft places whereas in the roots of *Hydrocotyle*, disorganization of the parenchymatous ground tissue has not been observed nor any new meristem has been found to develop anywhere. In *Hydrocotyle* the conducting cylinder of the root splits up into as many segments as there are primary xylem bundles and all these separate strands, thus formed, are found arranged in a regular ring unlike the innumerable, irregularly scattered vascular strands of *Azorella*.

The anomalous root structure of *Oenanthe*, *Magydaris* and *Myrrhis* of the same family (*Umbelliferae*) is, however, of a quite different nature (Solereder).¹⁴ Fission of the xylem-mass in roots of plants belonging to other families has also been reported from time to time. Dastur and Kapadia³ have observed the fission of xylem caused by the dilatation of parenchyma in the aerial and the underground roots of *Tinospora cordifolia* Miens. (Family *Menispermaceae*). Recently, P. C. Joshi¹⁰ has noted the splitting up of the stele of the old stems and roots of *Thylacospermum rupifragum* Schrenk., a Tibetan *Caryophyllaceous* plant, into numerous irregular vascular strands. A. C. Joshi⁹ has reported a somewhat similar anomaly in the roots of another Tibetan plant, *Stellera chamae-*

jasme L. of the family *Thymelaeaceae*. Solereder¹⁴ records the occurrence of the cleft xylem-mass in the stems and in some cases in the roots also of some plants belonging to the families *Caryophyllaceae*, *Malpighiaceae*, *Sapindaceae*, *Caesalpinieae* (*Bauhinia*), *Umbelliferae*, *Asclepiadeae*, *Convolvulaceae*, *Bigoniaceae*, *Acanthaceae* and *Aristolochiaceae*.

DISCUSSION

In great many cases secondary differentiation of the stelar tissues of the dicotyledonous roots has been found to deviate more or less considerably from that of the normal type. All stages, from the simpler cases of the unequal growth of the xylem through its furrowed appearance to the splitting up of the vascular cylinder into separate strands have been observed in a number of families by different authors. The segments, so formed, may be arranged simply in a regular ring as in the roots of *Hydrocotyle*, or by repeated cleavage and secondary growth they may produce masses of wood and bast irregularly interwoven with one another as in *Azorella*. Such anomalous vascular structures have also been observed in the stems of some tropical lianes belonging mostly to the families of *Combretaceae*, *Malpighiaceae* and *Bauhineae* (De Bary).⁵ Another type of cleavage has been noted by Lashevsky¹² in the underground stems of *Daphne julia* (Family *Thymelaeaceae*) where the fission is caused by the activity of the parenchyma of the pith, wood and wood-rays. The cause of these anomalies has, however, not been satisfactorily explained. Lashevsky thinks that this is an ancestral character retained by the species showing the anomaly but in the present case, as in all others, where great parenchymatous development with abundance of starch grains as the cell-contents is the consequence of such cleavage, the explanation put forward by Haberlandt⁷ appears to be very reasonable. He maintains that such peculiarities of secondary growth serve to ensure the production of the storage tissue characteristic of the roots of many *Umbelliferae*, rendering the deposition and renewal of reserve materials easier and more effective after the intermixing of the conducting and the storage tissues.

SUMMARY

1. The roots of *Hydrocotyle asiatica* L. show usually normal secondary growth and thickening characteristic of the dicotyledonous root with a great tendency towards the development of the parenchymatous tissues.

2. In some roots, however, the vascular cylinder at the basal region split up into numerous discrete vascular strands, their number being the same as the number of the primary vascular bundles of the root. Here the continuous cambial ring becomes progressively invaginated towards the center of the root and breaks up into separate arcs, each one of which ultimately encloses a xylem-mass including one primary xylem bundle.

3. The fission of the vascular cylinder is probably due to the tendency of the development of storage parenchyma, thus rendering the deposition and renewal of food materials easier and more effective in the roots.

In conclusion, I desire to express my grateful thanks to Dr. S. R. Bose, Professor of Botany of this College, for his valuable help and criticisms in this investigation.

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ILLUSTRATIONS

(Explanation of the abbreviation of the parts labelled in the figures is given at the end. Figures of Plate 1 are photomicrographs and those of Plate 2, are camera lucida drawings from the roots of *Hydrocotyle asiatica* Linn.)

PLATE 1

- FIG. 1. Transverse section of a root showing earlier stage of the formation of cambium ring around each xylem-mass including one primary xylem. A cork-cambium is forming in the pericycle. The cortex is in process of sloughing off especially in the lower side. (Eye piece 7.5 X and objective 16 mm.)
2. Transverse section from the base of an old root showing four discrete xylem-masses arranged in a ring. Pericycle 3 to 4 layered showing phellogen outside. Endodermis interrupted at places. Cortex and epidermis completely sloughed off. (Eye-piece 5 X and objective 16 mm.)

PLATE 2

- FIG. 1. Transverse section from the apical region of a young root showing tetrarch arrangement of vascular bundles and 1 to 3 layers of pericycle. X 430.
2. A portion of the transverse section from the middle region of an adult root after secondary growth showing the invaginating cambium and the metaxylem elements meeting at the center. X 450.
3. Transverse section from the basal part of an old root giving semi-diagrammatic view of the normal circular cambium becoming progressively invaginated towards the center. Also it shows among other parts a space within for 3 to 4 layered pericycle the inner limit of which has been shown in a circle of dots. X 80.
- 3a. One of the three xylem bundles of Fig. 3 showing details of a portion within the invaginated cambium and a portion of the primary medullary ray outside. X 430.
4. Semi-diagrammatic view of the root in transverse section showing the formation of a complete ring of cambium round each xylem-mass. The continuity of the endodermis is found interrupted at several places of the section. Just below this phellogen is shown in circular outline in dots. The innermost three small circles in dots represent the outer limit of the discrete vascular bundles. The bigger circle in dots enclosing the three separate vascular bundles is the inner limit of pericycle which is 3 to 4 layers of cells in thickness. X 70.
- 4a. One of the three xylem-masses of Fig. 4, shown in details. Here a few cells of the basal part of the primary medullary rays have been shown just opposite to protoxylem. X 440.
5. Drawing of an outer part of Pl. 1, fig. 2, showing interrupted endodermis, phellogen, glandular ducts, sphaeraphides, etc. X 430.

ABBREVIATIONS USED

<i>a</i> —air-space	<i>phl</i> —phellogen
<i>c</i> —cortex	<i>pph</i> —primary phloem
<i>cam</i> —cambium	<i>ptx</i> —protoxylem
<i>dvb</i> —discrete vascular bundle	<i>px</i> —primary xylem
<i>e</i> —epidermis	<i>sg</i> —starch grains in parenchymatous cells
<i>en</i> —endodermis	<i>s ph</i> —secondary phloem elements
<i>gd</i> —glandular duct	<i>sx</i> —secondary xylem elements
<i>nr</i> —medullary rays	<i>x</i> —both the primary and secondary xylem elements
<i>mx</i> —metaxylem	<i>xp</i> —xylem parenchyma
<i>p</i> —pith cells	
<i>pc</i> —pericycle	
<i>ph</i> —phloem	

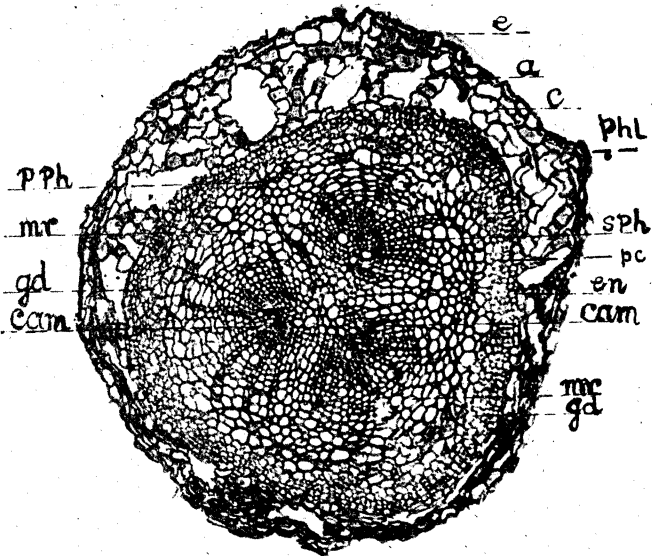


Fig. 1

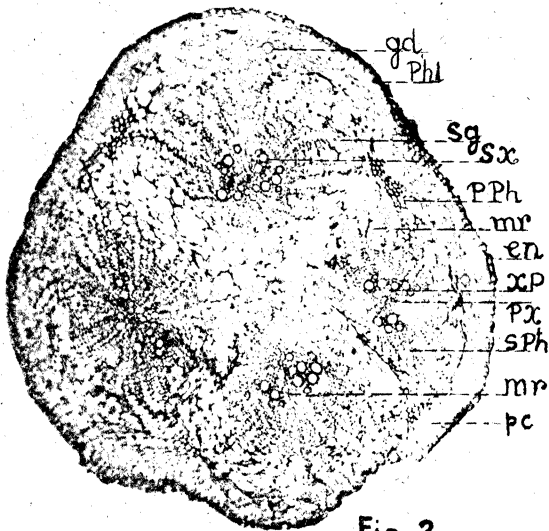


Fig. 2

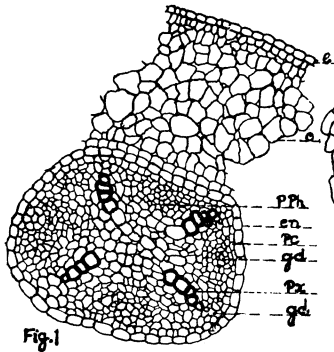


Fig. 1

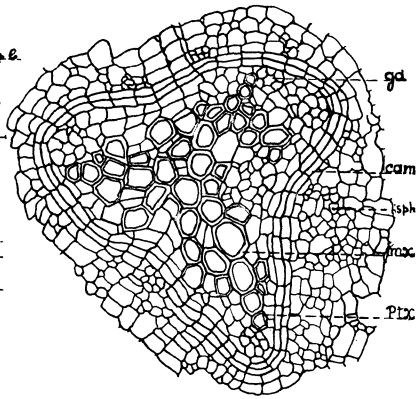


Fig. 2

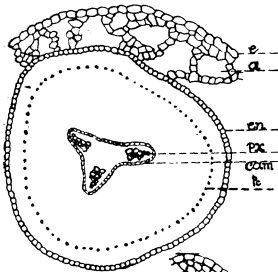


Fig. 3

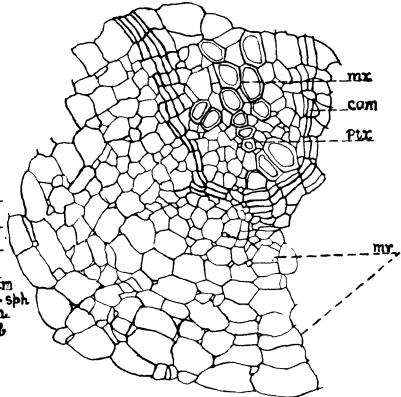


Fig. 3(a)

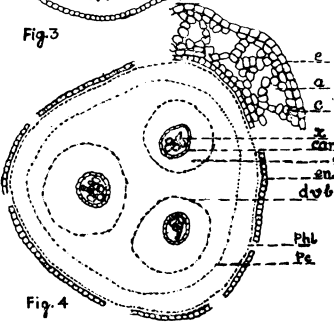


Fig. 4

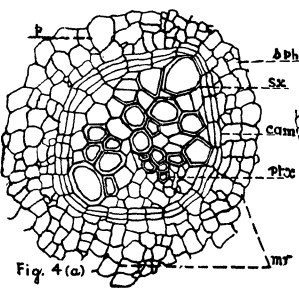


Fig. 4(a)

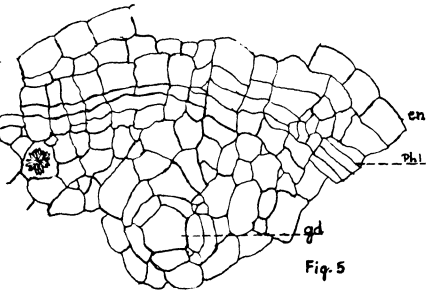


Fig. 5

THE CAROTENE CONTENT OF THE FRUIT OF *MOMORDICA COCHINCHINENSIS* SPRENG

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During the "Journées scientifiques des corps gras alimentaires" held in April 1949 in Paris Dr. Autret of the "Centre National des Etudes et Recherches sur la Nutrition et l'Alimentation" recorded the extremely high content of carotene in the fruits of *Momordica cochinchinensis* Spreng, called by the Annamites "day-gac". According to the minutes of the meeting in Oléagineux, 4, (1949) 309, 8 grams of carotene could be found in 1 kg (0.8 per cent). Further details will be published by Autret in the same journal.

As we are keenly interested in materials with a high carotene content, the investigation of this remarkable fruit was of great value and we succeeded in getting this fruit—carefully sealed in beeswax—from the Philippines.*

The fruit resembles in shape a great pear and in color an orange. The weight was about 300 grams. On first sight our attention was drawn by the deep red layer surrounding each of the 14 black seeds within the fruit pulp. According to the Carr-Price reaction this layer contains carotenoids, but analysis showed that carotene itself was present in only a small quantity.

The fruit was divided in four parts and the total carotene content of each determined:

	Weight	Per cent of total	Carotene	Per cent
a. Skin	46 g.	16	1.62 mg.	0.004
b. Fruit pulp (pale yellow)	198 g.	67	0.82 mg.	0.0004
c. Pulp round seeds (blood red)	20 g.	7	0.83 mg.	0.004
d. Seeds (black)	31 g.	10	-----	-----
Total	295 g.	100	3.27 mg.	0.0084

* We are very grateful to Dr. Eduardo Quisumbing, Director of the National Museum in Manila, Mr. Kenneth B. Day, Director, and Mr. G. J. Wouters, Asst. Technical Director of the Philippine Refining Co., Manila, for all the trouble taken in sending this fruit to Europe in a fresh condition.

The results are nearly negative, and we see once more that people are often attracted by the deep red color of some fruits, but that this is not always the sign of a high content of provitamin A in the form of carotene.

From these results we may conclude that Autret's statement must be based on an error, probably caused by the deep red color of the pulp. The coloring matter was not further investigated because the carotene content showed to be in no way abnormal.

SCYLLA (CRUSTACEA: PORTUNIDÆ) II. COMPARATIVE STUDIES ON SPERMATOGENESIS AND OÖGENESIS *

By EULOGIO P. ESTAMPADOR

Iloilo College, University of the Philippines, Iloilo City

FOURTEEN PLATES

MALE ORGANS

The genital systems of the four groups, namely, *Scylla serrata* (Forskål); *S. serrata* var. *paramamosain* Estampador; *S. oceanica* (Dana) and *S. tranquebarica* (Fabricius), do not show marked differences in their gross morphological features. Hence, the following general description will serve for all.

The abdomen of the male (Plate 2, fig. 1) is much narrower than that of the female, and is provided with only two pairs of appendages which are modified as copulatory organs. The external genitalia consist of a pair of tubules or ducts, which are about eight millimeters long in a crab that measures nine centimeters across the widest portion of the carapace. Each duct comes out from an opening at the base of the thoracic leg, and is received into the troughlike excavated area (*cisterna spermatica*) on the inner surface of the base of the terminal joint of the first abdominal appendage.

The first abdominal appendage (Plate 2, figs. 2, 3) is composed of two joints; the basal one is broad, rectangular, and flattened on its inner surface, which is held appressed to the sternal wall. The terminal segment has a sinuous outline; it is long and tapering with the point shaped like that of a quill pen or that of a hypodermic needle. The *cisterna spermatica* (Plate 2, fig. 2 c) apparently functions as a receptacle to receive the sexual products expelled from the ejaculatory duct. From this cistern a canal leads ventrally, that is, towards the outer surface and to the mouth of the funnel-tube—the remaining portion of the last segment, which is so constructed as to present a semblance to a slender funnel. Indeed, its structural peculiarities and its relations with the ejaculatory duct point to its probable function of transferring spermatozoa into the vulva of the female in copulation.

The second abdominal appendage (Plate 2, fig. 4) is a delicate, unsegmented structure. In the same animal, it measures thir-

* Pt. I. Revision of the Genus, Philip. Jour. Sci., 78 No. 1 (1949) 95-109.

teen millimeters in length, and hardly one millimeter in diameter at the base of the fork. One branch of the fork is spooned and provided with spinules; the outer branch (*c*), which contains a troughlike cavity, is inserted into the opening of the funnel-tube of the first appendage.

During copulation, the ejaculatory duct pours the male sexual products into the cisterna spermatica which is connected to the opening of the funnel-tube by a canal. The forked rodlike second abdominal appendage presumably helps by keeping the spermatophores confined in the funnel-tube, in forcing the male sexual products into the vulva of the female.

The testes (Plate 2, fig. 6) are paired and symmetrical. The two halves are connected immediately behind the foregut in almost the same situation as the ovaries in the female. They are symmetrical in position and lie immediately beneath the hypodermis. The size and shape vary with the condition of sexual maturity of the crab. They are small in immature specimens; while in sexually mature individuals, during the spawning season, they are massive, practically filling up the angular space between the carapace and the sternal wall, and may cover up almost the whole of the digestive gland. Each testis describes an arc following the outline of the carapace; the terminal portion extending as far as the postero-lateral teeth.

At the inner extremity, at about the region of the cardiac foregut, it dips inward and behind the pyloric foregut, it forms a prolongation that joins a similar portion from the other testis forming a sort of a bridge. Posterior to this bridge, it connects with a very much coiled tube, the vas deferens. At the point just above the level of the pyloric foregut, the duct turns inward and follows the course along the digestive tract. It becomes narrower and continues backward to the base of the last thoracic leg, where it empties into the exterior through an opening on the coxopodite of the last leg. We shall call this portion the ejaculatory duct. This is protected by the extension of the arthrodistal membrane from the base of the leg, the membrane rolling around it at the terminal portion. The duct lies closely appressed to the sternal wall and is covered by the lateral extension of the third segment of the abdomen. Its tip is received into the opening of the funnel-tube of the first abdominal appendage.

There are several factors which presumably lead to the expulsion of the sexual products into the funnels tube. Undoubtedly,

gravity plays an important rôle. So does pressure; this may arise from two sources, namely, internal and external. The first, we may qualify as the transmitted pressure which operates in the same manner as in a water-main. Pressure from outside is brought about by the movements of the copulatory apparatus during mating. In these movements, the ejaculatory duct is caught in between the sternal wall and the lateral extension of the wall, the cisterna spermatica. Other factors may be sought in the structural constitution of the duct itself. The epithelial cells that line the cavity of the ejaculatory duct are glandular and ciliated (Plate 2, fig. 7). Obviously, they produce some kind of secretion, the nature of which is not known at present. The cilia, of course, help in the movement of some metabolic products in the duct.

As in the ovary, the testicular follicles are closely packed together. The lumen of each follicle is continuous with that of the vas deferens. The cells that line the lumen are of three types, namely, the spermatoblast, the nurse cells, and the secretory cells. The last are probably collagen-forming cells.

The spermatoblasts are easily distinguished by the large amount of cytoplasmic materials present and by their large nuclei. The nurse cells are smaller, with distinctly smaller nuclei, and are more or less vacuolated. In both of these kinds of cells, the nuclei are basal in position.

The secretory cell is big, rounded in outline and possesses a big vesicle. Its metaplasma takes up a bluish tint with iron hæmatoxylin, acid fuchsin and anilin blue stain combination; the secretory product is apparently collagen or a related substance. The secretory cells present in the follicles are very much fewer and are smaller, compared to those present in the ovarian follicles (Plate 7, fig. 9).

The secretion presumably furnishes the necessary medium for the spermatozoa on their way to the outside. If such be the case, this medium must possess a certain degree of viscosity to protect the spermatozoa from the action of the water. In the case of the female, the secretory cells furnish the sticky material by means of which the eggs are attached to the endopodite setæ. Considering the large number of eggs and their relatively much bigger size, a considerably much greater amount of material is needed. Perhaps this fact may explain the presence in greater number of secretory cells in the ovarian follicles.

SPERMATOGENESIS

The spermatoblasts (auxocytes) may proceed in their development either singly or in groups. In either case, the growing auxocyte draws some of the cytoplasmic and nuclear materials from the surrounding cells and uses them for its growth. In the case where they are in groups, the competition among themselves results in some being used up by the more vigorous auxocytes. The group is held together by a sort of cyst, probably formed from the detritus from the used-up cells, and possibly cemented together by the secretion of the secretory cells. Such a group of auxocytes may be termed spermatocyst (Plate 5, fig. 1 and Plate 6, fig. 6). This group formation is frequently met with in the *mamosain* and *paramamosain* groups, and occasionally in the *parabanhawin* (*S. tranquebarica*). It does not seem to occur in the true *banhawin* (*S. oceanica*).

The most distinctive changes that take place during the growth of the auxocyte can be observed in the increase of its bulk due to the increase in volume of its cytoplasm and in the increase in size of the nucleus. At the termination of the growth period, the cell undergoes transformation in two distinct ways; one, the whole cell, or the greater portion of it, participates actively; the other, the apparent activity is seemingly centered around the nucleus and the rest of the cell undergoes no radical structural changes, except for the sloughing off of the cytoplasm.

Heteropycnosis.—A very peculiar characteristic is seen in what is termed "heteropycnosis," in which the sex-chromosomes become greatly condensed and form an intensely staining mass, appearing as a karyosome, or "chromosome-nucleolus," in sharp contrast to the threadlike or diffused and slightly staining ordinary chromosomes. It appears to be a very conspicuous feature during the growth period and, in some cases, it appears even as late as in some phases during spermatid-transformation (Plate 5, figs. 4, 5).

This condensed mass of chromatin materials give rise to the "hetero-chromosomes" of some authors. Among the groups of crabs under consideration, the chromosome-nucleolus represents either the XX- or the XY-pair of chromosomes.

Spermiogenesis.—After the growth period, the cell undergoes a series of transformations; the subsequent developmental phase may be termed "spermiogenesis" or "spermioteleosis." In *S. tranquebarica* (*parabanhawin*) and in the variety *paramamosain*, the process of spermatogenesis can be subdivided quite

distinctly into four general phases, namely, (1) the auxocyte, characterized by growth, (2) the pro-spermatid stage, characterized by reorganization, differentiation, and sloughing off of some of the materials leading to the formation of the definitive spermatid body, (3) spermatid transformation, also featured by reorganization, differentiation and further sloughing off of the materials, and (4) the spermatozoön. While in *S. oceanica* and *S. serrata* the four general phases cannot be distinctly differentiated, there is a considerable merging of these phases; hence, an apparent shortening of the process of spermatogenesis.

SPERMIOGENESIS IN *S. TRANQUEBARICA*

This group is described first, because the two types of spermiogenesis previously referred to occur in a somewhat more elaborate manner. The two types are linked with the chromosomal constitution of the germ cells involved: (1) in one class, there is tetrad formation and almost the whole of the cell actively participates; (2) in sharp contrast to the other class, the apparent activity is seemingly centered in the nucleus. We shall refer to the first as having the tetrad formation and to the second as without tetrad formation.

I. *Spermiogenesis in cells having tetrad formation.*—In this class the process involves telokinetic movements which include: (1) movements of the nucleus, (2) extrusion of some of the nuclear materials and most of the cytoplasm, (3) peculiar behaviour and movements of the acroblast, (4) rotation of the chromosomes. This phenomenon is especially noticeable in the hetero-chromosomes.

Some of the more obvious changes that take place in the series of transformations leading to the formation of spermatozoa may be seen in the following illustrations:

Plate 3, fig. 1, represents a growing auxocyte. Within its body, the shriveled nucleus of a nurse cell can still be seen. Its nucleus is apparently in the leptotene-stage, the spireme threads beginning to arrange side by side, evidently in preparation for synapsis (syndesis). The tetrad formation is quite obvious; this is shown by a loop giving rise to four chromatids. It seems that in this case synizesis is foreshadowed by a migration of the prochromosomes towards certain places along the periphery of the nuclear wall, where they become closely aggregated before the leptotene threads are spun out from them. The biggest of these pre-sinizetic knots apparently give rise to the hetero-chromosomes.

Plate 3, fig. 2, shows the surface view of an auxocyte at the termination of the growth period. Evidently, it is in the contraction phase; the chromosome-nucleolus is at the center, and from it, the prochromosomal threads radiate, apparently in pairs.

Plate 3, fig. 3, depicts a pro-spermatid body, wherein the process of concentration is going on, apparently in preparation for the subsequent reorganization. From this point on, the subsequent changes that follow are not those of growth, as these are characterized by diminution of the size of the cell accompanied by reorganization and differentiation. The term spermatocyte does not seem to fit in this particular case, taking into consideration the previous history, and the changes that are to follow. In this figure, the spireme has been transformed into chromatids. The tetrad formation is indicated by the grouping of chromatids into four. Though in a somewhat diffuse condition, the arrangements in pairs is quite apparent as in (1) in which each mate is composed of a row of chromatids. Presumably this pair will form in synapsis an anaschistic rod tetrad with terminal connection.

Plate 3, fig. 4, shows the chromosomes in pre-synaptic associations; the pairs are recognizable. Three types of tetrads are present: (1) the loop-shaped, which is apparently the X-chromosome in the XY-pair, the hetero-chromosomes (*h*); (2) rod-like; and (3) V-shaped. Some of the chromosomes are distinctly segmented.

Plate 3, fig. 5, shows the synaptic figures; the mates of some differ in size, form and in structure. Hence, they are heteromorphic. In the attraction sphere or idiosome (*i*) are darkly stained bodies with granular constitution; these are the pro-acrosome granules (*p. ac*).

The changes that bring about the transformations leading to the formation of spermatozoa are featured by series of concentration, contraction, and diminution of both the nuclear and cytoplasmic materials. Some of the phases of spermatid transformation are illustrated in the following figures:

In Plate 3, fig. 6, the pro-spermatid body has assumed a more definitive form, its outline has become more regular. The chromatin net-knot (nucleo-chromosome) appears as a big heavily stained body near the center; the rest of the chromatin materials have ranged along the border of the nuclear wall toward the apical pole as small deeply stained masses, while some are

apparently being sloughed off at the opposite pole. The darkly stained mass (*n. e*) is presumably composed of extruded nuclear materials; the other (*g*) containing heavily stained bodies probably constitutes extruded Golgi-remnant bodies. The picture shows clearly the process of diminution involving the cytoplasm and the karyoplasm. The attraction sphere or idiosome (*i*) is now at the apical pole and contains a heavily stained body, the *acroblast* (*ac*).

Plate 3, fig. 7, depicts the process of concentration, as evidenced by the broken and reticular condition of the cytosome at the basal portion of the pro-spermatid body. The nucleus has moved farther toward the apical pole; the chromosomes are now dyads, instead of tetrads, and the number has been reduced to six. The small U-shaped chromosome near the pole is evidently the extra sex-chromosome (*m*). It behaves differently by moving ahead of the others. Reduction of the amount of the chromatin materials and, consequently, the number and size of the chromosomes must have taken place in the preceding stages. This reduction was brought about by a sort of regrouping or segregation of the chromosome materials—the tetrads separating into dyads without undergoing division in the usual manner. One of the groups, evidently composed some of the nuclear materials that were cast off (Plate 3, fig. 6, *n. e*).

Plate 3, fig. 8, shows the differentiation of the definitive spermatid body (*sp. b*). The nuclear materials have reached the proximity of the attraction sphere; presumably the heavily stained body in the form of a nucleo-chromatin is the sex-chromosome (*x*). Apparently the *acroblast* has disaggregated. The spermatid has a form very much like that of a hat; the head is obviously composed of the sphere-substance referred to by Wilson (1924)⁴ as a clear substance inside the idiosome; the brim is composed of cytoplasm, and the nucleus is apparently located centrally in this region. This figure indicates clearly that only a small portion of the cytoplasm is utilized in the formation of the definitive spermatid body; the rest is sloughed off. This mass of residual protoplasm (*r. p*) degenerates without taking any further part in the sperm formation. Some of these discarded materials are presumably used in the formation of the cyst, in cases where the auxocytes are in group formation (spermatocyst). The remainder is released into the lumen of the follicle and into the spaces between the follicular tubules, where they are observed as the undifferentiated chro-

mophyllic mass. Some sloughed-off nuclear materials and Golgi-remnant bodies are commonly seen in this mass. The heavily stained mass (*c. e*) among the cast-off materials may represent either nuclear materials or a portion of the cast-off acroblast.

Plate 3, fig. 9, represents a sort of an abortive mitotic figure showing division involving mainly the nucleus. Part of the cytoplasm will undoubtedly go with the casting off of the daughter nucleus. Apparently, this process constitute the second meiosis, and reduces the chromosomes from dyads to monads. The small chromosome which is out of the alignment and nearer the acroblast, is evidently the extra sex-chromosome. It is no longer U-shaped (Plate 3, fig. 7, *m*). The acroblast (*ac*) is again aggregating. From its constitution, the cast-off daughter nucleus appears to be normal; whether it develops into a normal sperm is yet to be proved. There are indications, however, that it might be the case, as can be inferred from the presence within the remains of the auxocyte body of two spermatids or two spermatozoa in close proximity to each other, a condition which seems to be typical.

Plate 3, fig. 10, shows the top view of a spermatid representing a later stage than the preceding. It represents a figure similar to that of a conical lamp shade; the apex is occupied by the idiosome (*i*) containing two deeply stained bodies—the acroblasts, so disposed opposite each other. The process of concentration is going on, as indicated by the condition of the cytoplasm.

The subsequent concentration will result in the sloughing off of some materials, as shown in Plate 3, fig. 11; it also brings the two acroblast bodies together. These bodies do not fuse, however, the more homogeneous one leaning more to the outside of the idiosome. Further concentration and sloughing off of materials, apparently results in one of the acroblasts being pulled down towards the base to become the acroblast-remnant (Plate 3, fig. 12, *ac. r*), which eventually will be cast off.

The other acroblast body is not shown in Plate 3, fig. 12; apparently it has undergone disaggregation, as indicated by the somewhat clear appearance of the idiosome. The figure indicates that the process of concentration is going on. This is subsequently followed by contraction. Plate 3, fig. 13, illustrates this phase, showing the basal portion viewed from below, and the position of the nucleus at the center of the base of the spermatid body. It also shows the chromosomes which are located along the periphery of the nuclear wall.

Further contraction results in the sloughing off of some more cytoplasmic materials. Plate 3, fig. 14, represents a stage that results from the preceding changes. The figure is something like a dome with the nucleus forming the base. Apparently the acroblast is in a state of disaggregation. The subsequent processes of concentration and contraction that follow transform the figure into something resembling a bowl (Plate 3, fig. 15). The acroblast has reaggregated and occupies a position at the border of the idiosome.

In the subsequent phase, the spermatid assumes a conical form (Plate 3, fig. 16) and the acroblast has split into two bodies, of which one moved down toward the base, presumably to become the second acroblast-remnant. It is highly probable, however, that its materials may become finely disseminated and may be used in the formation of the nuclear cup. The other acroblast body remains at the apex, and it may eventually constitute the definitive acrosome body.

The diminution of the cytoplasm is quite obscure from this point on. It seems that in these later stages, in the basal portion wherein the nucleus is located, the surface-tension balance has reached a point which would establish a certain degree of rigidity in this region. Consequently the sloughing off of materials can no longer take place in this area; it is shifted to the lateral surface, where the surface tension has not reached the determinative fixity.

Plate 3, figs. 16 and 17, show this shifting and also that of the position of the definitive acrosome body towards the base. This apparent movement of the acrosome body is possibly brought about by the concentration of cytoplasmic materials which most likely exerts a pulling force and the subsequent contraction produces a further downward shift. Plate 3, fig. 18, illustrates the movement of the definitive acrosome.

Plate 3, fig. 19, shows the spermatozoön; it measures 13 microns in length and a little over 11 microns in diameter at its base. The form is similar to that of a funnel or a conical cup. The nucleus is located at the mouth of the cup; hence, we may call this region the nuclear cup. Forming the rim of the mouth and extending to the conical tip is the capsule, which may be regarded as a sort of a conical enclosure around the sperm body.

From the foregoing observations on the series of changes, featured by diminution of the constituent materials of the spermatid, each time followed by reorganization and differentiation,

it can be said that the spermatozoön is composed of nothing more than concentrated nuclear materials and a certain amount of cytoplasm packed in a conical capsule.

Acroblast and acrosome.—The most conspicuous features in the later part of spermatogenesis concern the appearance of the acroblast and the series of changes that finally lead to its transformation into a capsule. Acroblast is a body or group of bodies derived from the substance of the idiosome and Golgi-bodies and from which arises the acrosome (the capsule in this case). A brief summary of the behaviour and movements of these bodies will serve to portray the rôle they play in sperm formation.

In these crabs (*S. tranquebarica*), the acroblast is at first identified as a group of granular bodies (the pro-acrosome granules) within the idiosome (Plate 3, fig. 5, *p. ac*). The idiosome is composed of a clear substance called by some authors as the "sphere substance." From its position at the side, the acroblast shifts anterior to that of the nucleus and moves towards the apical pole (Plate 3, figs. 5, 6), where it appears as a heavily stained body inside the idiosome. This implies that during interkinesis, the granular bodies have disaggregated and later some portions reaggregated to form the acroblast (Plate 3, fig. 6, *ac*), while the rest is thrown off as the Golgi-bodies remnant (Plate 3, fig. 6, *g*).

In Plate 3, fig. 7, the idiosome bulges out to a conical form; there is no indication of the presence of the acroblast within its area, except for the presence of some fine granules. Obviously the acroblast has undergone disaggregation.

In Plate 3, fig. 9, the acroblast is shown as a group of heavily stained granular bodies near the apical pole. This indicates that, during the intervening phases, the acroblast underwent disaggregation and now it is again undergoing reaggregation.

Plate 3, fig. 10, shows the acroblast as two distinct bodies opposite each other at the periphery of the idiosome. The subsequent contraction that takes place brings these two bodies together (Plate 3, fig. 11, *ac*). With the sloughing off of some of the cytoplasm, the more homogenous body which is leaning more towards the outside of the idiosome becomes detached and sinks towards the base (Plate 3, fig. 12), from where it will be cast off eventually. We shall call this the acroblast-remnant (*ac. r*). The other acroblast body is not seen in this figure; apparently it has disaggregated.

In Plate 3, fig. 15, the acroblast reappears as a heavily stained body at the border of the idiosome. In the subsequent phase, it splits into two bodies, one remaining at the apical pole to become the definitive acrosome body; the other sinking towards the base, perhaps to become the second acroblast-remnant and to be eventually cast off. It is more likely, however, that its materials may become finely dispersed and used in the formation of the nuclear cup (Plate 3, figs. 16, 17).

During the series of concentration, contraction, and sloughing off of materials, the definitive acrosome body migrates nearer to the base (Plate 3, figs. 16, 17); then ultimately disaggregates to become incorporated into the materials that form the capsule of the spermatozoön.

The Capsule.—From the foregoing observations, we can regard the capsule as the structure formed from the idiosome and its sphere substance, together with what is left of the acroblast. Hence, it can be considered homologous with the so-called acrosome in some sperms, since both structures are derived from the same materials.

Cursory examination of Plate 3, figs. 16, 17, and 18 seems to indicate that the direction of the movement of the definitive acrosome body is from the base towards the apical pole (Plate 3, fig. 17). Wilson (1928, p. 381)⁴ states: "the most conspicuous feature in the history of the acroblast is its ultimate separation into two parts—one of which moves to the anterior pole and there gives rise to the definitive acrosome, while the other and often larger portion constitutes acroblast-remnant (idiosome-remnant) containing the original Golgi-bodies surrounding the sphere." This seems to be the case only in the early stages.

The observation described by Wilson may really be true for some animals. In these crabs, in the later stages, there seems to be no such movement, because the definitive acrosome is formed in the apical region, the idiosome which holds the acroblast being located in this area. Obviously, the series of reorganization and differentiation involving the acroblast and evidently the idiosome itself must take place in this zone. Hence, in this particular case, the more apparent direction of the movement of the definitive acrosome is from the apical pole and towards the base; whence, it presumably furnishes the material that forms the part of the capsule enclosing the nuclear cup.

Capsule formation in other crabs.—Binford (1913)² made the following observations:

1. The capsules arise in the cytoplasm as a clear vacuole which may be stained with Lichtgrun. Its contents is gradually changed and have a greater affinity for chromatin stains.
2. From a granule on the proximal side of the capsule, the central body develops into the capsule
3. The mitochondrial substance is aggregated from the cytoplasm and deposited as a ring between the nucleus and the capsule.

Wilson (1886), Sabater (1893) and Koltzoff (1906) described a similar vesicle which arises in the cytoplasm either against the nucleus or close to it. The vesicle described by Binford and other authors might be the idiosome and the granule referred to, the acroblast.

The observations of the foregoing authors, though made on different crustacean decapods, seem to be in agreement with my assumption that the idiosome and the acroblast form the capsule; it cannot be merely from a vesicle, this term being merely descriptive, indicating a structural feature. The idiosome, on the other hand, has in its make-up something that has active directive influence. Perhaps, it is this unknown factor that influences the transformation of the capsule during the penetration of the sperm into the egg. Binford himself (1913)² said: "for the interpretation of the entrance of the spermatozoön into the egg, the transformation of the capsule is more important than the changes in the protoplasmic cup."

II. *Spermatogenesis in the class without tetrad formation (S. tranquebarica).*—The mode of spermiogenesis involving cells with no tetrad formation differs markedly in many aspects from that of the class in which there is. In the former, the center of activity seems to be localized in the nucleus and to a very limited area immediately around it. The remaining portion of the cell apparently remains passive. The phases of changes are not so picturesque, and there is an obvious attempt at shortening the period of sperm formation. A brief description of some of the features may help show the differences between these two types of spermiogenesis.

Plate 4, fig. 1, shows a growing auxocyte, drawn from the cross-section of a follicular tubule. As in the auxocytes with tetrads, the characteristic features are: (1) the big nucleus which is basal in position; (2) the greater amount of cytoplasm present, compared with that in the nurse cells; (3) heteropycnosis, that is, the condensation of some chromatin materials

to form the chromosome-nucleolus. The nucleus, however, is relatively smaller in size compared with that of an auxocyte belonging to the class with tetrads.

Plate 4, fig 2, is drawn from the surface view of an auxocyte in a later stage. The chromatin materials are now organized into chromatids. There is no indication of tetrad formation.

Plate 4, fig 3, is drawn from the longitudinal section of the follicle. The condition of the nucleus of the auxocyte indicates that some sort of rearrangement is taking place; perhaps this foreshadows the differentiation of the spermatid body.

In the class with tetrad formation, we differentiate a pro-spermatid stage which subsequently undergoes a series of transformations involving the elimination of a considerably large amount of cytoplasmic materials prior to the formation of the definitive spermatid body. On the other hand, in the class with no tetrads this series of changes is omitted; hence, the mode of spermiogenesis differs in that it is somewhat abbreviated.

The chromosomes (Plate 4, fig. 4) are very much smaller compared with those present in the auxocytes with tetrad formation (Plate 3, figs. 4, 5, and 7). In both classes, however, the chromosomes are segmented. The hetero-chromosome may be seen as V-shaped body (*h*). Besides the relatively smaller size of the chromosomes, another significant difference is in number—there are only five, instead of six, (Plate 3, fig. 13 and Plate 4, fig. 9). This is a case of digamety. The difference in number is due to the presence in the group having tetrads, of an extra chromosome, the *monosome* (Plate 3, figs. 5, 7).

In Plate 4, fig. 5 are shown two spermatids that have differentiated from their respective auxocytes. In (*a*) the acroblast (*ac*) appears as a heavily stained body at the apical pole and the rather large nucleus is at the base. In (*b*) the acroblast has evidently split into two bodies; the one inside the acroblast-vesicle (*v. ac*) within the idiosome will probably form the definitive acrosome body; the other is not shown. No pro-acrosome granules have been observed in this case (Plate 3, fig. 5); the acroblast suddenly appeared as a single chromophyllic body within the acroblast-vesicle. The reticular condition of the auxocyte body may be attributed to the disorganization of the cytosome.

The darkly stained masses (*nc*) are evidently the sloughed-off chromatin materials and the other similarly stained mass (*g*) presumably represents the Golgi-remnant bodies. These masses

have their counterpart in Plate 3, fig. 6. It can be inferred that, with the disappearance of the nuclear wall as the chromosomes are formed, some of the chromatin materials are discarded. In other words, chromatin diminution took place when the spermatid differentiates from the auxocyte body; that is, during the differentiation, and in the reorganization that followed, only so much chromatin material is retained as is proportionate to the cytoplasm of the spermatid body. In other words, the amount of cytoplasm incorporated into the spermatid body determines the quantity of chromatin material that is to be included. This premise, however, does not necessarily preclude the occurrence of a reverse condition. This brings up the question regarding the casual relation between the nuclear volume and cytoplasmic growth—the so-called “karyoplasmic-ratio” of R. Hertwig (1903, 1908, etc.).

The present case seems to be in line with Conklin's observation that “the nuclear volume varies not with the total volume of the cytosome but with that of its active protoplasm.” Comparative measurements show a striking correspondence in size between the definitive spermatid body and the nucleus of the auxocyte at the termination of the growth period. The resemblance is such that on cursory examination the spermatid is likely to be mistaken as the nucleus.

This mode of spermiogenesis (in auxocytes without tetrads) was previously described as characterized by the apparent localization of activities in the nucleus including certain limited portion of the cytosome immediately around it. During the differentiation of the spermatid from the auxocyte body, the nucleus underwent reorganization so as to make its mass relatively proportional to that of the active protoplasm which is to be incorporated into the spermatid body. This perhaps accounted for the sloughing off of some chromatin materials.

There are features that yet remain to be explained, such as:

- (1) In the class that has no tetrad formation, what limit the activities to a very restricted portion of the auxocyte body?
- (2) Why does the whole auxocyte body take active part in the transformation in the other class (with tetrads)?

Aside from the physical constitution of the chromosomes, the particular phase wherein the two classes differ conspicuously is in the manner by which their respective spermatids differentiate from the auxocyte. Otherwise, in some broad aspects, the other phases of transformation are discernibly parallel.

Plate 4, fig. 6, presumably represents a later phase following the contraction of the spermatid body represented in Plate 4, fig. 5 (b). The spermatid body is now elongated and the definitive acrosome occupies a central position within the idiosome at the apical pole, while the acroblast-remnant (*ac. r*) lies at the periphery of the base, eventually to be cast off.

In one of the subsequent phases, a figure resembling a lampshade is formed (Plate 4, fig. 6), with the acrosome body at the apical area. (Cf. Plate 3, figs. 10 and 11, which belong to the group with tetrad formation.)

The next phase is featured by the extension of the apical area to a narrow tip while the base describes a flange at the periphery, (Plate 4, fig. 8).

Plate 4, fig. 9, shows the basal portion of a spermatid. There are five chromosomes. (Cf. Plate 3, fig. 13.)

Plate 4, fig. 10, shows a spermatid in about the last phase of transformation.

The existence of digamety in the sperms of this group of crabs (*S. tranquebarica*) is unquestionably evident. Whether dimegaly also exists at the same time is yet to be proved.

SPERMIOGENESIS IN *S. OCEANICA* (DANA)

There is only one method of spermiogenesis in this group, in sharp contrast to that in *S. tranquebarica*. Some of the phases of transformation are shown in the following illustrations.

Apparently, after the growth period the auxocyte nucleus splits into two spermatid nuclei (Plate 5, fig. 3). During the subsequent reorganization, some of the cytoplasmic materials around each daughter nucleus become incorporated into the spermatid body (Plate 5, fig. 3). The portion of auxocyte which is involved in the process of spermatid differentiation of the cytosome includes the zones in the immediate vicinity of the spermatid nuclei and the area around the rather enormously large centrosome (*a*), wherein a centriole can be seen at the center.

Plate 5, fig. 5, represents a pair of spermatid bodies that have developed from the spermatid nuclei referred to above. Apparently they are in the contraction phase; the dark condensed chromatin mass, evident in each of them, represents the sex-chromosomes. Each spermatid eventually transforms into a spermatozoön through a series of differentiation and reorganization accompanied by the diminution of both the cytoplasmic and karyoplasmic materials.

That the two daughter spermatid nuclei transform into functional spermatozoa is quite evident. Spermatids in about the same phases of transformation are commonly seen very close together (Plate 5, fig. 5) and spermatozoa in pairs are not uncommon. In this figure the two spermatids had evidently undergone diminution of both cytoplasmic and karyoplasmic materials. Both are evidently in the sinizesis stage.

Plate 5, fig. 6, shows a side view of a spermatid in a later phase. The acroblast appears as a big black mass at the periphery of a rather large idiosome (*i*).

The subsequent contraction splits the acroblast into two portions, one sinking to the base as the acroblast-remnant (Plate 5, fig. 7, *ac. r*), and the other remaining at the apical area as the definitive acrosome body. The figure shows the spermatid from the top, which is narrow, while the base is expanded. The figure corresponds to what we previously termed as the lampshade phase, (in *S. tranquebarica*, Plate 3, fig. 10; Plate 4, fig. 7).

Plate 5, fig. 8, represents an example of spermatozoa in pairs. Their presence in close proximity to each other is taken as an indication that the two spermatid nuclei that differentiate from the nucleus of an auxocyte may transform into two functional spermatozoa. In this figure, one of the pair is seen from the basal-side view; only the basal portion of the other is shown. Both spermatozoa show the central position of the nucleus in the nuclear cup.

Histogenesis in this group differs in many aspects from both of the two modes of spermiogenesis that we observe in *S. tranquebarica*. In the initial phases: (1) no tetrad formation is seen; (2) no pairing of chromosomes; (3) only a limited portion of the cytosome is actively involved. These are in sharp contrast to the mode of spermiogenesis involving the class of auxocytes (with tetrad formation) in *S. tranquebarica*, wherein the whole cell participates actively.

Compared with the mode of spermiogenesis that takes place in the class without tetrad formation, the contrast is also obvious. In *S. tranquebarica*, the nucleus of an auxocyte differentiates directly into a spermatid; presumably, this takes place by incorporating some of the cytoplasm after the sloughing off of a certain amount of the karyoplasm. In *S. oceanica*, on the other hand, the auxocyte nucleus splits first into two spermatid nuclei; then each nucleus reorganizes into a spermatid by incorporating a certain amount of the surrounding cytoplasm.

However, in the later phases of spermatid-transformation, the above mentioned three quite distinct modes of spermiogenesis run parallel in several aspects as indicated by: (1) the series of concentration, contraction and sloughing off of some materials with the consequent diminution of the size of the spermatid, each time followed by differentiation and reorganization until the definitive spermatozoön form is attained; (2) the behavior and movements of the acroblast and acrosome are essentially similar.

The chromosomes (Plate 5, fig. 9) of *S. oceanica*, exhibit the tendency of being formed loosely by groups of twos, threes (triosome or triplicate), and fours (quadruplicate) sets of chromatids. This is in contrast with the distinct-segmented character of the chromosomes of *S. tranquebarica*. (Plate 3, figs. 4, 5 and 7.)

The haploid number of chromosomes in *S. oceanica* is six (Plate 5, fig. 10). There is only one mode of spermiogenesis, in contrast to the two methods of sperm formation in *S. tranquebarica*.

SPERMIOGENESIS IN *S. SERRATA* VAR. *PARAMAMOSAIN*

Histogenesis in this group closely parallels that of *S. tranquebarica* in the sense that there are two types: (1) in one mode of spermiogenesis, the whole cell is practically involved actively. This is indicated in Plate 5, fig. 11, which shows a pro-spermatid in the contraction phase with some of its cytoplasmic and chromatin materials being sloughed off. The size is relatively large compared with that of the kinoplasmic area indicated in Plate 6, fig. 1.

We need not follow closely the details of the changes. On the whole, it can be said that, the phases of transformation broadly resemble in many essential details the spermiogenesis in one class of auxocytes (with tetrad formation) in *S. tranquebarica*.

(2) The other type involves some broad aspects which suggest a mode of spermatid-differentiation somewhat intermediate between that in *S. oceanica*, on one side, and that in *S. tranquebarica* (only in auxocytes without tetrads), on the other, that is, if we are to base the condition on the kinoplasmic area. There seems to be a degree of gradation regarding the relative amount of the cytoplasm which is actively involved—practically nil in *S. tranquebarica* (only in auxocytes without tetrads), small in *paramamosain*, and considerably greater in *S. oceanica*. (Cf. Plate 4, fig. 5; Plate 6, fig. 1 and Plate 5, fig. 3.)

In *paramamosain*, the nucleus with some portion of the cytosome (Plate 6, fig. 1) differentiates from the auxocyte and splits into two, each half transforming into a spermatid. The mode of spermatid-differentiation in this group is different then from what were observed in the two other groups (*S. tranquebarica* and *S. oceanica*).

Frequently, two spermatozoa can be seen side by side within the remains of an auxocyte. This indicates that the two spermatozoa must have developed from two spermatids, like the two referred to above. Plate 6, fig. 2, represents one of such pairs; the two spermatids have already attained the definitive form of the sperm; apparently, they have to undergo reorganization before they become full-fledged spermatozoa. The reticular appearance of the auxocyte body is noteworthy; the same condition may be observed in Plate 4, fig. 5. Perhaps, this condition is due to the withdrawal of the cytosome from some parts of the cell during the time when the spermatids are differentiating from the auxocyte body. Presumably, the large clear space (Plate 6, fig. 2, c) above the spermatids represents the centrosome with some centrioles and centrioplasm.

It is not unlikely to find two types of spermatozoa in the variety *paramamosain*, since there are two modes of spermiogenesis. This condition is observed in *S. tranquebarica*.

SPERMIOGENESIS IN *S. SERRATA* (FORSKÅL)

Spermiogenesis in this group proceeds in two distinct fashions varying distinctly in some details from the types that are observed in the preceding groups. In this species, the spermatids may differentiate from the auxocytes by either of two quite distinctly different methods.

I. In one class, after the growth period, the auxocyte nucleus undergoes a somewhat general reorganization. This involves both karyoplasmic and chromatin materials and their subsequent diminution (Plate 6, figs. 7, 8 and 9). The spermatid so differentiated then undergoes transformation.

Plate 6, fig. 7, shows an auxocyte nucleus apparently in the phase of the series of changes that lead to its transformation into a spermatid body. The chromosome-nucleolus appears as a condensed mass, while the other chromosomes are visibly still somewhat in a reticulated condition. The karyoplasmic materials are more or less concentrated on the opposite pole. The centrosome (c) appears as a clear space containing some centrioplasm. With acid fuchsin, anilin blue and haematoxylin, the latter appears as a somewhat dark mass with a bluish tint.

In the subsequent contraction phase, some of the materials are sloughed off. Plate 6, fig. 8, shows a picture wherein the process is apparently going on. The karyoplasm is in the diffused condition and the chromatids, excepting those that constitute the sex-chromosomes, are aligned along the periphery of the differentiating body.

Plate 6, fig. 9, shows a phase of reorganization following the differentiation and the subsequent sloughing off of some materials. The spermatid nucleus is in the netlike stage or resting period and the chromosomes are temporarily in a reticulated condition. The sloughed-off materials (*rp*) are seen above it.

Spermatids differentiated in this manner seem to be less common than the other class and, in their later phases of transformation, have not been followed very closely. This is quite difficult, because the determination as to how a spermatid differentiates from the auxocyte is rather uncertain. It is quite true that the spermatids belonging to the other class usually occur in pairs and, hence, they can be reorganized easily; but there still remains the uncertainty due to the accidental separation of the pairs which may happen during the sectioning of the tissues.

II. The other form of spermiogenesis in this species is characterized by the differentiation of the auxocyte nucleus as a body to form the spermatid nucleus (Plate 6, fig. 10). This then proceeds to reorganize and ultimately splits into two. Perhaps this explains the fact that many spermatids and spermatozoa are in pairs. Plate 7, fig. 4, shows a pair of spermatids still within the auxocyte body. The photomicrographic picture of a spermatocyst (Plate 6, fig. 6) also illustrates this condition.

The process of division is featured by what we may term "progressive heteropycnosis." The chromosome-nucleolus appears to be the focal point around which the activities are more obvious. The following figures illustrate some of the more characteristic features.

Plate 6, fig. 10, shows the nucleus of the auxocyte at the termination of the growth period. Apparently the resting phase, which is indicated by the netlike stage, or resting condition, in which all the other chromatin materials are reticulated; they are being broken by the initiation of activities. This can be inferred from the apparent tendency of the nuclear material to concentrate around the chromosome-nucleolus.

Obviously this results in the realignment of the nuclear constituents which finally segregate into two portions (Plate 6, figs. 11, 12, and Plate 7, fig. 1).

Plate 7, fig. 2, shows the nucleus only, wherein the chromosome-nucleolus (presumably the XX-chromosomes) now elongates at the equatorial region. The doubled appearance and the presence of clefts at both ends, instead of the two ends tapering and pointed, as observed by some authors in other animals, indicate that, in this particular case, the chromosome-nucleolus is composed of the XX-chromosomes. Obviously the pair is in diakinetik position, preparatory to their separation; hence, each daughter nucleus will have one X-chromosome.

The process of division is shown in Plate 7, fig. 3. A peculiar feature is seen in the sudden appearance of presumably the idiosome (*i*) at the angle where the splitting takes place.

Basing on what has been observed regarding the rôle and the active participation of the idiosome in the process of transformation in the other groups, it can be inferred that in this case a portion of the idiosome is incorporated into the body of each spermatid during the reorganization that follows the division.

This view is apparently supported by the appearance of the acroblast in a later phase (Plate 7, fig. 5). The acroblast appears at the apex of a cuplike structure; the nucleus fills the mouth of the cup. In this connection, it may be pointed out that the features and the circumstances associated with the appearance of the idiosome and the acroblast are different from what have been observed in *S. tranquebarica*.

The features are also different in the two other groups (*S. oceanica* and in the variety *paramamosain*), where the acroblast appears suddenly within the idiosome in the apical pole of the spermatid; whereas in this species (*S. serrata*), the idiosome appears first in the cytoplasm of the auxocyte at the place where the nucleus is splitting. On the whole, however, in the last three groups, namely: *S. oceanica*, the variety *paramamosain*, and *S. serrata*, the appearance of the acroblast takes place at some later stage of the transformation.

Plate 7, figs. 6 and 7, represent spermatids in the later stages. Plate 7, fig. 8, shows a spermatozoön. The existence of two classes of spermatozoa in this species is a possibility that can be inferred from the two distinctive ways by which spermatids differentiate from the auxocyte.

GENERAL SUMMARY AND COMPARISON

The principal points brought out in this study of spermatogenesis in these four groups of crabs are the following:

1. The lumen of the follicular tubule is lined by a single layer of cells. These cells are of three kinds: (a) the spermatoblasts; (b) the nurse cells; (c) the secretory cells.

2. The spermatoblasts (auxocytes) grow at the expense of the nurse cells and eventually develop into spermatozoa. The cells of the gonads of these four groups show discernible differences in size, form, and in their structural make-up. Generally, the spermatoblasts develop singly, but in some cases several cells may form into a group enclosed by a cyst. This group formation is called spermatocyst. Spermatocyst formation occurs quite commonly in *S. serrata* and its variety *paramamosain*, but quite rare in *S. tranquebarica*. It does not seem to occur in *S. oceanica* (*banhawin*).

3. The ways by which spermatids differentiate from the auxocyte differ in some broad aspects:

a. In *S. tranquebarica*, it proceeds in two ways:

(1) First, there is a pro-spermatid stage, which is characterized by the sloughing off of considerable amount of both cytoplasmic and karyoplasmic materials, leading to the formation of the definitive spermatid body. There is tetrad formation. The haploid number of chromosomes is six.

(2) Second, the nucleus, perhaps with a certain amount of cytoplasm immediately around it, differentiates into a spermatid. There is no tetrad formation and the haploid number of chromosomes is five. Therefore, the sperms of *S. tranquebarica* exhibit digamety.

b. In *S. oceanica*, spermatid formation proceeds in only one way. The auxocyte nucleus first splits into two spermatid nuclei; then each daughter nucleus reorganizes by incorporating some of the cytoplasm to form into a definitive spermatid body.

c. In the variety *paramamosain*, spermatid formation proceeds in a somewhat parallel manner to that in *S. tranquebarica*, in the sense that there are also two methods, namely:

(1) In one type, as in *S. tranquebarica*, there is a pro-spermatid stage; that is, the formation of the definitive body is preceded by gradual diminution of both the cytoplasm and nuclear materials.

(2) In the other type, the auxocyte nucleus differentiates as a body from the auxocyte by forming an active kinoplasmic area in which only a very limited amount

of the cytoplasm is incorporated. This active mass soon splits into two, forming two spermatids.

d. In *S. serrata*, spermatids may differentiate from the auxocytes by two methods: one resembles somewhat the mode of spermatid differentiation (only auxocytes without tetrad formation) in *S. tranquebarica*, but rather more abbreviated; this is rather obscure and needs to be studied further. The other method parallels that of *S. oceanica*, but in a fashion that is somewhat abridged and involves only considerably less cytoplasm.

(1) In the first case, the auxocyte nucleus is transformed into a spermatid through a process of differentiation and reorganization during which some of the materials are sloughed off. Apparently, if at all, only one spermatozoön develops from the auxocyte.

(2) In the second, the nuclear materials undergo a sort of realignment distinctly different in features from those observed in the first. The nucleus then divides into two spermatid nuclei, and each daughter nucleus reorganizes to form into a spermatid. Evidently, two spermatozoa are produced. Progressive heteropycnosis is a very conspicuous feature in this type of spermatid formation.

4. In all groups the main features of the transformation of spermatids to spermatozoa involve a series of processes of concentration, contraction, and diminution of both of the cytoplasmic and nuclear materials including other cellular bodies.

5. One main interesting feature involves the participation of the idiosome, the appearance and movement of the acroblast body tending toward the subsequent formation of the capsule.

6. The general form of the sperms is conical; the broad basal portion that holds the nucleus is the nuclear cup, the rim of the cup and the conical portion constitute the capsule. This latter is apparently composed of the idiosome which holds the non-chromophyllic "sphere-substance", and the acroblast material. The differences in size and in general outline between the spermatozoa of these four groups of crabs, and even between the spermatozoa of the same variety, are quite discernible. These differences, however, are hard to determine accurately due to several causes, such as: (1) the difficulty of getting accurate observation because of their being very minute; (2) the variable factors involved in staining and destaining, etc.

THE FEMALE ORGANS

The abdomen is broad and all the segments are freely movable, (Plate 1, fig. 4). There is a pair of appendages on each of

the second, third, fourth and fifth somites. The external genital apertures (Plate I. fig. 1, *g. o*) are a pair of large openings situated on the sternum of the sixth thoracic somite. The sterna are not so concave as those of the male, and the abdomen is not so closely applied to the thorax.

The ovaries (Plate 1, fig. 2) are paired, and lie in a position similar to that of the male reproductive organs. There is, however, a considerable posterior prolongation of each ovary. As in the male, the two anterior lateral portions are connected behind the pyloric foregut, the connection forming a sort of a bridge over the midgut. Behind this transverse connection, each ovary is prolonged backwards as a narrow strip extending to the extreme posterior end of the thorax, where they fuse together in mature specimens. These posterior extensions of the ovaries occupy a similar position to that of the vasa deferentia of the male; that is, they lie above the hindgut and below the pericardium. Beneath the anterior portion of the latter, each posterior branch is connected on its outer side with a large sac, the spermatheca (*spt*). This continues as a short oviduct which opens to the exterior by means of the vulva on the sternum of the sixth thoracic somite.

The seminal receptacle is composed of two parts, namely: (1) the glandular portion which is contiguous with the ovary, (2) the portion lined with chitin which is continuous with the oviduct. The oviduct (Plate 1, fig. 2, *od*) is chitinous, its terminal portion expanded to form a sort of funnel-like structure leading to the vulva.

The condition of the ovary depends upon the degree of maturity of the ova. When immature, the gonads are small and pale, and the presence of the eggs cannot be detected by the naked eye. But when mature, the gonads fill up almost the whole dorsal surface of the cephalothorax. They are orange-red and the eggs can be readily distinguished. The red color is due to the presence of a large amount of yolk.

The ovary is composed of numerous follicular tubules. When immature, the general outline in cross-section (Plate 1, fig. 3) is that of a triangle, with the apex fitting into the sterno-carapace angle. With the ripening of the eggs, the ovarian walls become very much distended; the outline of the gonads at this time becomes irregular. The gonads fill up the sterno-carapace angle and practically covering up the entire dorsal surface of the branchial region beneath the hypodermis. The follicles are no longer distinct; under the microscope, only some portions

of the follicular walls can be seen. The epithelial cells are obliterated; the gonads being filled up with compact masses of eggs.

The cavity of the follicular tubules (Plate 7, fig. 9) is lined by a single layer of epithelial cells. These cells may be grouped under four categories, namely: (1) ooblast; (2) nurse cells; (3) the secretory cells and (4) the auxiliary secretory cells.

The secretory cells.—Compared with those present in the testicular follicles, the ovarian secretory cells are generally bigger and more numerous. In a young ovarian follicle, there seems to be no marked differences between the principal and the auxiliary secretory cells, as both groups are vacuolated, the only difference being in the presence of a large vesicle in the former. This vesicle begins to enlarge (Plate 7, fig. 9, c. c), the enlargement seemingly correlated with the dissolution of the materials of the adjacent cells. In other words, the adjoining vacuolated cells act as auxiliary secreting cells by yielding their materials for the production of the metaplastm of the principal secretory cells. Presumably, there must be an enzyme the action of which is responsible for the conversion of cellular materials into secretory products. This metaplastmic product takes up a bluish color with iron-hæmatoxylin, acid-fuchsin and anilin stain combination.

OÖGENESIS

The oöblast (auxocytes) develop into eggs; that is, the epithelial cells metamorphose directly into ovocytes without division. The auxocytes can be easily recognized from the nurse cells by their relatively bigger germinal vesicles, and the presence of more cytoplasmic materials. In a young auxocyte, the cytoplasm is at first small in amount and simple in structure, seemingly consisting almost wholly of optically homogeneous hyaloplasm. As growth proceeds, the appearance becomes more or less alveolar, and there is an enormous increase in the amount of oöplasmic substance. In well-stained sections, streamers of both karyoplasmic materials and cytosome from the neighboring cells are discernible. The growing auxocyte does not only receive material contributions from the neighboring cells, but in some cases it engulfs a whole cell. Vestiges of such engulfed cells are quite apparent in some full-grown auxocytes.

The description above is based on the auxocytes of *S. oceanica* and those of *S. tranquebarica*. The auxocytes of the variety

paramamosain and especially those of *S. serrata* appear to be smaller and less alveolar; hence, they appear more compact.

The process of oögenesis parallels that of spermatogenesis to a certain extent. Both processes are featured by the growth of the auxocytes at the expense of the nurse cells; likewise, both germ cells undergo transformation at the termination of their growth period.

Oökinesis.—The amitotic oökinesis through which the ovocytes pass is apparently less complicated, compared with the changes that feature spermiogenesis. And, like the latter, the phases of transformation in each of the four groups differ in many aspects, some features being distinctive within the group.

OÖKINESIS IN *S. TRANQUEBARICA*

This proceeds in somewhat similar fashion as spermiogenesis with respect to the extent of the kinoplasmic area involved, namely: (1) in one type, the whole cell is actively involved; (2) in the other, only the nucleus and the area immediately around it participate actively. These two modes of oökinesis produce ovocytes that show differences in size, and also in the constitution of their chromosomes. The latter aspect, however, seems to be temporary in nature. These two forms of ovocyte are referred to as the macro and the micro-type.

The following figures illustrate some of the characteristics that feature the development of the macro-ovocytes.

Plate 7, fig. 10, shows the surface view of two developing auxocytes and Plate 7, fig. 11, represents one from the cross-section of a follicular tubule. The disorganized state of both the cytosome and the nuclei of the nurse cells is an indication that some of their materials are being absorbed by the growing auxocytes.

Plate 8, fig. 1, represents an ovocyte at the termination of the growth period. The germinal vesicle has grown to almost four times its original size. It seems to be in the zygotene stage. The pairing of the spireme is quite obvious. Around the germinal vesicle, roughly in the form of a horse-shoe, is the pallial layer, or vitellogenous mass (*v*; also Plate 12, fig. 4). The Golgi-bodies are seen as the heavily stained masses scattered in this layer. Vestiges of a nurse cell are discernible.

In Plate 8, fig. 2, the size of the ovocyte and its germinal vesicle has decreased considerably. Perhaps this is because of the contraction and the subsequent sloughing off of some of the cellular materials. The condition of the germinal vesicle is apparently that of the pachytene stage, some pairs of spireme

having fused and became thicker threads. The tetrad formation is evident in both Plate 8, figs. 1 and 2, as shown by the alignment of chromatids into groups of four. The vitellogenous layer is no longer present, but instead, irregular spherule masses that stain quite deeply at the periphery are scattered in the cytoplasm. Presumably, these masses foreshadow the formation of yolk-masses that develop later. Apparently these masses became finely disseminated through the oöplasm, since they do not appear in the stages immediately following.

Plate 8, fig. 3, shows the chromosomes scattered in the homogeneously diffused karyoplasm. There are apparently twelve, excluding the supernumerary ones. The masses containing deeply stained bodies are presumably composed of extruded nuclear materials and some Golgi-bodies. The XX-pair (*h*) is conspicuous. Apparently the germinal vesicle is undergoing an unequal division, leading to the formation of the first polar body; and the extrusion of some nuclear material takes place simultaneously.

Plate 8, fig. 4, shows an ovocyte with the polar nucleus being extruded out, together with some cytoplasmic material. It is in the contraction phase.

It seems that the ovocyte after the extrusion of the first polar body either goes through a temporary resting stage (Plate 8, fig. 5) or proceeds in its development. The latter case is indicated in Plate 8, fig. 6. The formation of chromatids in groups of twos indicates the dyad formation and their alignment with respect to the other pairs implies that they are in parasynaptic association. The six chromatids in a circle compose the heterochromosomes (*h*), the XX-pair in this case, since they are more or less alike. The monosome (*m*) is shown as a heavily stained body close to the nuclear wall.

Plate 8, fig. 7, shows the chromosomes prior to the second meiosis. The hetero-chromosomes (*h*) are easily recognizable, as is the monosome (*m*) which has no pair. Presumably the clear area in the vicinity of the germinal vesicle is the attraction sphere (*a. s*) and the two slightly stained masses within are the division centers (centrioles).

It can be inferred from Plate 8, figs. 7 and 8, that the formation of the second polar body apparently proceeds in this manner: (1) the division centers move apart, followed by the constriction of the attraction sphere; (2) the nuclear materials then become disseminated around the two division centers and

(3) around each division center a nucleus is reformed. One will become the second polar body.

In Plate 8, fig. 9, the two daughter nuclei have separated; evidently the smaller is the second polar body (*p. b*₂). In the subsequent contraction, these two bodies are pulled apart (Plate 8, fig. 10). The second polar body is distinctly recognizable by the presence of several chromatids that are irregularly disposed. The egg nucleus is bigger, with the chromosomes aligned along the nuclear wall. The expulsion of the polar nucleus will probably take place at the termination of the contraction phase.

The division that has taken place cannot be considered as an equational, but reducing division, since qualitatively dissimilar halves are produced. The first polar division may also be so characterized. Hence, the maturation division in this crab is an exception in the sense that ordinarily one maturation division is supposed to be equational and the other reductional.

Oökinesis in the micro-type.—The mode of oökinesis that leads to the formation of the micro-ovocytes is seemingly less involved, but the changes are rather obscure. The activity appears to be localized in the germinal vesicle, involving only that portion of the cytosome immediately around this body. In other words, the kinoplasmic area includes only these portions of the auxocyte.

From Plate 9, figs. 1 and 2, we can infer that at the termination of the growth period, the germinal vesicle with some portion of the cytosome differentiates as a body from the auxocyte to form the ovocyte. In this mode of oökinesis, there is seemingly an attempt at shortening the process of transformation.

Plate 9, fig. 1, shows an ovocyte that has differentiated from the auxocyte, with the first polar body (*p. b*₁) already formed. The deeply stained bodies scattered in the cytosome are probably Golgi-bodies.

In Plate 9, fig. 2, the polar nucleus is already extruded. Evidently the number of chromosomes is six, but they are bivalent. The heterochromosome (*h*) is easily recognizable, being the biggest and broadly V-shaped.

The second polar body.—The formation of the second polar body in the micro-ovocytes takes place after the completion of the growth period and after the sperm has penetrated into the germinal vesicle of the ovum. This fact is borne out by the presence in the ovary of full-grown crabs of germinal vesicles which are about twice as big as the germinal vesicles of the other groups. Plate 10, figs. 1 and 2, show the relative sizes of the

germinal vesicles of the two classes of ova, the macro-ovum and the micro-ovum, respectively. The dyad formation is still recognizable in Plate 10, fig. 2. Another evidence is seen in the presence of polar bodies still attached to the eggs that are already glued to the endopodite setæ (Plate 13, fig. 2). Since the eggs are already in advanced stages of development, it is quite apparent that the formation of these polocytes must have taken place in already mature eggs, or perhaps even later when these eggs are already outside the body and undergoing cleavage.

Quite frequently some protozoa, especially stalked ciliates, attached themselves to the eggs. Their reaction to the fixatives is to contract and round up; hence, they are likely to be confused with the polar bodies. They can be distinguished easily, however, by their elongated and deeply stained nuclei; while the polar bodies have clear nonstaining rounded vesicles, and in most cases, the protoplasmic connection between a polocyte and an ovum is still visible.

THE MATURE OVUM

From the time of the formation of the polar nucleus the egg increases immensely in size, from about 29 microns to over 266 microns in diameter. Undoubtedly this great increase in bulk represents a considerably long period of growth. Plate 8, fig. 10, and Plate 9, fig. 3, give a comparative idea regarding the increase in bulk of the ovum.

The appearance becomes alveolar because of the presence of closely crowded yolk-spheres suspended in the hyaloplasm, in which also lie numerous smaller granules of various kinds, some fatty materials and pigment granules. The ovary then becomes more compact and assumes a bright orange-red color and there are no longer recognizable traces of either the secretory or the nurse cells. These cells which originally constitute the main bulk of the follicle must have been used up to furnish materials for the growth of the ova.

The position of the germinal vesicle is invariably near the center, in the young ova and also in older ones which happen to be free from pressure. In closely crowded ova, the germinal vesicles become eccentric in position. The wall of the germinal vesicle is generally distinct in most places, except at points where it merges with the cytoplasm and from which radiating protoplasmic streamers branch outward to the peripheral cytoplasmic layer (blastema) around the egg. These

protoplasmic strands course deviously through the spaces between the yolk-spheres, and they form the connecting links between the germinal vesicle and the rest of the egg. The eggs are distinctly centrolecithal.

The foregoing description is based upon the eggs of *S. tranquebarica*.

OÖKINESIS IN *S. OCEANICA*

There is only one mode of oökinesis in this species. It proceeds in a manner somewhat similar to the mode of oökinesis that produces the micro-ovocytes in *S. tranquebarica*. There are distinct differences, however, as follows: (1) the bulk of the auxocyte; the first polar body (*p. b*¹) is already expelled. atively much greater in the auxocytes of *S. oceanica*; (2) hence, the ovocytes that develop are relatively bigger (Plate 9, fig. 2, and Plate 10, fig. 8); and (3) the formation of the second polar body follows immediately that of the first polocyte. In contrast with *S. tranquebarica* which exhibits sexual dimegaly, *S. oceanica* produces only one class of eggs.

Plate 10, fig. 7, shows an ovocyte that has differentiated from the auxocyte; the first polar body (*p. b*¹) is already expelled. The chromosomes are apparently getting into the diffused condition. Within the germinal vesicle are two "intra-nuclear division centers" (*i. dc*), one of them apparently moving toward the periphery. Presumably this foreshadows the formation of the second polar body. A feature of the process is shown in the other ovocyte, where the attraction sphere or portion of it is now seen outside the germinal vesicle. Apparently the second meiosis, or formation of the second polar body, takes place by the flowing out of some nuclear materials into that portion of the attraction sphere outside the germinal vesicle. Evidence that such actually happens is the presence of two division centers in an older ovum (Plate 10, fig. 8, *i. dc.*, *e. dc*)—one intra-nuclear, while the other is extra-nuclear. It seems that in this case the materials which had been withdrawn from the germinal vesicle supposedly to compose the materials of the second polar body were not cast off, but are disseminated within the ovum. Obviously, both maturation divisions in this group are reductional, as in *S. tranquebarica*.

Plate 10 fig. 8, and Plate 11, fig. 1, show the young ova in different phases of growth. In the first, the nuclear framework, that is, the nuclear wall and the network, are still well defined. In the other figure, the network has disappeared;

the germinal vesicle has increased considerably in size and so has the bulk of the cytosome. A spermatozoön (*sp.*) has penetrated into the cytoplasm.

Plate 11, fig. 2, is a photomicrograph of a large portion of a mature ovum. The yolk-spherule masses of various sizes appear as black. Within the germinal vesicle, the sperm can be seen as a black mass. A line is drawn to mark the boundary of the ovum and that of the adjoining one.

OÖKINESIS IN PARAMAMOSAIN

In this group, two classes of ovocytes are produced. As in *S. tranquebarica*, they are designated as the macro- and micro-ovocytes. In *S. tranquebarica*, however, the features of the changes that lead to the differentiation of these two classes of ovocytes from their respective auxocytes differ markedly.

In the *paramamosain* the general nature of the changes is somewhat closely identical. The two classes of ovocytes differentiate from their respective auxocytes in about the same manner; in both, some kind of reorganization takes place in the nucleus, resulting in the sloughing off of some of the nuclear materials. Then, the remaining nuclear portion, together with a certain amount of cytosome, reorganizes to form the ovocyte. There are, however, features, that distinguish the two classes of ovocytes: (1) the marked difference in size between the respective auxocytes including their nuclei; (2) the amount of cytosome involved, and the consequent difference in size of the ovocytes that develop, Plate 11, fig. 5, and Plate 12, fig. 3; (3) in the micro-ovocytes, the sloughed off materials form a mass, presumably forming the polar nucleus, Plate 12, fig. 3, *p.n.* This condition does not seem to be the case in the macro-ovocytes, wherein the sloughed off materials, apparently disseminate in the cytoplasm and presumably contribute to the materials of the ovocyte. Some of the characteristic features are shown in the following illustrations.

Plate 11, fig. 3, shows a full-grown auxocyte (macro-class), apparently in the contraction figure or synizeis. In this case, the leptotene-threads do not seem to show any tendency towards definite polarization, while the chromatids appear to shift. A conspicuously large centrosome (*c*) with some centroplasm lies above the nucleus.

Presumably the above condition is followed by the diffused stage, Plate 11, fig. 4. This is characterized by more or less diminished basophily and a loosening of the threads, which have

become more or less deconcentrated. It seems significant that the prochromosome threads are still distinguishable and that they are distinctly double, the halves or the pairs being widely separated. The tendency towards polarization is shown in the nucleus, which is divisible into two zones, namely: (1) the portion adjoining the centrosome wherein the materials are completely diffused and (2) the other portion holding the pro-chromosomal threads which run towards the opposite pole. Obviously the materials within the completely diffused area are being disseminated into the cytoplasm. In other words, the nuclear elements are undergoing reorganization preparatory to the differentiation of the ovocyte.

Plate 11, fig. 5, shows the second synizesis or contraction-figure. The nuclear substances are again concentrated in some degree. A similar change is also taking place in the cytoplasm. Apparently, the chromatids are being set in their alignment. One significant feature is the diminished size of the centrosome, compared with that in the preceding stages. The definitive form of the ovocyte is presumably attained at the completion of this phase.

The differentiation of the micro-ovocyte proceeds in a somewhat similar fashion. Plate 12, fig. 1, shows a micro-auxocyte in the contraction figure, or synizesis. The nucleus shows distinct polarization, the materials in the region adjoining the centrosome are more diffused; these materials are apparently drawn to this zone, the threads which are rather rough in outline are directed towards the centrosome. In the opposite pole, however, the threads are thinner and the chromatids are apparently being shifted. The nuclear figure may be regarded as similar to the so-called "amphitene" phase of some authors if polarization and the formation of two types of threads are taken as the sole bases. The case seems to be different, however, in the sense that the formation of the thicker threads is due to the crowding of nuclear materials preparatory to their being sloughed off.

Further contraction results in another contraction-figure, or synizesis, Plate 12, fig. 2. On the side adjoining the centrosome, a portion is pinched off from the main nuclear body. The shifting of the centrosome towards the apical region of the differentiating ovocyte seems to be associated with the somewhat abortive nuclear division. Apparently the segregation of nuclear materials is taking place; the pro-chromosomal

threads are shown radiating from the condensed, deeply stained mass located at the place of division.

In Plate 12, fig. 3, the micro-ovocyte is shown to have completely differentiated from the auxocyte body and the two nuclear portions have also separated, the smaller one (*p. n.*) presumably representing the first polar nucleus. It appears to be within the centrosome. Whether the micro-ovocytes develop into functional ova is yet to be determined. There are indications to the contrary.

A photomicrograph (Plate 12, fig. 4) of a portion of the ovary shows that some of the developing ova appear to be stunted (*mi*); presumably these are some of the micro-ovocytes. Some sperms (*sp*) may be seen outside the eggs; one (*sp₂*) is shown as having penetrated into the cytoplasm of a growing ovum and another (*sp*) may be seen already inside the germinal vesicle. The heavy black ring that partially surrounds the germinal vesicle represents the vitellogenous layer, or pallial substance. It is apparent that in these crabs insemination may take place even before the ova become full-grown.

OÖKINESIS IN *S. SERRATA*

The following illustrations are taken from the sections of the ovary of a young female, which measures 7.7 cm. across the carapace. The color of the ovary is orange, and from all appearances, it looks normal like the ovaries in mature females. The cells appear to be developing normally. It is rather doubtful, however, whether the eggs can be fertilized in this stage; there are apparent obstructions in the form of the deep sternal concavity which partly hides the rather too small opening of the vulva.

In this species, the process of oökinesis proceeds in a manner not very much different from that in *S. oceanica*. In both species, the differentiation of the ovocyte takes place simultaneously with the diminution of the nuclear materials and the formation of the first polar body.

Plate 12, fig. 5, shows an auxocyte after the growth period. It presents a contraction-figure, or synzinesis. Some of the threads radiate from the condensed heavy mass at the center, while those that are close to the border form loops.

In Plate 12, fig. 6, the ovocyte has differentiated from the auxocyte body; the polar nucleus (*p. n.*) and some nuclear materials have been extruded. The quadripartite constitution of the chromosome-nucleolus, which is presumably the X-chro-

mosome, is distinctly shown. The prochromosomal threads are apparently undergoing realignment.

Plate 12, fig. 7, shows an ovocyte where concentration and contraction processes are apparently going on. The first polar body (*p. n*) is still embedded in the cytoplasm. The centrosome (*c*) with some centropiasm is distinctly visible.

Plate 12, fig. 8, shows a contraction phase and the sloughing off of some cytoplasmic materials. The two polar bodies are still within the ovum.

The form, size and character of the chromosomes are shown in Plate 12, figs. 9 and 10; the X-chromosome, or chromosome-nucleolus, is quadripartite.

SUMMARY AND COMPARISON

The principal points in oögenesis may be summarized as follows:

1. The auxocytes (oöblasts), after a period of growth characterized by a greatly increased bulk at the expense of the nurse cells, metamorphose directly into ovocytes.
2. At the termination of the growth period, the auxocytes undergo transformation. The process is characterized by features that are quite distinctive for each group.
3. In *S. tranquebarica*, oökinesis proceeds in two distinct ways: In one type, the differentiation of the ovocyte from the auxocyte involves practically the whole cell. In the other the kinoplasmic area includes only the germinal vesicle and a very limited portion of the cytoplasm around it. In other words, the rest of the cell does not participate actively. Consequently, two classes of ovocytes are formed, namely: the macro-ovocytes and the micro-ovocytes. The macro-ovocytes complete the maturation period earlier; the formation of the second polar body follows immediately that of the first polocyte. The oötid then proceeds to grow into mature ovum. In the micro-ovocyte the formation of the second polar body takes place when the ovocyte has become full-grown ovum, and after insemination has taken place. There is no corresponding oötid formation, and it seems that the penetration of the sperm into the germinal vesicle is necessary before the formation of the second polar body can take place. Throughout the period of growth to the time of the formation of the second polar body, the number of chromosomes is six, but they are bivalent. The chromosomes become univalent after the formation of the second polar body. Apparently, the eggs of *S. tranquebarica* exhibit sexual dimegaly.

4. In *S. oceanica* (*banhawin*) the formation of the first and second polar bodies seems to run parallel with the differentiation of the oötid from the auxocyte. Only one class of eggs is produced.

5. The *paramamosain* variety has more in common with *S. tranquebarica* in the sense that both groups produce two classes of ovocytes. One main difference between them lies in the fact that the micro-ovocytes in *paramamosain* do not appear to develop into normal eggs, in *S. tranquebarica* the two classes of ovocytes develop into functional ova.

6. The process of oökinosis in *S. serrata* has much in common with that in *S. oceanica*; in both the differentiation of the ovocyte from the auxocyte takes place in conjunction with the formation of the polar bodies. Both produce only one class of eggs; that is, they do not exhibit sexual dimegaly.

FERTILIZATION

During copulation the spermatophores are transferred from the vas deferens into the vulva of the female and into the spermatheca where they are stored. By some means the spermatophores find their way into the lumen of the ovarian tubules, where the spermatozoa are released from the enclosing capsules.

If a crushed portion of a fresh testis is examined under the microscope, the material has the appearance of an alveolar substance containing numerous globules of various sizes. The bigger ones, which vary considerably in size, are probably fat globules. The spermatozoa appear as very minute globular bodies resembling cocci bacteria, except that they show some sort of oscillatory movement. The tapering conical portion of the sperm body is not visible except in stained sections.

The relation of the spermatozoa to the eggs taken from the lumen of the ovary of a *parabanhawin* (*S. tranquebarica*) is shown in Plate 8, fig. 11; Plate 9, fig. 3; Plate 10, figs. 1 and 3, also in Plate 12, fig. 4, which is a photomicrograph of a portion of the ovary of a *paramamosain*.

I cannot state definitely how the entrance of the sperm into the ova is effected in these crabs. Investigators on other crabs differ in their observations. Koltzoff (1906)¹² claimed that in certain decapods, the spermatozoa settle on the eggs with the clear cup towards the egg and the capsule pointed away from the egg. He believed that the rebound from the explosion of the capsule is sufficient to drive the nucleus into the egg.

Binford (1913)² observed that in *Menippe mercenaria* the entrance of the sperm into the egg is effected by the turning

inside out of the tubule and capsule. According to him, the nucleus does not even enter the egg; hence, it does not participate in the process of fertilization. The fact that the nucleus holds the chromosomes regarded to be the bearer of paternal qualities to the egg, and hence, are the essential thing in fertilization, he tried to reconcile by assuming that during the transformation of the spermatid, the nuclear material, at least the chromatin, is transferred to the capsule. He said: "the contents of the capsule may be derived from the nucleus of the spermatid and is probably oxychromatin which deposits basichromatin after it enters the egg and so gives rise to the chromosomes of the male pronucleus".

In the present crabs the whole sperm enters the egg, and both nuclear cup and capsule play important rôle. But the mode of penetration and the dynamics involved are problems that need further study. It seems that some kind of an eversion which is explosive in nature takes place, whence the nuclear cup is turned inside out. This is suggested in Plate 8, fig. 11, and Plate 10, fig. 3.

Insemination.—This process may take place as early as during the early part of the growth period of the ovum (Plate 8, fig. 11, and Plate 11, fig. 1) or later, when the egg has attained its full growth (Plate 9, fig. 3). The eggs are relatively so large and opaque and the spermatozoa so very minute that it is impossible to observe the actual process. Inference can merely be made only from a study of a series of sections of the fertilized eggs.

By some means a sperm finds its way into the germinal vesicle, where the penetration path is discernible, but the path through the yolk-laden cytoplasm is entirely obscured. There is no actual bodily fusion between the male and the female pronuclei; that is, they do not unite to form a single nucleus, or conjugation nucleus.

CHANGES IN THE GERMINAL VESICLE

The following description is based upon the eggs of *S. tranquibarica* (*parabanhawin*).

The enormous increase in the size of the ovum is accompanied by that of its germinal vesicle. Two classes of ovocytes previously referred to as macro- and micro-ovocyte were observed in *parabanhawin*. The germinal vesicle in the micro-ovocyte is enormously big, compared with that in the macro-ovocyte (Plate 10, figs. 1 and 3). The general framework of the germinal vesicle of the micro-ovocyte is distinctly oxyphilic; the

framework constitutes the major part and there is a decided tendency for the chromatin materials to collect at the periphery (Plate 10, fig. 2.)

After the entrance of the sperm, the germinal vesicle begins to fragment (Plate 10, figs. 3, 4); the karyoplasm becomes organized into karyomerites (*k*) and karyomicrosomes (*m*), or nuclear microsomes. The former are masses of karyoplasm containing chromosomal elements, while the latter are only granular masses or karyoplasm. These masses stream out of the germinal vesicle (Plate 10, fig. 4); hence, the germinal vesicle gradually becomes smaller and smaller and finally disappears entirely.

The tendency of the chromatin materials to align at the periphery of the germinal vesicle (Plate 10, fig. 2) assumes added significance if coupled with the apparent polarity of the formation of karyomerites (Plate 10, fig. 3, *k*). Presumably these phenomena are associated with the formation of the second polar body and may be regarded as phases leading to the segregation of the potential functional pronuclear elements from those which are to constitute the materials of the second polar nucleus. The following events seem to support this idea:

At about the time the germinal vesicle is reduced to about half its original bulk, resulting from the extrusion of the karyomerites and nuclear microsomes, the remaining part begins to differentiate into two portions. One of these portions eventually segregates and becomes the second polar body. The framework of this portion is deeply oxyphilic and appears more homogeneous than the other portion. In this latter, there are indications that the process of fragmentation is proceeding, because its wall is indistinct; the ground substance merges with the outlying materials which are largely composed of minute masses similar to those present within this body and in the karyoplasmic streamers. Eventually this portion disappears as a body, leaving in its place a homogenous granular mass. A number of masses similar to this is scattered in various parts of the egg. They are obviously cytoplasmic masses together with some nuclear materials (karyo-cytoplasmic masses.)

The formation of the second polar body in this type of eggs (micro-ova) may be summarized as follows: The potential formative pronuclear elements are sorted out in the germinal vesicle through the operation of agencies which are not known. The entrance of the sperm into the germinal vesicle initiates

the movement of the karyomerites and karyo-microsomes out from the germinal vesicle, and when the latter is reduced to about half of its original bulk, it splits into two portions. One of them becomes the second polar body, the extrusion of which from the egg takes place presumably during cleavage.

CHANGES IN THE YOLK

The yolk-spheres (Plate 9, fig. 3) appear at first as more or less homogenous masses, commonly bearing some pigments. The homogenous aspect of the spheres is transformed later to that of a vacuolated appearance, becoming divided into separate masses of deeply staining materials and interspersed by non-staining areas. They soon break up into smaller vacuolated bodies, which then gradually break up into small granular masses. Finally, the oöplasmic framework in the egg appears to be divided into somewhat homogenous blocks, separated by faintly staining to nonstaining lines. These lines presumably represent the protoplasmic strands that radiate from the center of the egg to the superficial cytoplasmic layer, the blastema. It is along these somewhat clear spaces that active formation of protoplasmic islands takes place during cleavage and, consequently, where the active assimilation of the yolk is going on. Along some of these areas are formed the secondary cleavage of some authors.

SPAWNING

When a crab is ready to spawn, she raises her body and assumes an upright position holding the abdomen away from the body; the abdomen together with the exopods form a sort of a basket into which the eggs are run. The eggs become attached to the setæ of the endopodites, where they pass their embryonic stages.

According to the observation of Mr. Arriola (1940), these crabs spawn throughout the year, the peak of activity falling between May and September. This observation was made at the Experimental Station of the Division of Fisheries at Dagat-dagatan, Malabon, Rizal Province. My observations on the conditions of the gonads of crabs dissected during different months of the year corroborated Arriola's findings.

That the period of the peak of spawning activity may vary perhaps slightly in different regions of the Philippines is probable. For example, in Dumangas, a town in Iloilo Province noted for the abundance of *alimango*, the season of highest

spawning activity appears to be between August and November. During the intervening period, crabs with gonads full of eggs are sold abundantly in the markets.

Mr. Arriola (1940, p. 443)¹⁰ presumed that the crabs die shortly after laying one batch of eggs. The presumption is based on the behavior of his specimens, which were kept in floating cages. I can not entirely subscribe to his view. In the first place, it should be borne in mind that the crabs are distinctly bottom-dwellers and fossorial in habit. The *mamosain*, for instance, live in burrows, while the others live concealed in mud-holes and under shelter among heaps of debris. By placing the animals in floating cages, he subjected them to unnatural conditions. Certainly, it is not safe to draw conclusions purporting to be the same with what is expected to happen under natural conditions, especially when the experiments were performed under conditions at variance with the natural setup wherein the animal thrives favorably.

In the second place, his assertion does not seem to find support from facts observed under natural conditions. According to his observations, these crabs attain sexual maturity when they reach the size of about 84 by 122.5 mm. across the carapace. Possibly, his specimen must have been a true *banhawin*, for I had in my collection a berried *parabanhawin* that measures only 100 mm. across the carapace. From the studies on the sections of ovaries and testes from crabs of different sizes, I found female crabs of 90 mm. across the carapace already with mature gonads. Nevertheless, just for the sake of having something to base on, let us take 84 by 122.5 mm. as the size at which some of these crabs attain sexual maturity. What can we say of some female crabs reaching the size of 200 mm. or 225 mm. across the carapace? Big crabs of these sizes are not very rare. Certainly, we cannot say that these crabs had not spawned previously.

Egg membrane.—Upon reaching the exterior, each egg is surrounded by two membranes: the vitelline (or fertilization) membrane and the chorion. Between these two membranes is a perivitelline space which, according to Williamson,¹¹ contains a fluid possessing adhesive properties. Microscopic studies made on stained sections of both ovarian eggs and on eggs already attached to the endopodite setæ did not reveal any indication of the presence of this fluid. On the other hand, the two membranes are intimately fused in some places, though

generally the two membranes show separately (Plate 13, fig. 1 and Plate 14, fig. 1).

How the eggs of crabs become attached to the endopodite setæ is a question that has not been satisfactorily answered. Some of the earlier observers believed that a sticky substance is secreted around the eggs as they are shed. The objection to this theory is that it does not explain why the eggs become attached only to the endopodite setæ. The view given by Herriek (1895) is that the tegumentary glands of the endopodites of the pleopods secrete an adhesive fluid. However, there are physical aspects which this theory implies that cannot be explained. In the first place, if the eggs became attached as they came in contact with the surface that secreted this adhesive fluid, then some of the eggs should adhere to the endopodite itself. This does not seem to happen, however. In the second place, there are possibilities for the eggs to become attached together in groups around a point. This does not seem to happen either. There are other aspects that point to the unacceptability of the premise.

A different theory is suggested by Williamson. He explains that the endopodite setæ penetrate the chorion of the egg in two places, and thus the egg becomes skewered on the seta. The piercing of the chorion liberates the adhesive perivitelline fluid which assists in making the attachment more permanent, and the egg appears to be attached to the seta by a stalk.

Williamson's theory implies two things: (a) either there must be some kind of a guiding mechanism that enables the seta to pierce the egg in two places or (b) this piercing takes place merely by chance. Since the setæ are very fine and long, they must be in motion constantly, moved by the water currents which must be especially active at the time the eggs are being extruded. The extrusion of the egg itself will cause some water movements. No such mechanism implied in the theory can operate under such conditions. If the piercing of the chorion is just a matter of chance, then the probability is that many of the eggs will be lost, if not the majority of them. Sometimes the number of eggs attached to a seta reaches a hundred or more; the eggs are ranged from the base to the tip of a seta. This condition cannot be possible with the mechanism implied in the theory. Moreover, Williamson's idea about the presence of an adhesive perivitelline fluid is not supported by the findings from cytological studies.

The most plausible explanation seems to be that a sticky substance is secreted around the eggs as they are shed. To the question as to why the eggs do not become attached to the exopodite setæ, the following answers may be given:

(1) The topographical position of the exopodite setæ, their being on the outside, reduces the chances for the eggs to become attached to them.

(2) The eggs on being released outside, first come in contact with the endopodite setæ, which are so thick that they form a sort of an impenetrable barrier. Their tangled mass affords the eggs all chances of becoming attached, and at the same time help keep them within the confines of the entanglement.

(3) The structural make-up of the exopodite setæ and their peculiar arrangement render them less adapted for the attachment of the eggs. They are shorter and finer, and possess side branches (Plate 1, fig. 5, *b*). These branches interlock forming a more or less compact surface, and together with the broad expanded surfaces of the exopodite stalks, a sort of a wall is formed, guarding the sidespaces between the sternal wall and that of the abdomen, when the latter is drawn away from the cephalothorax during the act of spawning. In other words, a sort of basket is formed with the abdomen serving as the bottom and the exopodite stalks and their setæ form the wall. One has only to see a berried crab in order to form an idea, that the exopodites and their setæ are structural devices adapted to act as barriers.

There are other factors that prevent the eggs from attaching to the exopodite setæ, namely: (1) the mobility of the exopodites due to their being loosely joined at the basal segment and (2) the water current. The current set by the movement of the water as it is drawn into the inhalant chamber glides down the sternal wall; its impact upon the broad expanded surfaces of the exopodites spreads the latter outward. The eggs as they glide down within the sternal concavity also produce some water movement. Cross-currents are then produced within the sterno-abdominal space. The interplay of the currents helps to prevent the eggs from attaching to the exopodite setæ and at the same time keeps them within the confine of the sterno-abdominal space amongst the endopodite setæ. The water current also keeps the eggs apart from one another and sets them in motion amongst the setæ until they become at

tached. It is surprising to note that the eggs do not become attached to one another.

The adhesive fluid by means of which the eggs become attached to the endopodite setæ is produced by the secretory cells (Plate 7, fig. 9, c, c) of the ovarian follicles. This substance was previously referred to as something collagenous in character. While on their way to the outside, the eggs become coated with this substance which enables them to adhere to the endopodite setæ with which they come in contact. The stalk with which an egg appears to hang on a seta presumably is formed in this manner: the weight of the egg stretches out a portion of this sticky substance and in the meanwhile the action of the water gradually hardens it. Microscopic studies on stained sections of the eggs reveal the presence of a layer of this material around the chorion, and this layer is continuous with the material that forms the stalk (Plate 14, fig. 1, st).

DEVELOPMENT

The development may be divided into three stages, namely embryonic, larval and postlarval.

The embryonic development takes place while the egg is attached to the pleopods of the mother. Since the embryonic stage has not been observed in the present study, an attempt will merely be made to give a fragmentary sketch.

Cleavage.—The entrance of the sperm into the germinal vesicle initiates radical changes in this body. It begins to fragment into karyomerites and karyomicrosomes (Plate 10, fig. 3). In the meantime the sperm body also begins to undergo reorganization inside the germinal vesicle. It becomes vesicular and then begins to fragment into karyomerites (Plate 10, figs. 1, sp). In this fragmentation process, the idiosome (attraction-sphere) seems to play a very important rôle. It should be recalled in this connection that the idiosome and the acrosome materials form the capsule of the sperm. The fragments of the sperm together with those of the germinal vesicle stream out and this process continues until the germinal vesicle disappears as a body.

The fragments from both the sperm and the germinal vesicle find their way into the cytoplasmic areas scattered amongst the yolk masses. Presumably it is within these cytoplasmic areas where the paternal and maternal elements come into intimate association and where the male and the female pronuclear elements do actually unite.

It is then apparent that syngamy does not take place by the direct bodily fusion of the egg and sperm nuclei; it is effected in a somewhat diffused manner by the fusion of their essential fractional units (karyomerites) in the karyo-cytoplasmic areas. Each zygote-karyomerite resulting from this fractional syngamy seems to influence the active changes that take place around its immediate vicinity.

Starting from those located near the center of the egg, profound changes then take place in the karyo-cytoplasmic areas. They soon begin to form into more or less separate irregular masses, into a number of nonstaining areas, each surrounded by protoplasm; these are the so-called "protoplasmic islands". Some authors consider the protoplasmic islands as cleavage cells, although they are not cells in the sense compared to other types of segmenting eggs. By continuous division, they approach the periphery of the egg and finally unite with the superficial cytoplasmic layer (the blastema). Then the cytoplasmic boundaries become visible and the layer becomes a blastodermic epithelium—the layer assuming the appearance of being divided into plasma blocks (Plate 13, fig. 1). Since the divisions do not extend through the yolk, cleavage in this crab is distinctly superficial.

In each plasma block there is generally present in stained sections a big, heavily stained mass. The presence of this peculiar structure indicates that the blocks are really syncytial masses of cytoplasm and chromatin materials, and possibly including some pigments and other oöplasmic substances. The absence of protoplasmic islands in the vicinity of the heavily stained mass, in sharp contrast to the presence of several of them in blocks that do not contain darkly stained masses, seemingly supports this view.

The term "protoplasmic island" in this sense merely purports the presence of nuclear materials in a mass of cytoplasm, rather than the existence of fully formed nucleus, since its formation is traceable to the inflow of karyomerites of both the sperm nucleus and those of the germinal vesicle into the cytoplasmic area amongst the yolk-masses. The view will hold, if we conceive the idea that these nuclear fragments become reorganized into full-fledged nucleus within the cytoplasmic mass. This idea, however, recognizes total potentiality of a portion (the karyomerite) to reproduce the whole chromosomal complements of a cell. This contravenes the established idea regarding the individuality of chromosomes since a karyomerite is only a fractional portion of a nucleus.

Presumably, what takes place in a cytoplasmic mass is that a karyomerite from the sperm nucleus unites with one from the germinal vesicle of the ovum to form a zygote-karyomerite. This zygote-karyomerite soon undergoes a series of divisions forming a number of daughter karyomerites which then undergo reorganization and become what we may regard as "protoplasmic islands." The formation of plasma blocks may be interpreted as a phase tending toward bringing together what had been scattered before through nuclear fragmentation. In other words, the chromosomal complement that each karyomerite is supposed to carry must be brought together with those borne by the other sister karyomerite before the organization of the nucleus of a cellular unit can proceed; that is, in some sort of a reassociation. The plasma block was previously referred to as a syncytial mass of cytoplasm, chromatin elements, and possibly with some oöplasmic and other materials. The formation of a number of cells from each block in the later stages of development seems to bear out this inference—that the reorganization taking place within the blocks is a counterphase leading to bringing about nuclear reconstruction, and foreshadowing the formation of definitive cellular units.

Some investigators regard the nuclei (karyomerites in this case) that remained in the yolk as "vittelophags," because they assume the special function of the assimilation of the yolk. Around these vittelophags some incomplete boundaries are formed giving rise to what may be called secondary yolk-cleavage. The vittelophags are regarded by some authors as endoderm, and some investigators have described superficial cleavage as leading directly to the formation of a gastrula-like stage, since two kinds of cells, ectodermal and endodermal, develop about the same time.

Some authorities classify superficial cleavage into two groups: (1) cleavage at first total but later superficial; (2) cleavage purely superficial. Both groups may again be divided into two subdivisions, namely: (a) the blastomeres forming on all sides simultaneously and (b) the blastoderm in the ventral side developing precociously.

Cleavage in these crabs (*S. tranquebarica*) is purely superficial, and may be classed under the second subdivision; that is, the blastoderm in the ventral region develops precociously (Plate 13, fig. 2). The character of the cleavage is determinative; that is, the cytoplasm of the egg and the regions are clearly organized in relation to their future destiny.

The egg is ovate in outline, the narrower end being the future anterior part of the body. There seems to be more cytoplasmic masses in the presumptive ventral side, but fewer yolk-masses; whereas, in the presumptive dorsal side the yolk-masses appear to be more numerous. Perhaps the precocity in the development of the ventral side can be attributed to the presence of more cytoplasmic masses, in which region the process of development is less hindered by the yolk material.

MOVEMENTS OF PARTS DURING DIFFERENTIATION

The movements of protoplasm are quite discernible and at least from the mechanical point of view they may throw some light on certain features of development.

The ovarian egg has its cytoplasm in a delicate superficial layer (blastema) and in numerous delicate intravitellar strands connecting this with the cytoplasmic layer around the adcentral germinal vesicle. In some places among the yolk-spheres, the cytoplasm collects in masses forming what we may term "cytoplasmic areas." These partake the nature of outposts where the karyomerites of the male and the female pronuclei presumably meet and unite. After fertilization these areas become "karyo-cytoplasmic" masses; starting from those located at the center, these masses soon undergo division, giving rise to numerous protoplasmic islands.

The cleavage of the eggs consists of movements leading to the transposition of both nuclear and cytoplasmic materials to the surface. This is in a sort of general cytoplasmic movements of the nature of either a flowing or a contraction. The latter movements are in part upon the yolk surface; in part they consist of movements of vitellocytes within the yolk, but they are blastodermic and not vitellar.

Cleavage in this crab does not lead to a definite blastula and gastrula formation. These two stages, ordinarily occurring as distinct phases, are indistinguishable in this case.

The early blastoderm consists of a peripheral layer of plasma blocks (Plate 13, fig. 1). The ventral germ-disc becomes established by more rapid formation of plasma blocks, and to a certain extent by the apparent rapid migration of protoplasmic islands towards this side. Cell membranes begin to appear while the germ disc is forming; prior to this time the vitelline membrane and the cytoplasm represented one great reticular syncy-

tium, composed of more or less definite masses, the "plasma blocks".

In the absence of definite cell wall and of definite nuclear body, the term "plasma block" is quite appropriate for these masses. They soon, however, give rise to cells with distinct membranes. While this is taking place around the periphery, plasma blocks are also formed within the embryo. The rate of proliferation in the peripheral plasma blocks differ; consequently, the embryo appears to be divided into independent territories wherein active changes are taking place.

Growth differences between cephalothorax and abdomen.—The cephalothorax and abdomen show certain striking differences in their growth and differentiation. The boundary between the two can be recognized as a thin region of the ectoblast where a certain degree of insinking takes place and active proliferation of the cells in the adjoining regions (Plate 14, fig. 1) appears to take place.

Nearly the whole extent of the cephalothorax is laid down, thereafter to lengthen but little more, when the abdomen is represented only by a small lobe (Plate 14, fig. 1, *c. l.*). With the segmentation of the mesoblast the abdomen commences to increase rapidly in length, pushing around the yolk until the caudal lobe finally comes in contact with the head lobe. Its growth is teloblastic, and the successive segments formed from its anterior end caudal. This rapid elongation of the abdomen explains why the caudal lobe is narrower than the cephalic lobe. Segmentation becomes more distinct in the abdomen (Plate 14, fig. 2, *ab*).

Protozoa (Plate 14, fig. 3).—Hatching takes place at this stage. The large paired eyes are present; there are no frontal or dorsal spines. The abdomen is well defined, but only five somites and the telson are distinguishable. The sixth somite is still fused with the telson; the latter forked with strong spines in each branch. All the cephalic and the first two pairs of thoracic limbs are present. The antennule consists of a basal segment from which arise two branches and each fork is armed with rather long setæ. Antenna consists of two segments with a few terminal setæ. It is postoral in position. Apparently during the stage of reversion it is shifted anterior to the mouth. The mandible is a small plate. The first and second maxillæ are similar. The first and second pairs of maxillipeds are large and biramous. The protopodite is large and the en-

dopodite and the exopodite have few setæ. As shown in the illustration, the cuticular covering is becoming loose; apparently this indicates that the larva is about to change into the zoea stage.

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ILLUSTRATIONS

PLATE 1

- FIG. 1. Ovigerous female, with chelipeds removed. *g. o*, genital opening; *i o*, inhalant opening.
2. Ovaries, X 1. *c*, chitinous portion of the spermatheca; *g*, granular portion of the spermatheca; *g. m*, gonadial membrane; *od*, oviduct; *ov*, posterior extension of the ovaries; *ov. f*, ovarian follicle; *spt*, spermatheca; *v*, vulva.
 3. Cross-section of ovary through region above cheliped, X 2. *bv*, blood vessel; *c*, canal formed by the ligamental fold; *d.w*, dorsal wing; *t*, one of the follicular tubules; *v.w*, ventral wing.
 4. Abdomen of female *S. tranquebarica*, showing character of segmentation, X 1.
 5. Second abdominal appendage, of a female, X 2. *a*, coxopodite; *b*, basipodite; *en*, endopodite; *ex*, exopodite; *s*, fringe of setae.
 6. Portion of exopodite seta, showing dendritic characteristic, X 600.

PLATE 2

- FIG. 1. Abdomen of male *S. tranquebarica*, showing character of segments, X 1.
2. First abdominal appendage of male, modified as copulatory apparatus; left side, inner surface, X 2. *a*, basal joint; *b*, groove; *c*, cisterna spermatica; *d*, excavated area; *e*, groove along funnel tube.
 3. First abdominal appendage of male, modified as copulatory apparatus; right side, outer surface, X 4. *a*, tip of the funnel tube; *b*, free edge of rolled portion of tube; *d*, canal leading to mouth of tube.
 4. Second abdominal appendage, also modified as copulatory apparatus. Right side, dorso-lateral surface; enlarged. *c*, canal in the fork; *f*, fork; *mf*, membranous fold.
 5. Second abdominal appendage, terminal portion only, inner surface to show the spinules on trough of fork, enlarged.
 6. Testes X1. *ed*, ejaculatory duct; *f*, follicular tubule; *gm*, gonadial membrane; *ps*, pedal sinus; *te*, testis; *vd*, vas deferens.
 7. Two epithelial cells from lining of lumen of ejaculatory duct, X 1350, camera lucida. *a*, attachment; *b*, *co*, basal corpuscle to each cilium; *c*, cilia; *cb*, cell body; *f*, fibrils corresponding to each cilium; *n*, neck.

PLATE 3

- FIG. 1. A growing auxocyte in follicular tubule of testis of *S. tranquebarica*, X 1350, camera lucida.
2. A pro-spermatid undergoing reorganization. The spiremes radiating from heterochromosomes, the darkly stained mass at center of germinal vesicle, X 1350, camera lucida.

3. A pro-spermatid undergoing further reorganization. The spiremes are transformed into chromatids and their groupings indicate tetrad formation, X 1350, camera lucida, *l*, a pair of tetrads.
4. Pre-synaptic stage, showing number of chromosomes and pairing, X 1350, camera lucida. *h*, heterochromosomes (the XY-pair); X-chromosome in form of loop, Y-chromosome small; *m*, monosome.
5. Chromosomes in synaptic stage; appearance of the idiosome and acroblasts, X 1350, camera lucida. *h*, heterochromosomes; *i*, idiosome; *m*, monosome; *p. ac*, pro-acrosome granules.
6. Pro-spermatid body in process of reorganization, showing concentration, contraction and sloughing-off of materials, X 1350, camera lucida. *ac*, acroblast (central body); *g*, Golgi-bodies remnant; *i*, idiosome; *ne*, nuclear extrusion.
7. Pro-spermatid undergoing concentration and contraction; X 1350, camera lucida. *i*, idiosome; *m*, monosome, the extra X-chromosome. The chromosomes are now dyads and the acroblast body has disaggregated.
8. Formation of definitive spermatid body; sloughing-off of residual protoplasm and diminution of both nuclear and acroblast materials, X 1350, camera lucida. *c.e*, possibly cast-off nuclear or acroblast materials; *i*, idiosome; *r.p*, residual protoplasm; *sp.b*, spermatid body; *x*, sex-chromosome.
9. Spermatid undergoing abortive mitotic division involving largely the nucleus; this results in neiosis, X 1350, camera lucida. *ac*, acroblast; *d*, daughter nucleus; *m*, probably the extra X-chromosome (monosome).
10. Top view of spermatid, wherein process of concentration is going on, X 1350, camera lucida. *ac*, acroblast; *i*, idiosome.
11. Side view of spermatid in contraction phase, X 1350, camera lucida. *ac*, acroblast; *r.p*, residual protoplasm.
12. Basal-side view of spermatid undergoing concentration, X 1350, camera lucida. *ac.r*, acroblast-remnant.
13. Basal portion of spermatid, showing number of chromosomes, X 1350, camera lucida.
- 14-18. Later phases of transformation characterized by peculiar behavior and movement of acrosome body, X 1350, camera lucida.
19. Spermatozoön, X 1350, camera lucida. *ca*, capsule; *nc*, nuclear cup.

PLATE 4

- FIG. 1. Developing auxocyte (of class without tetrads), drawn from cross-section of follicular tubule, X 1350, camera lucida. *f*, follicular wall; *ch.n*, chromatin nucleolus; *n.nc*, presumably nucleus of nurse cell.
2. Surface view of auxocyte (without tetrads), X 1350, camera lucida. *n.c*, nurse cell.
 3. Side-view of auxocyte (without tetrads), at termination of growth period, X 1350, camera lucida. *f*, follicular wall.
 4. Chromosome pairs of auxocytes without tetrad formation, X 1350, camera lucida. *h*, heterochromosomes (possibly XY-pair).

5. Showing two spermatids that have differentiated from auxocytes (of class with no tetrad formation), X 1350, camera lucida. *ac*, acroblast; *g*, Golgi-bodies remnant; *n.c*, nurse cell; *n.e*, nuclear extrusion; *sp*, spermatid body; *v.ac*, acroblast vesicle.
- 6-10. Later phases of transformation of spermatids (of class with no tetrad formation), X 1350, camera lucida. *ac*, acroblast; *ac.r*, acroblast-remnant; *ca*, capsule; *i*, idiosome; *n.c*, nuclear cup.

PLATE 5

- Fig. 1. Group formation of auxocytes (spermatocyst), X 1350, camera lucida. *cys*, cyst; *sp*, spermatoblast (auxocyte).
2. Auxocyte from group formation (spermatocyst), showing chromosomes, X 1350, camera lucida. Y-chromosomes (γ) is small, apparently trisomic and attached to big X-chromosome.
3. Auxocyte of *S. oceanica*, in which nucleus has split into two spermatid nuclei, X 1350, camera lucida. *a*, attraction sphere; *c*, centriole; *f*, follicular wall; *sp. n.*, spermatid nucleus.
4. Spermatid that has developed from spermatid nucleus, X 1350, camera lucida.
- 5-7. Some phases of transformation of spermatid (in *S. oceanica*) to spermatozoa, X 1350, camera lucida. *ac*, acroblast; *ac.r*, acroblast remnant; *i*, idiosome.
8. Spermatozoa (*S. oceanica*), X 1350, camera lucida. *a*, Basal side view; *b*, Basal portion only.
- 9-10. Chromosomal complement (*S. oceanica*), X 1350, camera lucida.
11. Pro-spermatid of *paramamosain*, showing nuclear diminution and sloughing-off of some cytoplasmic material, X 1350, camera lucida.

PLATE 6

- FIG. 1. Somewhat more abbreviated process of pro-spermatid differentiation from auxocyte (in *paramamosain*), X 1350, camera lucida.
2. Formation of two spermatids from pro-spermatid body, X 1350, camera lucida.
- 3-4. Some phases of transformation leading to formation of spermatozoa, X 1350, camera lucida.
5. Spermatozoa, X 1350, camera lucida.
6. Photomicrograph showing spermatocyst of *S. serrata*, X 400. Note that some spermatids appear in pairs.
- 7-8. Process of reorganization in nucleus of auxocyte (of *S. serrata*) leading to differentiation of spermatid, X 1350, camera lucida. *c*, centrosome with some centroplasm.
9. Differentiation of spermatid nucleus from auxocyte nucleus (in *S. serrata*), and sloughing-off of some material, X 1350, camera lucida. *r. p.*, sloughing-off material.
- 10-12. Phases of nuclear reorganization in auxocyte nucleus (in *S. serrata*), tending toward differentiation into two spermatid nuclei, X 1350, camera lucida.

PLATE 7

FIG. 1. Phases of nuclear reorganization in auxocyte nucleus (in *S. serrata*), tending toward differentiation into two spermatid nuclei, X 1350, camera lucida.

2. Nucleus, with chromosome-nucleolus at equatorial region prior to its splitting, X 1350, camera lucida.
3. Division, X 1350, camera lucida. *cy*, portion of cytoplasm of auxocyte; *i*, idiosome.
4. Side view of remains of auxocyte; the spermatids are still within, X 1350, camera lucida.
- 5-7. Later phases of spermatid transformations, X 1350, camera lucida.
8. The spermatozoön, X 1350, camera lucida.
9. Cross-section of ovarian follicle, X 600, camera lucida. *c*, some collagenous material in lumen of follicle; *c.c.*, collagen-forming cells; *f*, follicular wall; *l*, lumen of follicle; *n*, nurse cell; *o*, growing oöblast (auxocyte).
10. Two developing auxocytes together with some nurse cells, from section of surface of ovarian tubule of *S. tranquebarica*, X 1350, camera lucida.
11. Developing auxocyte together with some nurse cells, from cross-section of ovarian tubule of *S. tranquebarica*, X 1350, camera lucida. *f*, follicular wall; *n. c.*, nurse cell; *a*, developing oöblast (auxocyte).

PLATE 8

FIG. 1. Auxocyte at termination of growth period, X 1350, camera lucida. *cn*, chromatin-nucleolus; *g*, Golgi-bodies; *n*, germinal vesicle; *nc*, vestiges nurse cells; *v*, vitellogenous or pallial substance.

2. Ovocyte in pachytene stage of contraction phase, X 1350, camera lucida. Irregularly scattered spherules appear in place of pallial substance.
3. Diploid number of chromosomes, supernumerary chromosomes and diminution of nuclear materials, X 1350, camera lucida. *h*, hetero-chromosomes, evidently XX-pair.
4. Ovocyte, showing extrusion of first polar body, X 1350, camera lucida. *p.b.*, first polar body.
5. Ovocyte apparently in contraction phase, after formation of first polar body, X 1350, camera lucida.
6. Pairing of chromatid groups prior to meiotic division which involves nucleus only, X 1350, camera lucida. *h*, hetero-chromosomes; *m*, monosome; *p. pb*, path of first polar body.
7. Chromosomes in secondary pairing prior to meiosis, X 1350, camera lucida. *h*, hetero-chromosomes; *a.s.*, attraction sphere with two division centers; *m*, monosome.
8. Meiotic division involving germinal vesicle only, X 1350, camera lucida. This will result in formation of second polar body.
9. Ovocyte with germinal vesicle divided into two daughter nuclei, X 1350, camera lucida. *p. b.*, the second polar body.
10. Young ovum with second polar body still within its body, X 1350, camera lucida. The egg pronucleus is turning around towards center.

11. Young ovum showing penetration of sperm into oöplasm, X 1350, camera lucida. *ch*, chorion; *m*, path of penetration; *ps*, perivitelline space; *sp*, sperm body; *v*, vitelline membrane.

PLATE 9

- Fig. 1. Ovocyte (of class with no tetrad formation) differentiating from auxocyte body, X 1350, camera lucida. *g*, Golgi-bodies; *p.b.*, first polar body.
2. Extrusion of first polar body, X 1350, camera lucida. Both ovocyte and polar nucleus still within auxocyte body. *a*, attachment of the auxocyte to the follicular wall; *h*, hetero-chromosomes; *p.n.*, polar nucleus; *o*, ovocyte.
3. Fertilized ovarian ovum (macro-ovum), X 900, camera lucida. *b*, peripheral cytoplasmic layer (blastema); *ch*, chorion; *cy*, cytoplasmic mass; *g.v.*, germinal vesicle; *sp*, sperm vesicle; *y*, yolk-sphere.

PLATE 10

- Fig. 1. Germinal vesicle of macro-ovum, with sperm inside, X 1350, camera lucida. Sperm evidently undergoing reorganization. *cy*, cytoplasmic layer around the germinal vesicle; *cs*, cytoplasmic strand; *sp*, sperm body.
2. Germinal vesicle of growing micro-ovum, X 1350, camera lucida. *cs*, cytoplasmic strand; *cy*, cytoplasmic layer around germinal vesicle.
3. Germinal vesicle of full-grown micro-ovum; with a sperm within, X 1350, camera lucida. *cs*, cytoplasmic strand; *cy*, cytoplasmic layer; *e*, penetration path of the sperm; *k*, karyomerite; *m*, microsome; *sp.n.*, sperm nucleus.
4. Remaining portion of germinal vesicle undergoing fragmentation, X 1350, camera lucida. *k*, karyomerite; *ks*, karyoplasmic streamer.
5. Sperm body within germinal vesicle becoming vesicular preparatory to fragmentation, X 1350, camera lucida.
6. Sperm body within germinal vesicle fragmenting into karyomerites, X 1350, camera lucida.
7. Ovocytes differentiating from auxocytes (in *banhawin*), X 1350, camera lucida. *c*, centrosome; *p.b.*, first polar body; *i.dc.*, intra-nuclear division center.
8. Young ova in different phases of growth, X 1350, camera lucida. *e.dc.*, extra-nuclear division center; *i.dc.*, intra-nuclear division center; *sp*, sperm after penetration.

PLATE 11

- Fig. 1. Young ova, X 1350, camera lucida. *sp*, sperm that has penetrated.
2. Photomicrograph of a large portion of mature ovum, X 900. Note sperm within germinal vesicle.
3. Full-grown macro-auxocyte of *paramamosain*, in the contraction-figure, X 1350, camera lucida. *c*, centrosome with some centropiasm.

4. Diffused stage, tending toward diminution of karyoplasmic material preparatory to differentiation of the ovocyte, X 1350, camera lucida. *c*, centrosome.
5. Second synizesis, or contraction-figure, showing differentiation of ovocyte from auxocyte body, X 1350, camera lucida.

PLATE 12

- FIG. 1. Micro-auxocyte, in contraction-figure, or synizesis, X 1350, camera lucida. Nuclear material undergoing rearrangement preparatory to differentiation of ovocyte.
2. A contraction-figure in advance stage; nucleus undergoing abortive division, X 1350, camera lucida. *c*, centrosome.
 3. Micro-ovocyte that has differentiated from auxocyte body, X 1350, camera lucida. *p.n.* polar nucleus.
 4. Photomicrograph of portion of ovary of *paramamosain*, X 900. *f*, follicular wall; *mi*, micro-ovum; *sp.*, sperm outside of egg; *sp.*, sperm within egg but still outside the germinal vesicle; *sq.*, sperm inside germinal vesicle; *v*, vitellogenous layer.
 5. Auxocyte of *S. serrata* (from an immature individual) showing contraction-figure, or synizesis, after growth period, X 1350, camera lucida.
 6. Ovocyte differentiating from auxocyte body, X 1350, camera lucida. *p.n.* polar nucleus.
 7. Ovocyte wherein processes of concentration and contraction are apparently going on, X 1350, camera lucida. *c*, centrosome with some centroplasm; *p.n.* polar nucleus.
 8. Ovocyte in contraction phase, showing sloughing-off of some material, X 1350, camera lucida. *p.n.*, first polar nucleus; *p.n.*, second polary body.
 - 9-10. Chromosomal constitution, X 1350, camera lucida. *x*, apparently X-chromosome.

PLATE 13

- FIG. 1. Egg undergoing cleavage (*S. tranquebarica*), X 900, camera lucida. *1*, presumptive head region; *2*, presumptive dorsal region; *3*, ventral region; *ch*, chorion membrane; *b*, plasma block; *p*, blastema; *p.s.* perivitelline space; *s.f.* secondary yolk-cleavage furrow; *v*, vitelline membrane.
2. Eggs in different stages of development, still attached to the endopodite setæ, X 150, camera lucida. *c*, collagenous material attaching egg to seta; *ch*, chorion membrane; *p.b.* polar body; *s*, seta; *st*, stalk drawn out from layer of collagenous material around egg.

PLATE 14

- FIG. 1. Outline drawing of embryo, showing growth differences between cephalothorax and abdomen, X 900, camera lucida. Only plasma blocks along periphery are drawn. *c.l.* caudal lobe; *ch*, chorion membrane; *c.m.* layer of collagenous material; *p.l.* procephalic lobe; *st*, stalk formed from collagenous material that enables embryo to attach to endopodite setæ; *th. l.* thoracic lobe.

2. Early protozoa, X 150, camera lucida. *ab*, abdomen; *e*, eye; *t*, telson.
3. Later protozoa stage, X 150, camera lucida. *a-1*, antennule; *a-2*, antenna; *e*, eye; *m*, mandible; *mx-1*, first maxilla; *mx-2*, second maxilla; *mp-1*, first maxilliped; *mp-2*, second maxilliped; *t*, telson; *1-5*, abdominal segments.

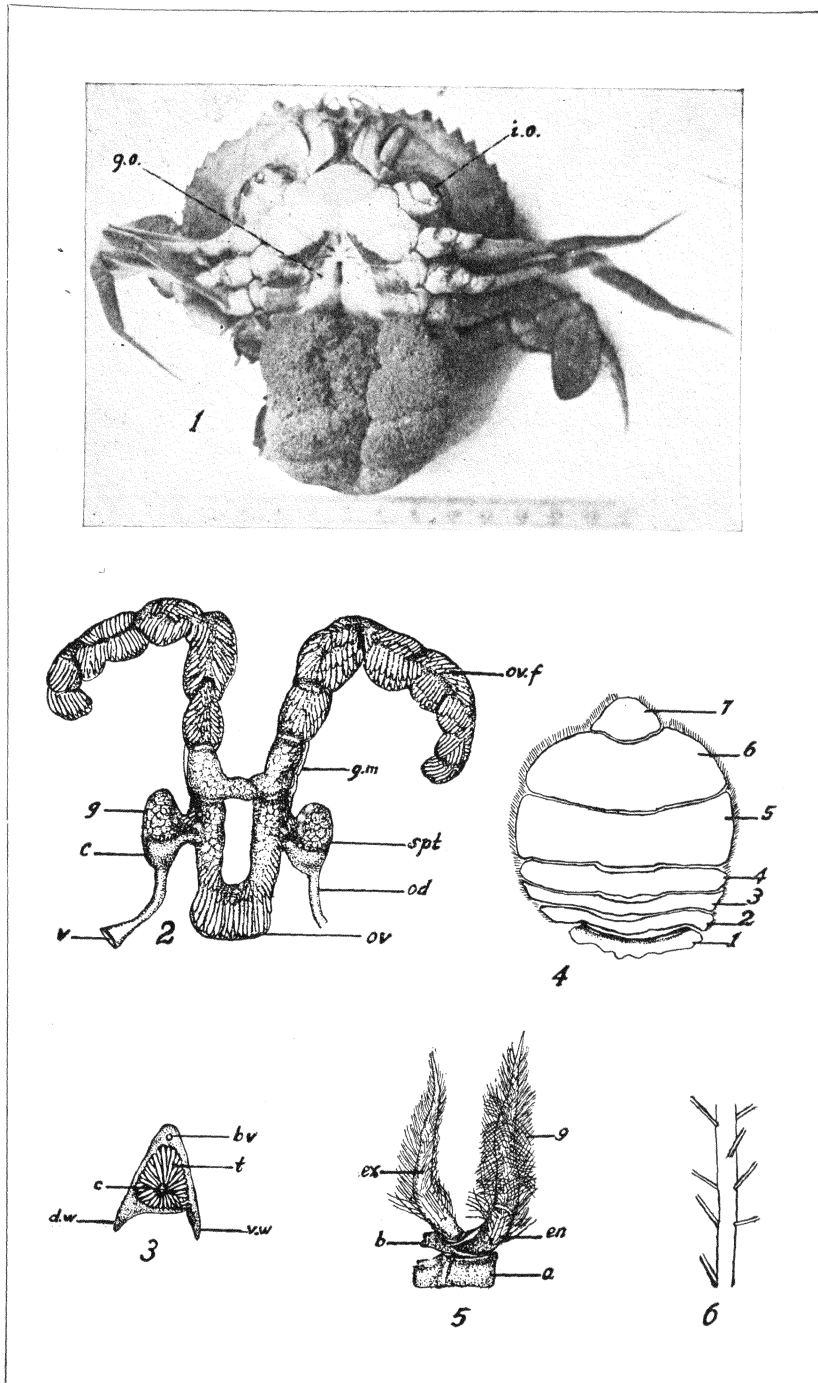


PLATE 1.

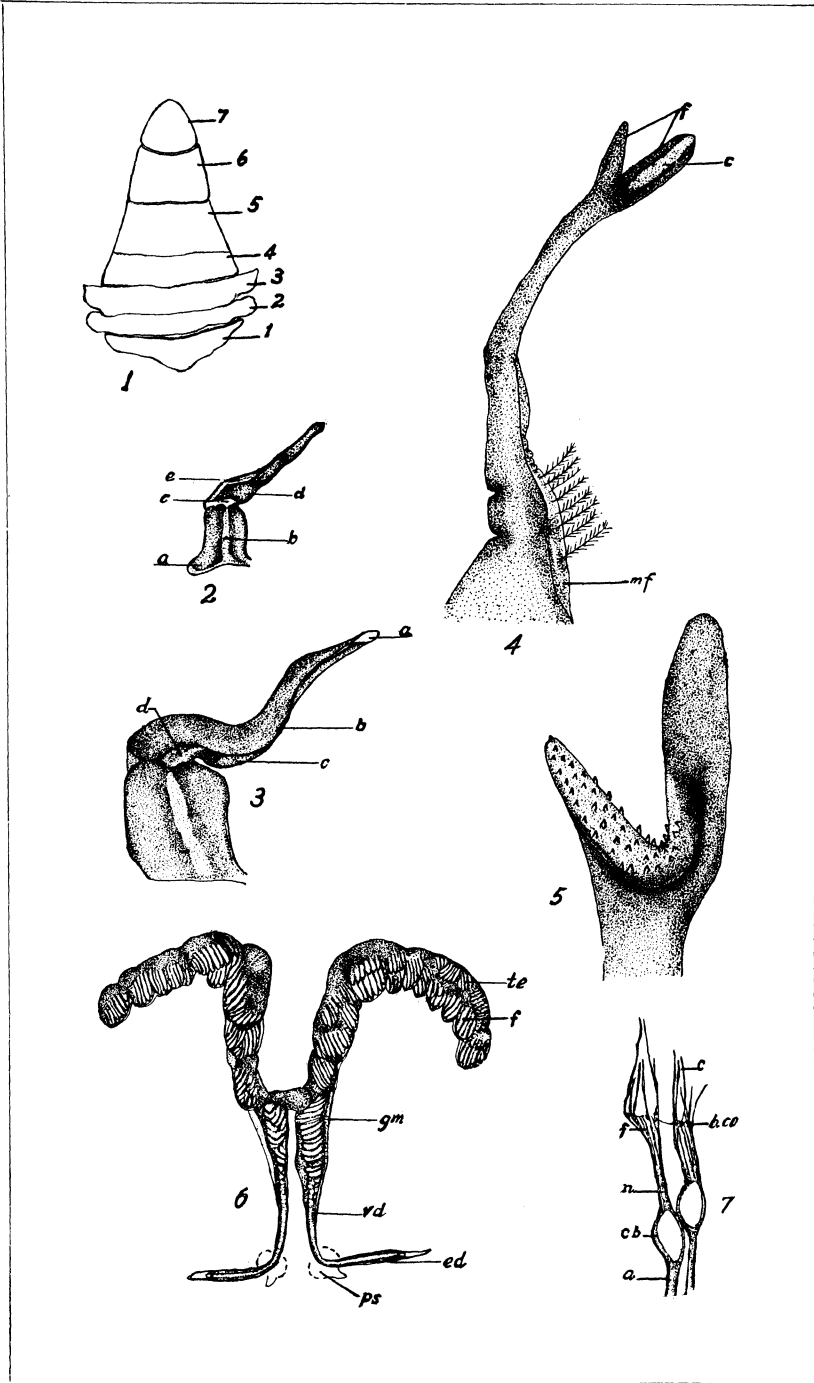


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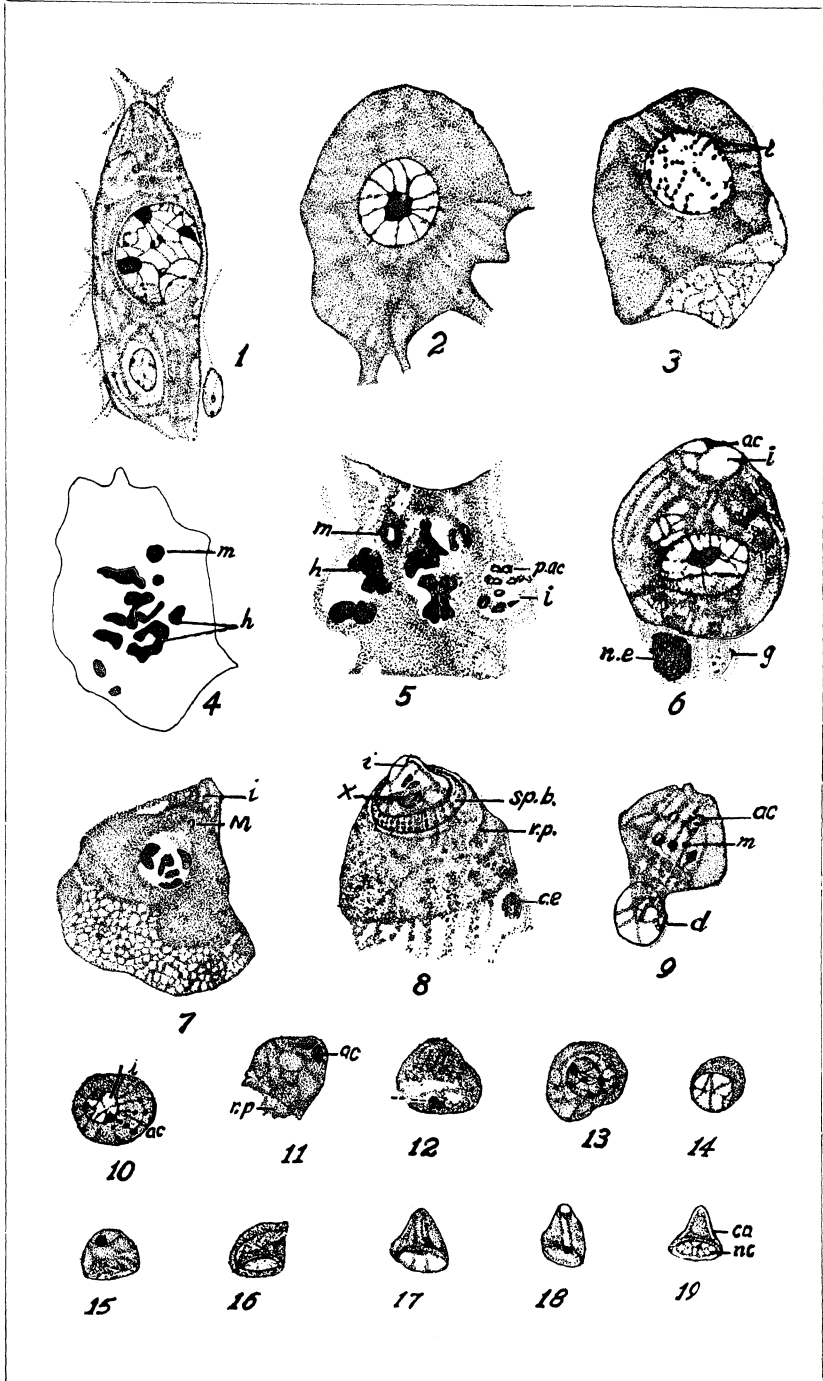


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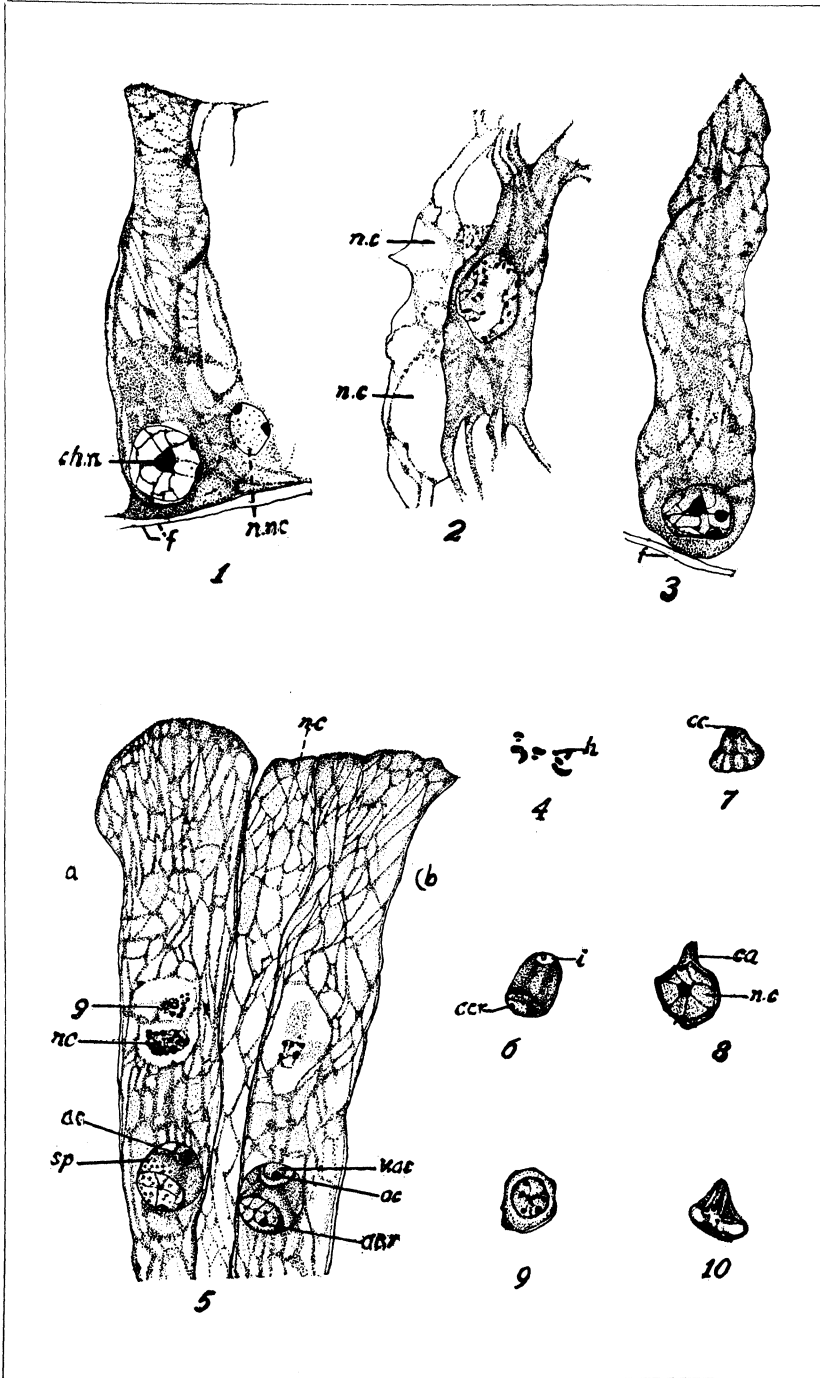


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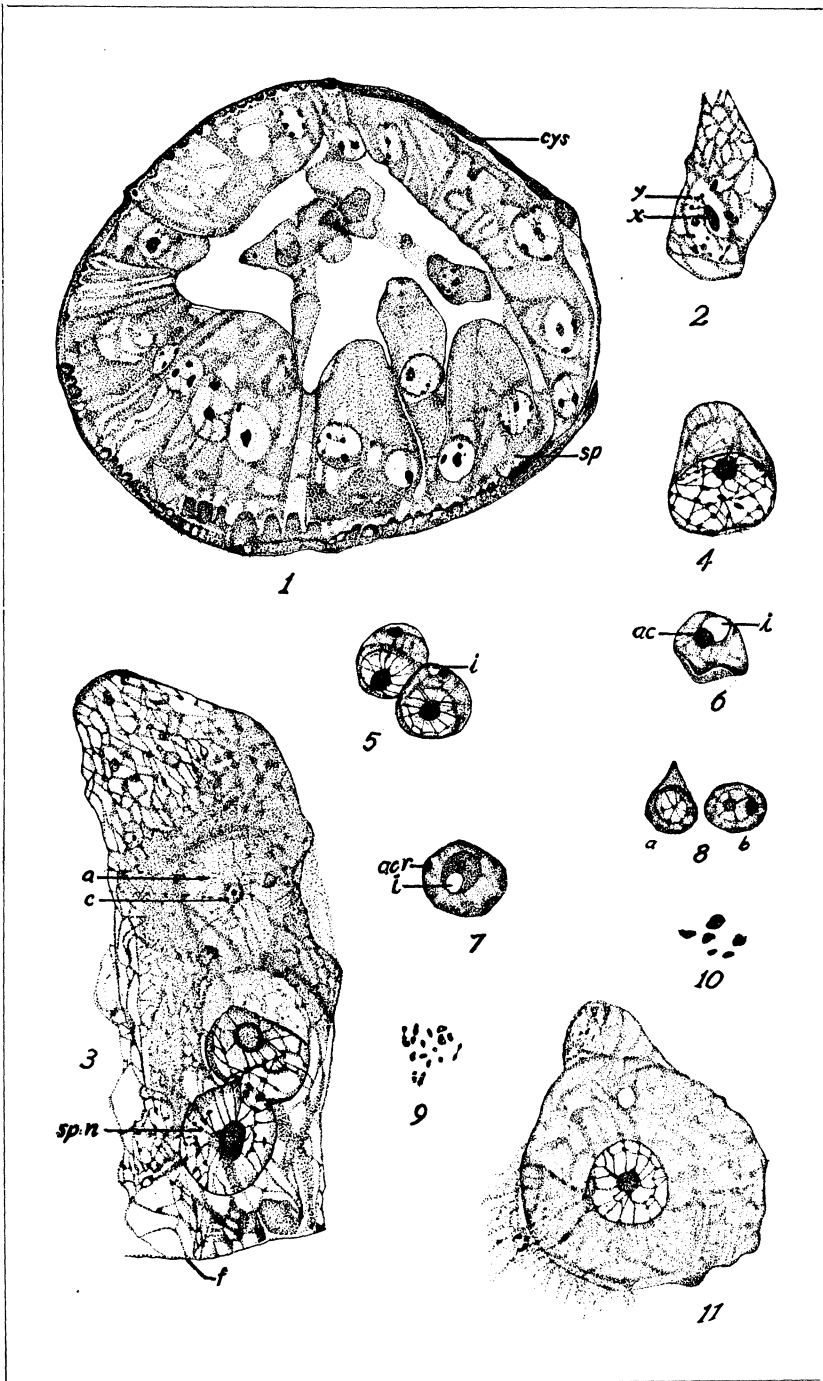


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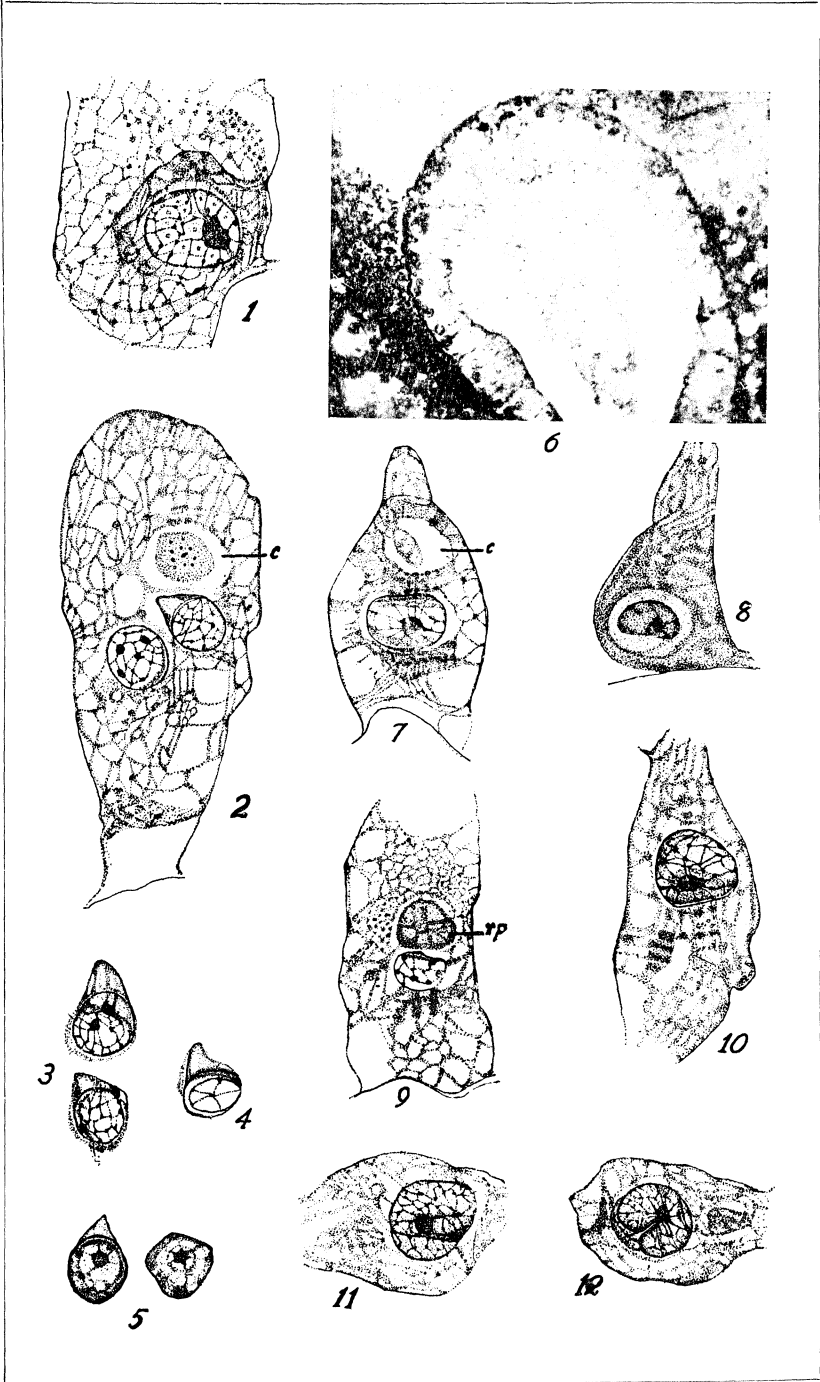


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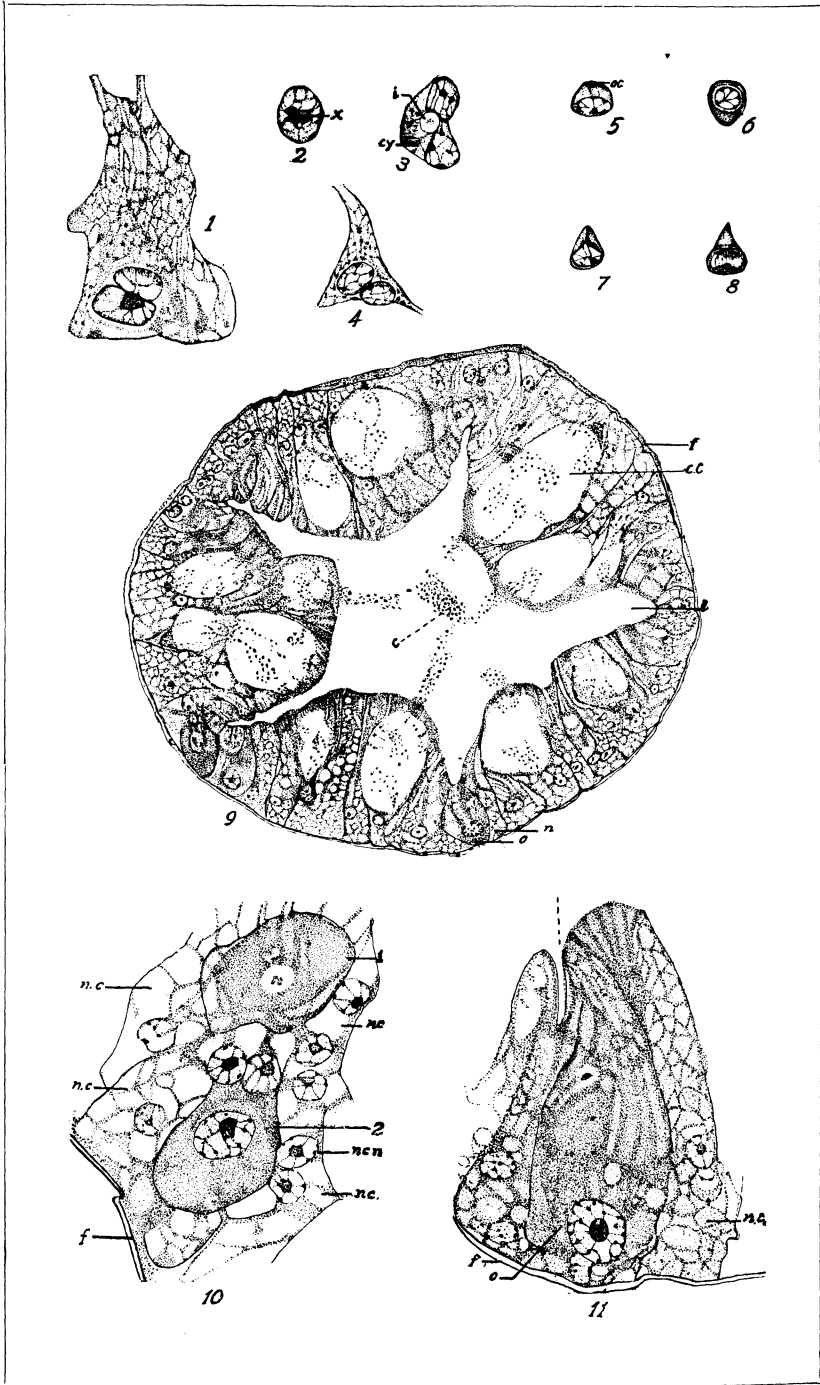


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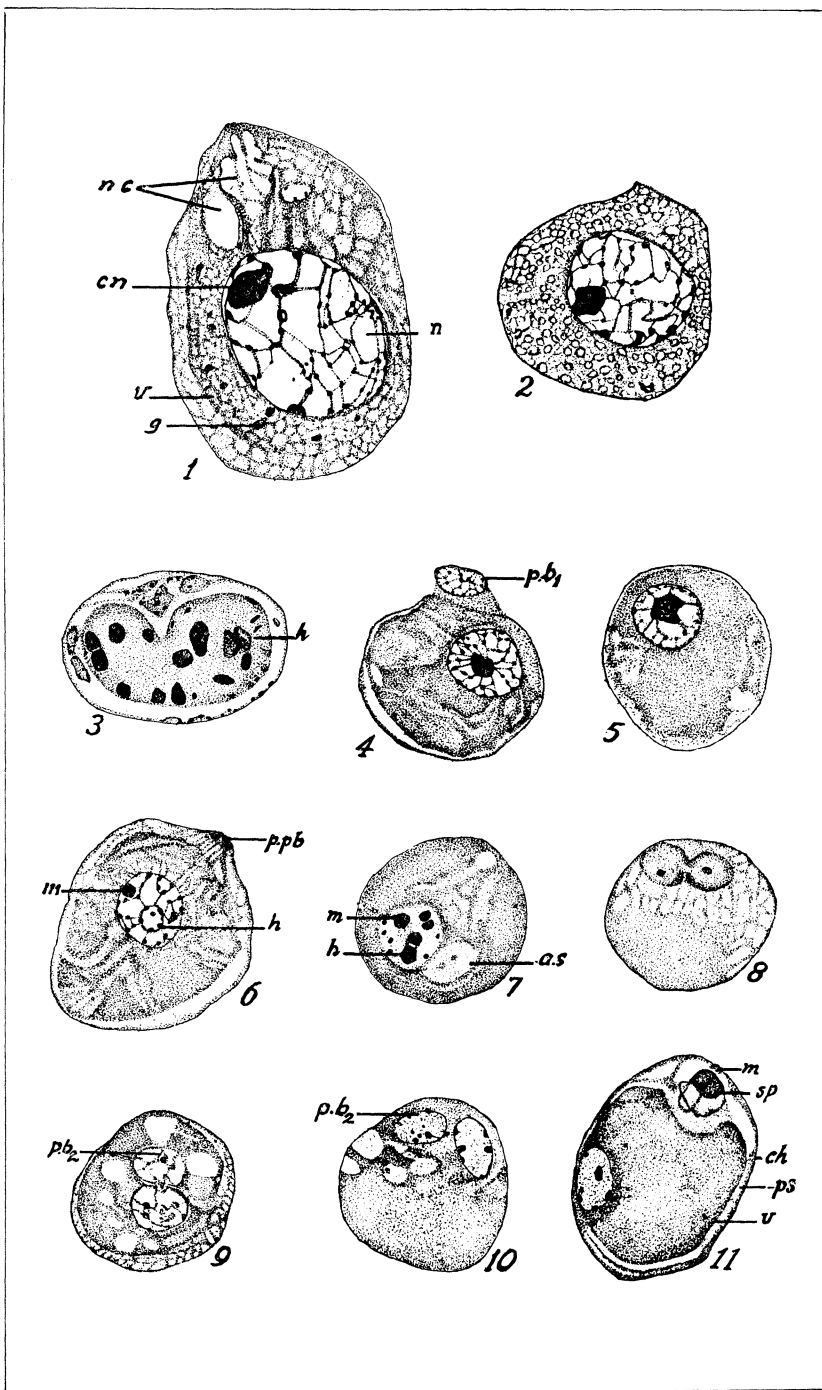


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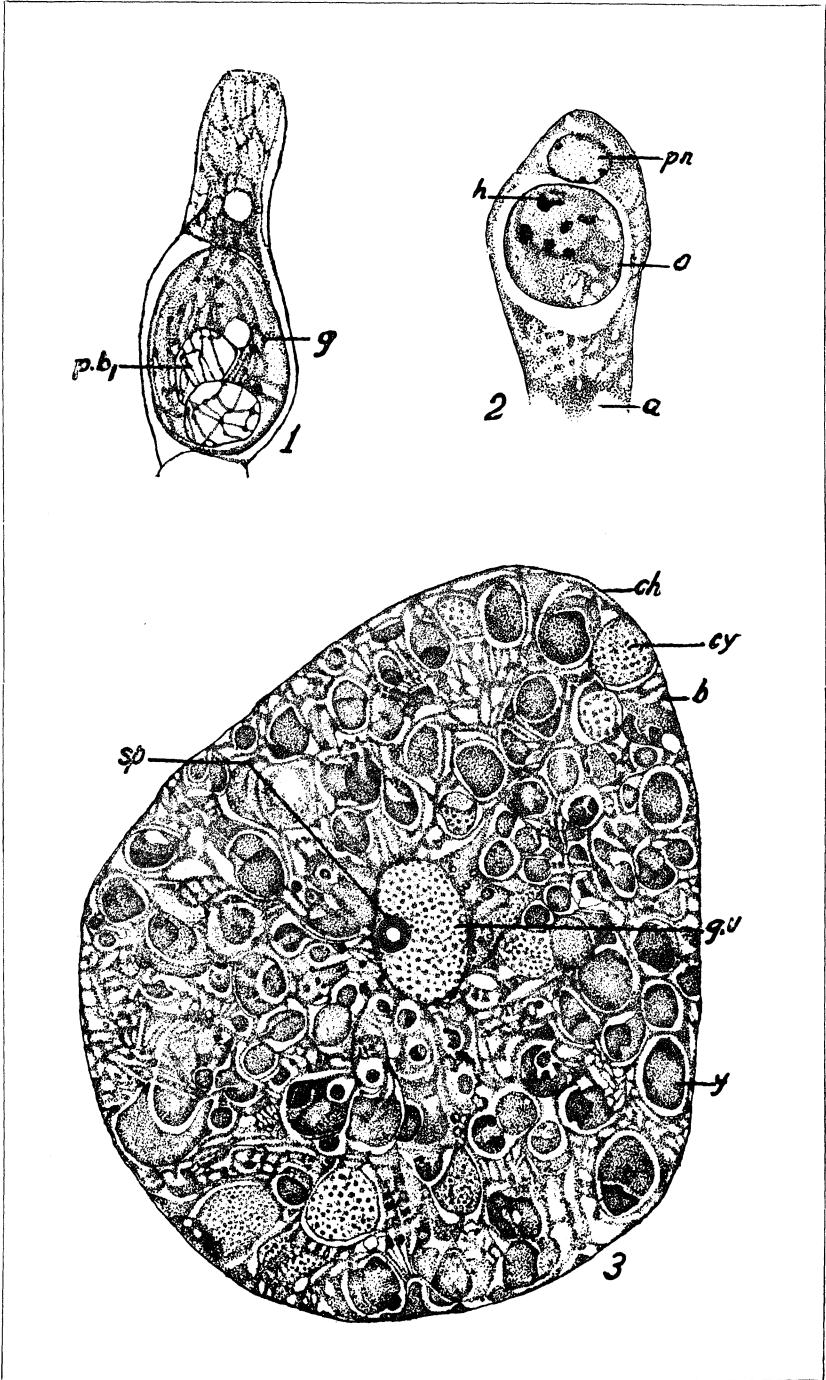


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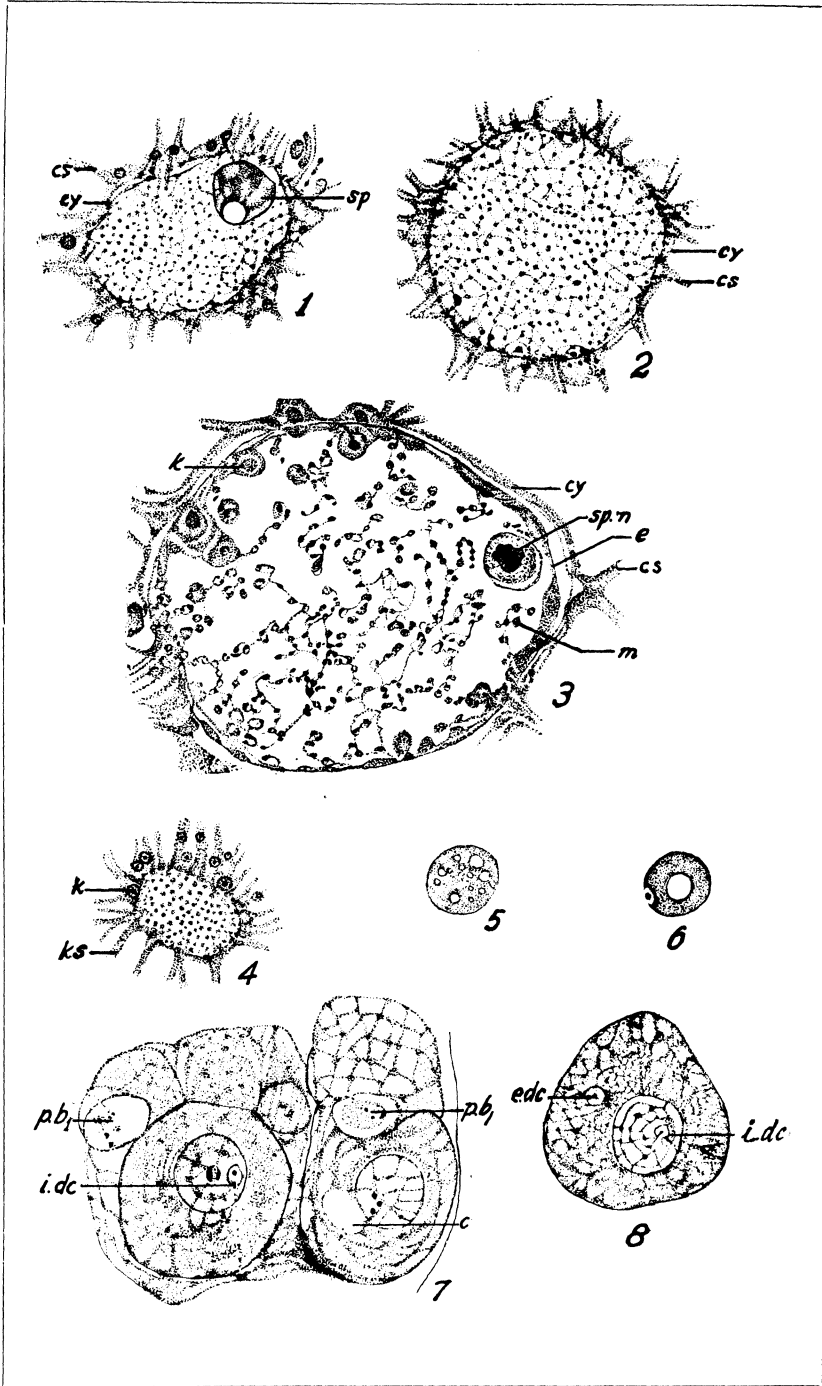
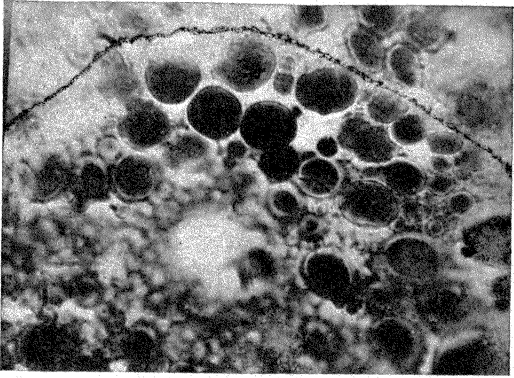
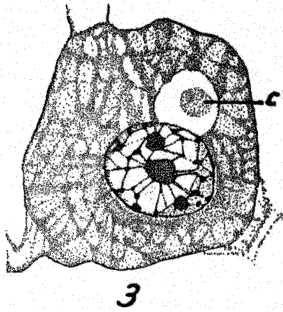
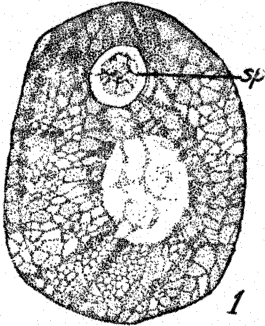


PLATE 10.



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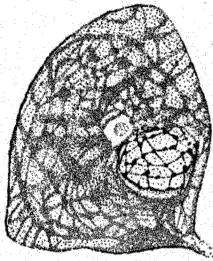
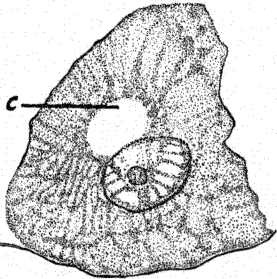


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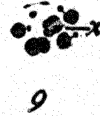
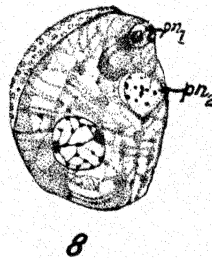
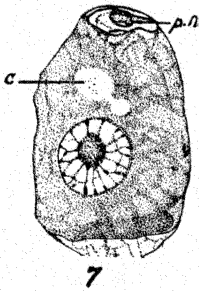
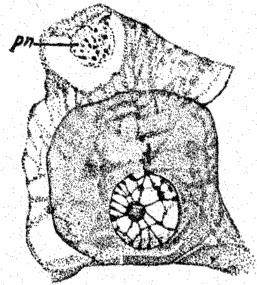
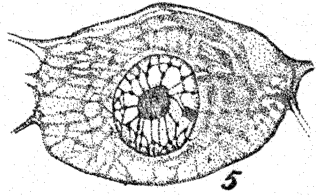
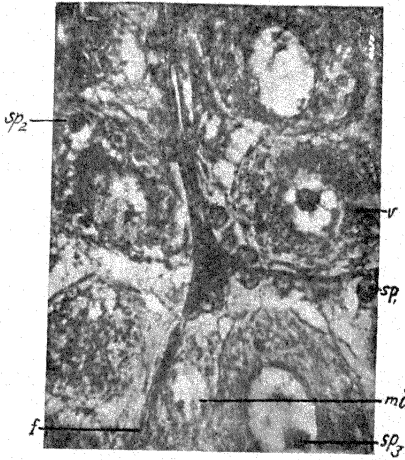
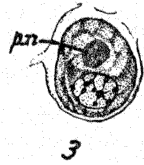
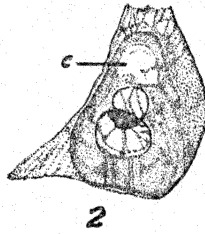
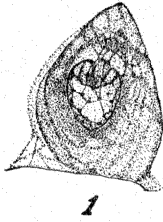
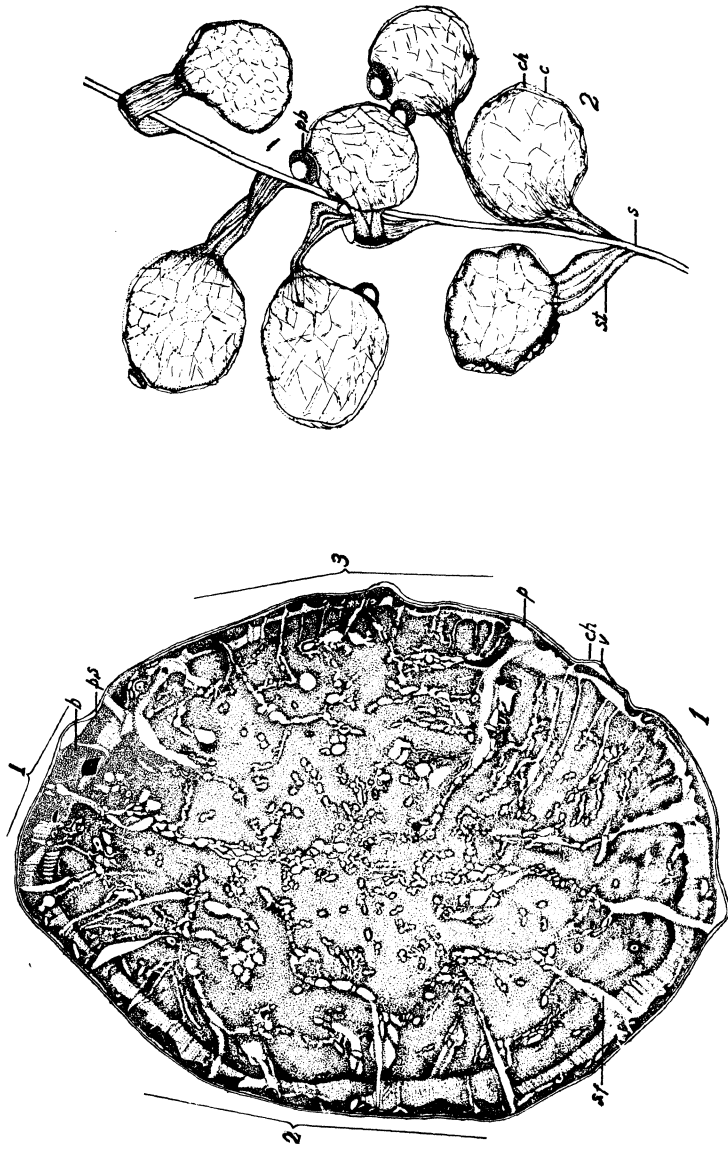


PLATE 12.



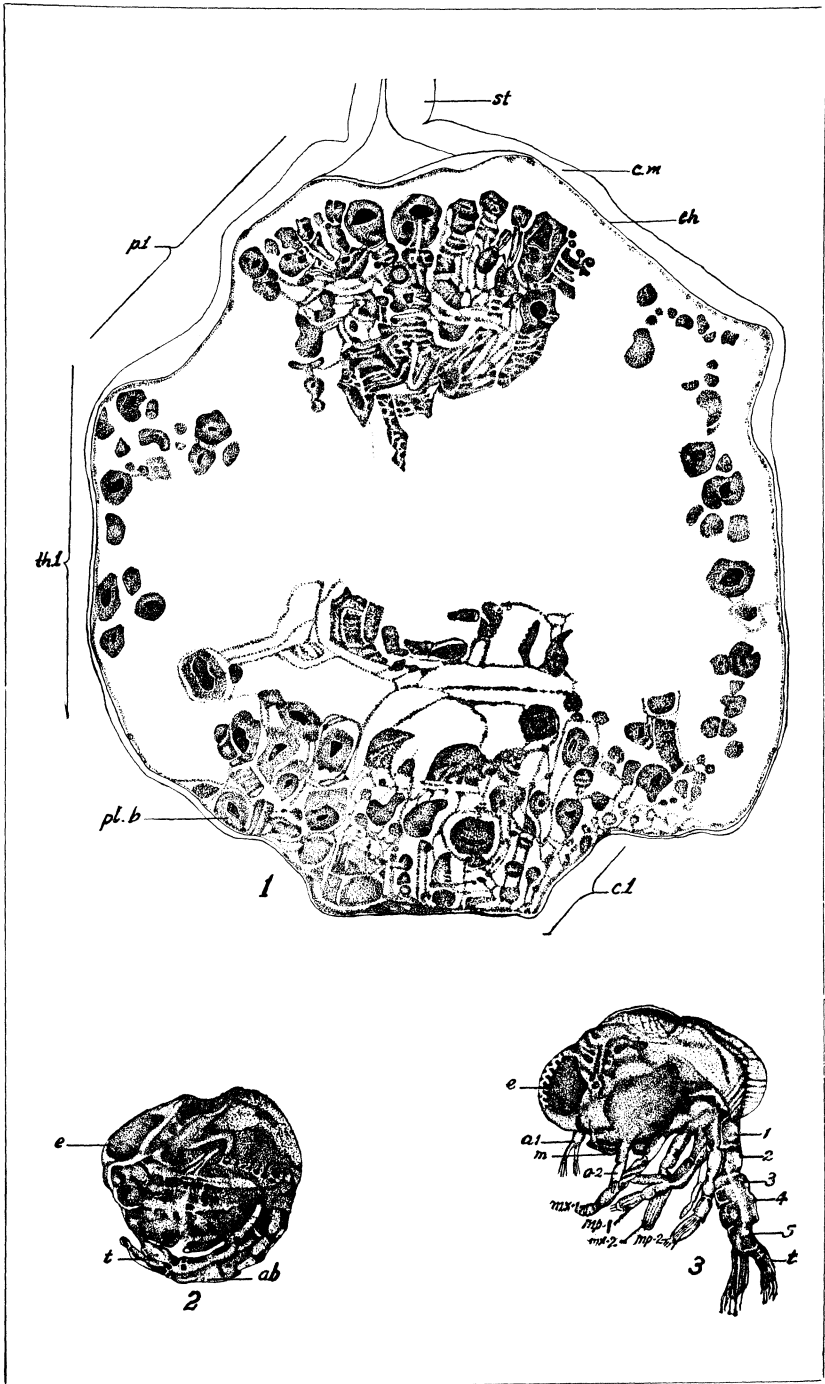


PLATE 14.

SUITABILITY OF MANILA HEMP WASTE FOR PAPER MAKING MATERIAL

I. PULPING OF MANILA HEMP WASTE BY THE SODA PROCESS

By MARIANO P. RAMIRO *

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Abaca (Manila Hemp) waste is available in large supply in the Philippines and is a source of useful fibers that could be converted into valuable products of commerce and industry. This investigation was carried out to determine the most suitable conditions for reducing this material into pulp of good yield, strength and color.

The term "manila hemp" is commonly applied to the fiber extracted from the leaf-stalks of *Musa textilis* Née (family *Musaceæ*), a plant indigenous to the Philippines. The plant which is locally called "abaca," shoots from its underground rootstock spurious stems consisting of concentric sheathing leafstalks. The stalk attains a height of 15 to 20 feet in 1½ years and spreads out into large undivided leaves. Clusters of from 12 to 20 stalks are developed from each rhizome. In its native habitat, particularly the southern regions of Luzon, abaca grows well with the least cultivation and care.

"Abaca" is sufficiently matured for stripping at flowering age. The stalk is cut down and the outer fiber-bearing layer of each successive leaf-stalk is divided or torn into ribbons of from one to two inches wide and about one-fourth of an inch thick. While fresh and succulent, the ribbons are scraped with a knife-block stripping device to render the fiber free of the soft cellular materials that surround the fiber strands. The

* The author wishes to extend his appreciation to the Office of International Information and Cultural Affairs of the U. S. Department of State for its support in carrying out this work; to the Forest Products Laboratory, Madison, Wisconsin, for furnishing the facilities; to John Manning Paper Company, Inc., for furnishing the information on pulping Manila hemp; and to Messers, Mark W. Bray and John S. Martin, Forest Products Laboratory, for their advice and assistance in planning the experiments herein reported.

extraneous material is called abaca bagasse or the plantation waste of the abaca industry.

LITERATURE

Acid sulfite pulping of abaca bagasse waste³ results in the retention of most of the cellular constituents in the pulp. This type of pulp is suitable only for paper where strength is of primary consideration, but not paper for which color is essential.

The conventional manila hemp for rope manufacture, and to some extent as base material for plastic articles, is usually clean and of high quality. It is perhaps on this account that the pulp yield from old manila rope by the caustic soda, soda ash and lime-soda ash processes is higher than the yield from rope factory waste⁵ and low grade abaca fiber. Papers made from the factory waste are found also to be inferior to those from old rope stock.

By digesting manila hemp with a strong solution of caustic soda at 320 degrees Fahrenheit Osborne² obtained non-hydrated pulp which was converted into thin paper suitable for stencil base, condenser, and tissue paper. Shaw and Bicking⁵ found that cooking with soda ash gave satisfactory results as to pulp yield and quality of paper from rope stock.

The use of abaca in the paper industry dates back to the American civil war⁴ when the production of cotton fell so low that the price of cotton bagging which was used exclusively for transporting flour and other articles prior to the war became prohibitive. Flour bag substitute was then an urgent problem. It was not very long, however, before paper of exceptional strength and durability was prepared from old rope stock to replace the cotton bag. The paper known commercially as manila paper has been so successfully manufactured from old rope that it has become an important material for the transportation of food articles, cement and other commodities. The convertibility of manila hemp into various types of paper is responsible for the increasing interest and demand of the fiber by many industries.

SOURCES AND PHYSICAL PROPERTIES OF THE MATERIAL

The sample of abaca waste, consisting of fifteen bales weighing about 150 pounds each which was used for these pulping experiments, came from Manila and was received at the Forest Products Laboratory, Madison, Wisconsin, in May, 1946. A

history of the fiber was not received. However, it appeared to be a fairly good rope factory waste, which fell under the T3 quality based on the grading practice of the cordage industry. Besides being dusty, some of the fibers were so badly decayed that they crumpled on handling. Leaves, twigs, and shrub stalks, estimated at approximately one per cent, constituted some of the foreign materials mixed with the fibers. The presence of these undesirable materials, particularly the decayed portions of the hemp, contributed undoubtedly to the low pulp yield.

PULPING EXPERIMENTS

Preparation of material.—In order to eliminate as much as possible the effect of the decayed fibers on pulp yields, only sound material was used in the pulping experiments. Twigs and other foreign matters were also removed but some escaped examination and finally emerged from the digested material as screenings. To overcome the difficulty of sampling and packing the fiber into the digester, the original fiber was cut into convenient sizes of from 2 to 4 inches long.

Equipment.—Digestion experiments were carried out in three autoclaves each consisting of two hollow concentric cast-steel spheres mounted on trunnions. Each autoclave had a convenient opening for charging and discharging and was provided with a removable ground-in cover held in place by a suitable clamp attached to the cooking vessel. Between the spheres there was an annular space serving as a steam jacket for heating the inner sphere. One trunnion was used as an inlet for the admission of steam, or of cooling water to the jacket which may be drained through a pet cock. The other trunnion which projects to the center of the inner sphere served as a thermometer well and also supported a guard for the projecting stem of the thermometer.

Each autoclave was driven by a $\frac{1}{4}$ h. p. geared motor at about one revolution per minute. To the $\frac{1}{2}$ inch steam line leading to the cooking vessel, about a foot from the end of the trunnion, a pressure gauge is installed as a means of showing the pressure of the steam in the steam jacket.

Chemical.—For each digestion, an equivalent amount of the chemical required for a cook was taken from a relatively strong stock solution containing 118 grams of sodium hydroxide per liter.

Procedure.—A sample equivalent to the moisture-free weight of two pounds of the fiber was used in all the digestion

experiments. This quantity of material, when properly packed was sufficient to charge one autoclave to its full capacity of 3.7 gallons (1/2 cu. ft.). The fiber was placed in the digester and the cooking liquor diluted to the proper concentration was added to it. For all the experimental tests, the ratio of the volume of the cooking solution to the moisture-free weight of the fibrous material was 7 to 1. The digesters were rotated throughout the entire cooking period.

During the temperature rise period of one hour, steam was admitted to the jacket at a rate sufficient to effect a uniform rise of temperature. One set of pulping experiments was made at a maximum temperature of 140° C., another at 150° C., and a third at 160° C.

In order to gain an idea of the effect on pulp yield, strength, color of the pulp of digestion temperature and ratio of chemical to raw material, a series of ten cooks was made. The liquor-hemp ratio and the temperature rise schedule were maintained constant. The length of the cooking period was also held constant except in certain instances where it was desired to determine the progress of the reaction under a particular set of conditions. At the end of the digestion, the steam pressure in the jacket was relieved and the autoclave was cooled by allowing cold water to replace the steam in the jacket. The digested material was discharged in a wire-screen-bottom box where the pulp was thoroughly washed. Although the digested material was considerably softened, the fiber bundles were still intact. These were broken up by agitating the raw cooked pulp with a sufficiently large amount of water in a tank provided with an impeller stirrer. The resulting pulp was screened through a one foot square flat vibrating screen with slotted opening of about 0.014 inch wide. The total yield of pulp, the screenings, and the screened pulp were calculated from the moist weight and the moisture content of the materials.

The physical characteristics of the pulp were determined according to the standardized procedure and testing practice of the Technical Association of Pulp and Paper Industry. The average values obtained from the tests are a measure of the quality of the pulp.

DISCUSSION OF RESULTS

The data presented in Table 1 show the pulping conditions employed, pulp yields, and the physical properties of the pulps. In general the strength properties of the pulps were slightly

affected by the several digestion variables including temperature of digestion, concentration of cooking liquor, chemical ratio, and time of cooking. It is apparent that in cases where a light-colored paper is not required, pulps from reasonably mild digestions are almost identical to and consequently just as good as the products obtained under more drastic cooking conditions. Incidentally, the data tend to show that pulping abaca waste for two hours at a maximum temperature of 150° C. with from 12 to 16 per cent caustic soda (cooks 1712 and 1713), based on the moisture-free weight of the raw material, give satisfactory pulps of good bursting, tearing, folding, and tensile strengths. The color of the unbleached pulps obtained under these conditions has a brightness of from 22 to 29 per cent as measured with the Hunter Reflectometer using a blue glass filter and calibrated according to TAPPI Method T-217M45.

An increase in either the concentration of chemicals in the cooking liquor, the chemical ratio, the temperature, or the duration of cooking resulted in a decrease in the permanganate number of the pulps. Pulps with low permanganate number generally have a low bleach requirement.

In order to determine the most suitable conditions for converting the hemp into pulp with reasonably good physical properties, batches of the raw material were digested under a number of cooking conditions using several chemical ratios, concentrations, temperatures and cooking times. For the first trial, cook 1712, an initial set of cooking conditions was arbitrarily selected as a guide for the subsequent digestion experiments. The results show that the screenings were relatively low, an indication that the chemical used was almost sufficient for the complete reduction of the fiber to pulp. A reduction of the chemical ratio from 12 to 8 per cent (cook 1723) resulted in a decrease of from 54.7 to 48.3 per cent in the yield of screened pulp and an increase in screen rejects of from 1.9 to 22.4 per cent. Conversely, as the chemical ratio was increased from 12 to 20 per cent at constant volume and the solution concentration increased from 17.0 to 29.0 per cent there was a corresponding decrease in the yield of screened pulp.

A correlation of screened yield and total yield, as affected by the chemical ratio and solution concentration, is indicated in Fig. 1. It will be noted that in the regions of low concentration, the two curves are divergent but they converge at the higher concentrations.

TABLE 1.—Pulping conditions and properties of abaca (manila hemp) pulp

Digestion number	Hemp		Cooking conditions and yield data										Interpolated test-beater strength data							Permanaganate number	Brightness (unbleached pulp)		
	Moisture	Molat weight	Caustic soda			Duration at maximum temperature		Chemical consumed		Yield moisture-free		75° C. and 50 per cent relative humidity											
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	
	Per cent	Lb.	Grams per liter	Lb.	Gallons	Hrs.	°C.	Per cent	Per cent	Bc. 1	Per cent	Per cent	Cc.	Minutes	Grams per cc.	p Pts. per ream	Grams per lb. per ream	Double folds	Lb. per sq. in.	Lb. per inch-width		Per cent	
1723	89.98	2.22	11.44	8.08	84.8	2	150	100	11.44	3.7	48.3	22.4	860	0	0.41	0.54	3.64	235	2,050	15.2	31.6	18.3	
1712	89.98	2.22	17.16	12.0	83.93	2	150	97.6	11.71	4.8	54.7	1.9	570	20	0.67	1.28	2.42	3,418	6,040	27.6	29.0	21.6	
													200	40	0.65	1.09	1.80	3,418	7,815	34.4			
													150	80	0.70	1.34	1.56	2,097	8,260	38.7			
1713	89.3	2.24	22.85	16.0	83.93	2	150	87.6	14.02	6.0	61.6	.2	860	0	0.47	1.56	4.82	2,385	8,130	35.1	15.2	28.8	
													815	5	0.52	1.02	3.72	2,097	4,010	23.5			
													760	10	0.50	1.32	2.75	3,418	5,720	34.9			
													615	20	0.54	1.42	2.87	2,802	4,850	27.5			
													520	25	0.51	1.59	1.94	1,624	6,680	37.7			
													495	30	0.64	1.52	1.83	1,345	7,190	30.7			
1734	90.16	2.21	22.85	16.0	84.87	2	150	85.9	13.76	6.0	52.5	.2	412	35	0.63	1.52	1.69	1,345	7,860	37.2			
													850	0	0.44	1.56	1.81	2,843	9,750	37.5			
													740	10	0.57	1.31	3.07	2,867	8,850	19.6	14.5	29.4	
													620	20	0.61	1.54	2.58	2,639	6,300	33.6			
													530	30	0.60	1.28	2.34	1,970	7,350	36.7			
													285	40	0.67	1.30	2.97	1,814	7,790	39.7			
													255	50	0.69	1.30	1.88	1,666	8,420	37.9			
																		1,797	9,140	40.3			

1724	89.2	2.22	28.69	20.2	83.98	2	150	78.4	14.83	6.6	49.3	.2	250	60	74	1.46	1,901,338	10,040	41.5	9.5	36.4	
													770	0	.58	1.20	3.64	2,427	5,790	30.5		
													670	10	.58	1.42	2.85	2,143	7,410	39.9		
													600	20	.64	1.38	2.55	1,231	8,400	40.3		
													385	40	.64	1.25	2.12	2,176	8,370	39.8		
1751	91.1	2.20	22.85	16.0	83.93	1	150	88.2	14.1	6.8	50.2	1.5	860	0	.44	.41	4.80	2,100	10,560	44.0	17.0	29.5
													760	10	.53	1.14	2.97		5,400	31.0		
													600	20	.61	1.23	2.38		6,800	34.1		
													440	30	.67	1.43	1.86		7,970	35.9		
													270	40	.63	1.34	1.93		8,260	39.6		
													230	50	.66	1.43	1.90		8,260	37.8		
1752	91.1	2.20	22.85	16.0	83.93	3	150	95.3	15.2	5.3	50.3	.7	135	60	.71	1.41	1.71		8,320	35.8		
													820	0	.50	.68	4.36		2,592	15.7		22.6
													690	20	.61	1.06	2.71		5,942	30.6		
													600	30	.66	1.29	2.10		7,580	37.8		
													395	40	.69	1.34	1.95		8,420	38.7		
													320	50	.70	1.40	1.49		7,560	32.8		
1755	90.16	2.21	22.85	16.0	83.93	2	160	91.2	14.6	6.0	49.0	.2	240	60	.73	1.37	1.51		8,880	38.3		
													850	0	.45	.60	5.12		9,320	38.6		
													755	10	.64	1.37	2.88		2,600	17.5		28.5
													610	20	.58	1.28	2.22		7,140	33.9		
													455	30	.65	1.50	2.02		6,760	35.2		
													320	40	.66	1.42	1.85		8,280	47.1		
													255	50	.74	1.34	1.72		8,610	39.0		
1753	88.4	2.25	22.85	16.0	84.37	2	140	88.6	14.19	6.0	50.4	2.4	220	60	.70	1.57	1.64		9,300	38.2		
													850	0	.41	.57	4.88		7,740	33.5		
													755	10	.46	1.02	8.11		2,060	15.3		19.2
													610	20	.56	1.12	1.91		4,580	30.4		
													470	30	.74	1.31	1.93		6,640	34.6		
													340	40	.65	1.34	1.78		8,190	33.5		
													255	50	.72	1.19	1.73		6,840	32.4		
													160	60	.76	1.32	1.60		7,210	32.5		
1753	90.15	2.22	22.85	16.0	83.93	3	140	94.8	15.2	5.8	50.3	1.5	860	0	.48	.48	4.67		8,380	33.6		
													730	10	.57	1.18	2.88		2,810	14.6		28.3
													550	20	.63	1.45	2.03		6,020	32.2		
													320	30	.66	1.45	1.93		7,390	35.6		
													230	40	.75	1.35	1.93		8,580	39.5		
													190	50	.74	1.36	1.53		9,400	38.3		
													165	60	.74	1.34	1.47		8,590	35.4		
																			9,460	39.2		

! One hour was allowed for the temperature to rise to maximum.

The pulps from cooks 1712, 1713 and 1724 when processed in the test beater for 20 minutes developed a bursting strength of 1.28, 1.46 and 1.42 points per pound per ream, respectively, and a tensile strengths of 6040, 6680 and 7410 lbs. per square inch, respectively. A tear of 2.42 grams per pound per ream was attained for cook 1712, 2.15 grams per pound per ream was obtained from 1713, while 2.85 grams per pound per ream was reached in 1724. The small range of variations in the physical properties of the pulp due to a change in chemical ratio and concentration of the cooking liquor tends to show that pulping abaca waste could be satisfactorily accomplished under mild conditions provided the color of the pulp is not considered important. Pulp yields from mild cooking conditions are generally higher than those obtained from a more drastic type of digestion. Both high pulp yields and low chemical requirements, associated with mild cooking conditions, are advantageous from the point of view of conversion economy.

Maintaining other variables constant, a difference of from 1 to 2 hours in the cooking schedule had no distinct effect on the yield of screened pulp (cooks 1713, 1751 and 1752). With an increase of one hour in the time of digestion (cooks 1751 and 1713), however, a decrease of approximately 1.3 per cent in the screenings on the basis of the moisture-free weight of the material was noted. The total yields from cooks 1713 and 1751 were equal and differ from that of cook 1752 (51 per cent) by 0.8 per cent. The brightness of the pulp from the one hour digestion was slightly higher than the color of the pulps from cooks of longer duration. The pulp obtained from a two-hour digestion (cook 1713) developed, after 20 minute beating, a burst of 1.46 points, a tearing resistance of 2.15 grams per pound per ream and a tensile strength of 6680 pounds per square inch as compared to a burst of 1.23 points, a tearing resistance of 2.38 grams per pound per ream and a tensile strength of 6800 for a one-hour digestion (cook 1751). On the other hand, a three-hour cook (1752) gave a burst of 1.29 points, a tearing resistance of 2.10 grams per pound per ream and a tensile strength of 7580 pounds per square inch. From the standpoint of screened yield and physical properties of the pulps, the two-hour digestions at a maximum temperature of 150°C. with chemical ratios of 12 and 16 per cent on the moisture-free weight of the material were suitable for reducing abaca waste to pulp.

The significance of digestion temperature on pulp yields and on the physical properties of the pulp may be noted from the results obtained from cooks 1733, 1713, and 1735, which were digested at 140°C., 150°C. and 160°C., respectively. It was observed that there was a little difference in the yields of screened pulps when the temperature was increased from 140°C. to 160°C., although the screenings were reduced from 2.4 to 0.2 per cent. Cook 1713 which was digested at a maximum temperature of 150°C. gave the best yield of screended pulp and good physical properties which were practically identical to those obtained from cook 1735 which was digested at a maximum temperature of 160°C. A pulp resulting from a low digestion temperature (cook 1733) seemed to exhibit low bursting strength compared to the strengths of pulps prepared at the higher temperatures.

TABLE 2.—*Physical properties of manila paper and hand sheet.*

Material	Bursting strength	Tearing resistance	Tensile strenght	Folding endurance
	<i>Pts. per lb. per ream</i>	<i>Grams per lb. per ream</i>	<i>Lb. per square inch</i>	<i>Double folds</i>
Experimental hand sheet (cook 1734).....	1.54	2.58	7,350	1,970
Commercial manila paper ¹	1.40	-----	7,305	4,272

¹ Forest Products Laboratory Project 7253-J4.

The physical properties of one of the experimental pulps (cook 2734) beaten for 20 minutes are compared with those of a commercial manila paper in Table 2. In contrast to the identical tensile strengths of the two samples, the folding endurance of the experimental pulp, which could be considered satisfactory, is one half of that of the commercial manila paper. On the other hand, the bursting strength of the commercial sample is a little lower than that of experimental test sheet.

CONCLUSION

1. Abaca waste can be easily reduced to a suitable soda pulp under mild condition of digestion. The production of lighter colored pulps, however, requires slightly more drastic cooking conditions and employing higher temperatures and liquor concentrations.

2. Abaca can be satisfactorily reduced to pulp by cooking for two hours at a maximum temperature of 150°C. with from 12 to 16 per cent caustic soda (NaOH) based on the moisture-free weight of the material.

3. The rate of hydration on beating soda pulp from abaca waste is relatively fast. The pulp is sufficiently hydrated in 20 minutes to give a Schopper-Riegler freeness within the range of 550 to 700 c.c. and an average bursting strength of 1.33 points per pound per ream.

4. The lightest colored pulp had a brightness of 36.4 per cent. The color of most of the pulps was similar to that of kraft pulps made from wood.

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REVIEWS

Bergey's Manual of Determinative Bacteriology. By R. S. Breed, E. G. D. Murray and A. Parker Hitchens. Sixth edition. Baltimore, The Williams & Wilkins Company, 1948, 1529 pp. Price \$15.00.

The sixth edition of Bergey's Manual of Determinative Bacteriology is to the present the most complete study of taxonomy and nomenclature of bacteria. The work is accomplished by the permanent nomenclature committee created by the International Society of Microbiologists.

The nomenclature used in the latest edition differs from that in the previous edition. In the present edition the nomenclature is based upon the similar antigenic structures which identify the serotypes rather than the species. The inclusion of the *Salmonella typhosa* in the Genus *Salmonella*, called formerly *Bacillus typhosus* and *Eberthella typhosa*, is an example.

Besides the committee, sixty contributors assisted in the preparation of this edition. Since this book is the product of extensive study of renowned bacteriologists and specialists it

is therefore highly recommended as a valuable reference material for all scientific institutions and researchers. The duplication of names of certain species of bacteria has been rather confusing to any one who is unaware of the existence of certain synonyms. The publication of this manual has solved that confusion. Furthermore, this book also gives the general rules of nomenclature and principles of taxonomy so that a student of bacteriology may readily recognize the terms used regularly in classification. Following the rules outlined in this book it is easy for the students to identify a certain microorganism which they may encounter in their research work.

The book is really an invaluable help. People interested in bacteriology should consider its acquisition as a real and permanent investment.—M. B.

Biochemical Preparations. By Advisory Board, W. Mansfield Clark and others; Editorial Board, Herbert E. Carter, Ed.-in-Chief. New York, John Wiley & Sons, Inc., 1949. v.1. Price \$2.50

This book is the first volume of what is to be hoped a rich and comprehensive contribution to detailed methods of the preparations of various substances of biochemical origin.

It follows the same trend as the series of Organic Synthesis and Inorganic Synthesis series—but as the title indicates the book gives detailed methods as to the separation and purification of certain biochemical products from natural sources, as well as synthesis of some from organic compounds.

Methods are claimed to be precise as they have been counter-checked.—F. M. Y.

Experimental Physics for Colleges. By Walter A. Schneider and Lloyd B. Ham. Revised edition. New York, The Macmillan company, 1949. 442 pp., illus. Price, \$3.80.

The book is a revised edition of the text by the same authors on experimental physics for elementary students.

The new edition is, as the title indicates, intended for use in colleges. It is composed of 7 parts: Part 1, Units and Measurements; Part 2, Mechanics; Part 3, Sound; Part 4, Heat; Part 5, Electricity; Part 6, Light; Part 7, Notes and Tables. There are 34 chapters, 56 experiments and 12 standard tables. An index is included.

The authors succeeded in this new revised edition, in presenting the subject of experimental physics for colleges, in a clear and concise manner, particularly to those who want to pursue advanced studies in physics. The mathematical treatment is in

accord with those covered in the first year of college. Figures are included to help the reader in understanding the different principles involved in the experiments. Like any other book of this kind, numerous problems are given to increase its usefulness to both the instructors and students. The chapter on Notes and Useful Instruments and Procedures is a good addition to the book. As a whole, the book is recommendable as a reference or as a text to those interested in somewhat advanced treatment of experimental physics, especially those in colleges.—G. O. O.

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MARCOS A. TUBANGUI: IN MEMORIAM *

On October 26, 1949, Dr. Marcos A. Tubangui, our foremost Filipino parasitologist of international renown, passed to the Great Beyond after a short illness. His passing is a great loss, not only to the Philippines, but also to the whole science of parasitology; it left a void which will be difficult to fill for many years to come.

Dr. Marcos A. Tubangui was born in Porak, Pampanga, on April 25, 1893. He studied in the public schools and graduated from the College of Veterinary Science, University of the Philippines, in 1918. After graduation, he served as veterinarian in the Bureau of Agriculture for a year, and then was sent abroad as fellow of the University of the Philippines.

While in the United States, he attended the Marine Biological Laboratory at Woods Hole, Massachusetts; the University of Illinois; and worked at the Bureau of Animal Industry, U. S. Department of Agriculture. In 1921, he received his Master of Science degree at Cornell University.

Upon his return to the Philippines in that year, he was made instructor and, later, assistant professor of veterinary parasitology, University of the Philippines. In 1931, he transferred to the Bureau of Science and spent the best years of his life as Chief of the Division of Biological Research. In 1948 he was appointed Professor and Head of the Department of Parasitology, Institute of Hygiene, University of the Philippines, a position which he held until his death.

* By Dr. T. P. Pesigan, senior parasitologist and chief, Schistosomiasis Control Program, Department of Health, Republic of the Philippines.

Dr. Tubangui was an active member of many learned societies and professional organizations. He was a member of Sigma Xi, the American Association for the Advancement of Science, the American Society of Parasitologists, the Society for the Advancement of Research, Los Baños College, of which he was once Secretary, the Philippine Scientific Society, the Philippine Veterinary Medical Association, the Philippine Medical Association (associate member), the National Research Council of the Philippines (Charter Member), and the Philippine Society of Parasitology, of which he was President for many years until his death.

He contributed a great deal to the science of parasitology, particularly taxonomy of many helminths. He wrote and published many scientific papers on both medical and veterinary parasitology. Most outstanding of his contributions to medical parasitology are the complete life cycle of *Euparyphium ilocanum* which he worked out, and his discovery of the molluscan intermediary host of the *Schistosoma japonicum* in the Philippines. With these investigations, he paved the way towards the control of these parasitic diseases in this country. He also left several unfinished works, especially on paragonimiasis and filariasis, which even a few days before his death, he repeatedly told his wife he would wish to continue, still hoping he would get well.

The career of Dr. Tubangui is a great inspiration to the young researchers of the Philippines; for as a leader in his field, he was always helpful and kind to his younger associates. They, in turn, loved and respected him. Above all, he was always a silent and devoted worker. He sustained his enthusiasm for research until his death, despite difficulties. His deep understanding of human nature and his undying interest in his work always kept him away from controversies. He died a true scientist in the strict sense of the word.

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MARCOS A. TUBANGUI

HUMAN MILK STUDIES: I. THE THIAMINE CONTENT OF MATURE NORMAL MILK AND BERIBERI MILK¹

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The study of thiamine content of breast milk is important in this country since it is the only natural source of thiamine available to breast fed babies. Moreover, it has been found in the past that the death rate among the breast fed infants was higher than that of artificially fed babies. This was due to the fact that infantile beriberi was mostly found among the breast fed infants.

Vedder and Clark(1) have found that 5 cc of fresh cow's milk did not prevent polyneuritis in birds on a polished rice diet. Gibson(2) in studying the protective power of normal breast milk of Filipinos against polyneuritis gallinarum has found that it contained not more than one-fourth the amount of vitamin of cow's milk. Again Gibson and Concepcion(3) in studying the influence of fresh and autoclaved milk on the development of neuritis in animals have demonstrated that 20 cc of fresh human milk of Filipino mothers did not prevent birds on a polished rice diet from developing polyneuritis. The observation of Clements(4) that breast fed infants frequently exhibit partial thiamine deficiency is of interest in this connection. He also noted that partial thiamine deficiency was frequently found among the breast fed infants in Australia and attributed it to suboptimal quantities of thiamine in the milk, resulting from insufficient intake. On the other hand, Sundarajan(5) found that the average thiamine content of milk among women with beriberi in India was not less than the values found among normal women. In view of this contradictory findings the determination of thiamine content of normal as well as beriberi milk is of special interest in this country in

¹ Aided by special grant from the Institute of Nutrition.

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order to establish the relationship, if there is any, between low thiamine and infantile beriberi.

METHOD OF STUDY

The present study is a report on the thiamine determination made on 140 samples of mature milk taken from both breasts of healthy mothers eating self-chosen diets and 21 samples of beriberic milk from others whose babies showed characteristic symptoms of infantile beriberi. The samples were taken between 9 and 10 a.m. and in different stages of lactation. The total thiamine was determined by the method described by Kendall(6) with a slight modification and can be described as follows:

Five ml. of milk is placed in each one of the four reaction vessels and then 0.25 ml. of 10 per cent freshly prepared takadiastaseis added. Then 0.25 ml. of 10 per cent acetic acid is added. Incubate for 3 hours at 37°C. At the end of the period remove the reaction vessels and add 1 ml. of thiamine standard solution to the reaction vessel No. 3. Then add 3 ml. of the oxidizing reagent (0.1 ml. of 1 per cent $K_3Fe(CN)_6$ in 3 ml. of 15 per cent NaOH) to each of the vessels Nos. 1, 2 and 3. To vessel No. 4 add 3 ml. of 15 per cent NaOH. Shake the vessels from end to end gently for 45 seconds then add to each vessel 13 ml. of redistilled isobutanol. Shake again gently for exactly $1\frac{1}{2}$ minutes. Centrifuge for 5 minutes, draw off the aqueous layer. Pour the isobutyl layer into the cuvettes and read after adjusting the reading of the fluorophotometer with the quinine standard.

The calculation is made as follows: The average reading of reaction vessels Nos. 1 and 2 less the reading of the blank (R.V.4) divided by the reading of the reaction vessel No. 3 minus the average readings of reaction vessels Nos. 1 and 2 times 20 equals micrograms of thiamine per 100 cc milk.

RESULTS

The results of the present investigation are summarized in Tables 1, 2, 3 and 4.

As shown in Table 1 the mean of 140 samples of normal milk is $7.691 \text{ mcg.} \pm 0.322$ with a standard deviation of 3.820. On the other hand, the mean of 21 cases of beriberic milk as shown in Table 2 is 4.97 ± 0.677 with a standard deviation of 3.0277.

TABLE 1.—Total thiamine content of normal milk.

Age of milk	No. of samples	Mean thiamine	S. D.	S. E. M.
		<i>mcg</i>		
1 month.....	15	7.995	3.944	1.054
2 months.....	21	5.438	3.122	0.698
3 months.....	22	9.31	4.256	0.9286
4 months.....	14	6.99	3.494	0.969
5 months.....	19	8.813	4.092	0.964
6 months.....	14	9.22	5.775	1.602
7 months.....	8	6.218	3.955	1.722
8 months.....	11	7.957	2.851	0.902
9 months.....	4	5.335	3.007	1.736
10 months.....	1	12.03		
11 months.....	4	6.337	0.948	0.548
12 months.....	7	6.79	4.489	1.837
	140	7.691	3.820	0.322

TABLE 2.—Total thiamine content of beriberic milk.

Age of milk	No. of samples	Mean thiamine	S. D.	S. E. M.
		<i>mcg</i>		
1 month.....	7	4.34	3.935	1.607
2 months.....	4	4.03	2.607	1.558
3 months.....	2	6.25	3.35	3.35
4 months.....	5	5.912	2.736	1.368
5 months.....	3	5.24	1.087	0.769
	21	4.97	3.0277	0.677

TABLE 3.—Total thiamine content of normal milk during the first five months.

Age of milk	No. of samples	Mean thiamine	S. D.	S. E. M.
		<i>mcg</i>		
1 month.....	15	7.9954	3.944	1.054
2 months.....	21	5.4380	3.122	0.698
3 months.....	22	9.3100	4.256	0.9286
4 months.....	14	6.9900	3.494	0.969
5 months.....	19	8.8130	4.092	0.964
	91	7.740	3.984	0.420

TABLE 4.—Thiamine content of human milk as reported by various authors.

Investigator	Method	Subjects	Samples	Period of lactation	Total thiamine
					<i>mcg</i> 100 cc
Kendall.....	Thiochrome ..	63	-----	2-10 da.	0.0-9.0
Slater and Rial.....	Thiochrome ..	29-31	80-61	3-38 wk.	12.7
Roderuck et al.....	Thiochrome ..	65	90	2-10 mo.	14.8
This series.....	Thiochrome ..	140	140	1-12 mo.	7.6

Since the beriberi cases were only found between the ages one and five months, we cannot very well compare them with the normal because their ages range from one to twelve months. The logical comparison is to compare the beriberi cases with the normals from one to five months also. This is summarized in Table 3. The difference in the mean between the normal and beriberic milk, as shown in Tables 2 and 3, is 2.77. This difference when studied statistically was found to be significant. The value of t being 3.48 which is significant even at 1 per cent level.

COMMENT

According to Slater and Rial(7) the average total thiamine content of milk from 3 to 38 weeks is 12.7 mcg. per 100 cc. as shown in Table 4. Roderuck *et al.*(8) found an average of 14.8 mcg. per 100 cc. from 2 to 10 months. Knott's group(9) found an average of 15.1 mcg. per 100 ml. for mature milk. All these findings were higher than the result of the present investigation. This can only be explained by the difference in the thiamine content of the diet. This explanation is supported by the high incidence of beriberi in this country. According to Roderuck *et al.*, diet showed a clean cut relationship to the thiamine content in human milk.

The average concentration of thiamine in milk remained relatively constant after the fourth week of lactation according to Roderuck *et al.* Knott reported that the thiamine in milk reached the level characteristic of the subject in three weeks. On the other hand, Slater and Rial found a gradual increase in the thiamine content until the twentieth week. Our results cannot corroborate or disprove those findings because our samples were not 24-hour samples.

Knott(9) reported some determination of thiamine content of breast milk from 17 women where figures range from 3-18 mcg. per 100 cc. with an average of 9 mcg. She attributed this low thiamine content of human milk to the low content of thiamine in the diet since food is an important factor influencing the thiamine content of breast milk. The question of whether breast milk is adequate in meeting the thiamine requirements of infants has been answered by Knott *et al* when they stated that the minimum thiamine requirement of young infants (1 to 6 months of age) is approximately 200 mcg. daily. This amount can just be met by a normal healthy infant if his mother's milk contains 20 or more mcg. of thiamine per 100 cc. They suggested that 40 mcg. per kilogram body weight may be necessary to supply the needs of the infant. This finding was corroborated by Holt *et al.*(10).

SUMMARY

1. One hundred forty samples of mature human milk from normal women taking ordinary diet have been assayed for total thiamine and a value of 7.691 mcg. \pm 0.322 per 100 ml. with a standard deviation of \pm 3.820 was found.

2. Twenty one samples of mature human milk from mothers whose babies showed clinical symptoms of infantile beriberi have been assayed for total thiamine and a mean value of 4.97 \mp 0.677 per 100 ml. milk with a standard deviation of \mp 3.0277 was found. The difference in the mean between normal and beriberic milk was found to be statistically significant. The value of *t* being 3.48 which is significant even at 1 per cent level.

3. The determination of thiamine content of milk may be of some help in the diagnosis of beriberi when the clinical symptoms of the disease are not quite conclusive.

4. Because of the limited number of samples of beriberi milk examined, it is rather risky to give a definite conclusion whether the mean figures given here are of some practical value in the diagnosis of beriberi or not even though the difference between the two means is statistically significant.

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OBSERVATIONS ON THE PREVALENCE OF TABANID FLIES AND SURRA-TRANS- MISSION EXPERIMENTS

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ONE PLATE AND ONE TEXT FIGURE

Of the known vectors of surra, the horseflies are considered the most dangerous. It has been estimated that there are about 2,000 known species of horseflies in the world. Patton and Cragg (1913) recorded 106 Oriental species belonging to the genus *Tabanus*, two of which are known to exist in the Islands (*Tabanus vanderwulpi* and *Tabanus striatus*). Schuurman Stockhoven, Jr. (1926) recorded 239 species in the Dutch East Indian Archipelago and neighboring countries in the Far East, of which four occur in the Philippines, namely, *Tabanus striatus*, *Tabanus reducens*, *Tabanus flexilis* and *Tabanus factiosus*. Perhaps the most comprehensive systematic study of the genus *Tabanus* in the Islands is that of Kroeber (1924) who listed 13 species, among which are the following: *Tabanus ixion*, *Tabanus univentris*, *Tabanus flaviventris*, *Tabanus rubidus*, *Tabanus fumifer*, *Tabanus malayensis*, *Tabanus philippinensis*, *Tabanus malanopygatus* and *Tabanus graiseoscutellatus*. All told, fourteen species of *Tabanus* have been described from the Philippines, of which *T. striatus* and *T. reducens* appear to be the most common (Pl. 1, figs. 1 and 2).

INCIDENCE OF *TABANUS STRIATUS* AND *TABANUS REDUCENS*

The study on the occurrence of horseflies was conducted on the grounds of the Bureau of Animal Industry, and also on a lot formerly occupied by the College of Veterinary Medicine in Pandacan, Manila. The marshy land and the zacate field in the immediate vicinity were also included in the survey. Most of the flies collected were caught from the telegraph and electric posts on the sides of the abandoned railway tract crossing the area. A random examination of the soil in this area revealed the presence of larvæ of horseflies, suggesting that it is a breeding place of tabanid flies. Previous observations have shown that the flies usually rest on the posts during

the middle of the day. For this reason, the collection of flies was made between 12:00 and 1:00 o'clock in the afternoon. The work was started during the Japanese occupation but since some of the data pertaining to that period were lost, only those collected after liberation are included in this paper.

During a period of three years and two months (November, 1945 to December, 1948), 854 tabanids were caught, of which 480 were *Tabanus striatus* and 374 *Tabanus reducens*, the former exceeding the latter by 106 flies. Of the 480 *Tabanus striatus* 57 were males, the male—female ratio being thus 1:7.42. In the case of *Tabanus reducens*, 14 were males and 360 females, the male—female ratio being 1:25.71. It will be noted that there were more than 4 times more males of *Tabanus striatus* than *Tabanus reducens* and this may account partly for the greater number of *Tabanus striatus* collected during the period under consideration.

While the female flies were seen throughout the year, the males were absent during certain months. In the case of *Tabanus striatus*, males were not found during June and July; the maximum catch of 15 male flies was made during the month of February and the minimum catch of one fly, during May. In the case of *Tabanus reducens*, three males were collected during each of the months of January, October, November, two in December and one each in February, March and May. None were found during April, June, July, August and September.

THE INFLUENCE OF RAINFALL ON THE MONTHLY DENSITY OF TABANID FLIES

Of the factors which may be responsible for the monthly fluctuation in the prevalence of tabanid flies, only the rainfall seems to have an appreciable influence. A summary of the fly collections during the three year period and the corresponding rainfall data are presented in Figure 1 and Table 1. Although tabanid flies were always found during the three-year period, it is shown they were more abundant during certain months. A subpeak representing 37 flies was observed in February and this was followed by a gradual decline up to June, when the smallest collection of 4 flies was recorded. Thereafter, the monthly average catch increased up to October when the maximum collection of 72.6 flies was made. After this month, the fly-densities decreased up to the end of the year. In general, the data agree with those of Mitzmain (1913) who found *Tabanus striatus* to be prevalent from October to March in the

vicinity of Manila. On the other hand, Kelser (1927) observed that during 1926 *Tabanus striatus* commenced to make its appearance in and around Manila in appreciable number during the later part of July and that by the middle of August great numbers of flies were in evidence. Manreza and Mondoñedo (1935), working in Los Baños, Laguna, also recorded a monthly fluctuation in the density of *Tabanus striatus*. They made their maximum collection in May, the minimum in October. It thus appears that the monthly prevalence of horseflies varies considerably in different localities and possibly during different years. Correlating the monthly collections with the seasonal distribution of the annual rainfall, as shown in Figure 1, it is seen that

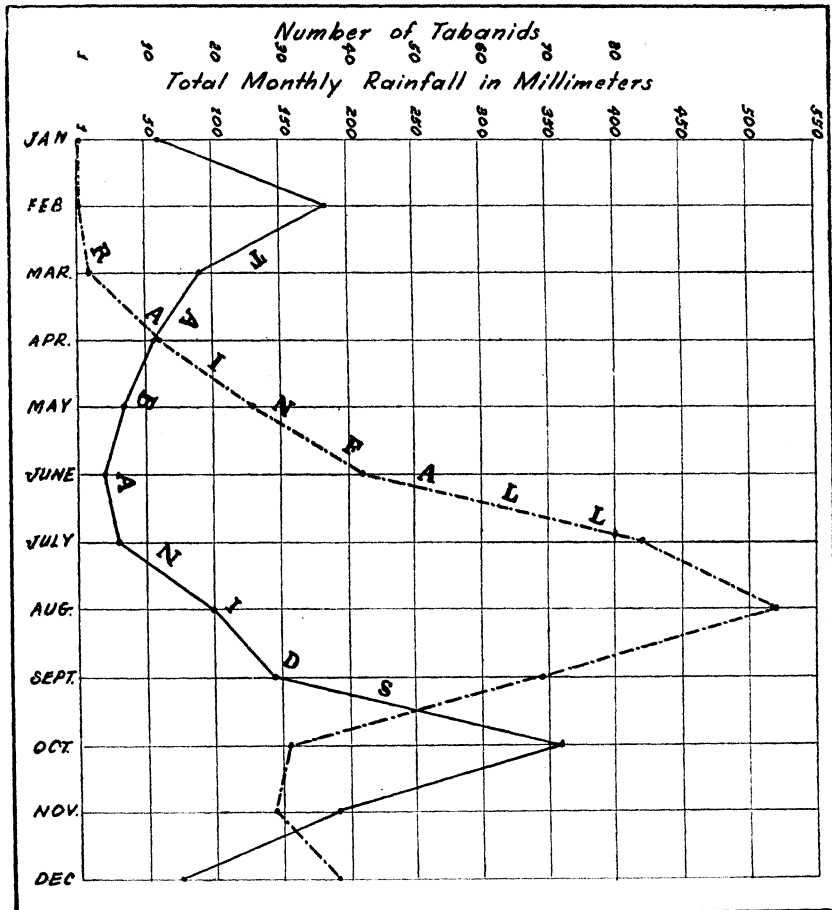


Fig. 1. Influence of rainfall on the numerical fluctuation of tabanid flies.

tuation in the density of *Tabanus striatus*. They made their maximum collection in May, the minimum in October. It thus appears that the monthly prevalence of horseflies varies considerably in different localities and possibly during different years. Correlating the monthly collections with the seasonal distribution of the annual rainfall, as shown in Figure 1, it is seen that

the peak of fly incidence in October occurs two months after the heaviest rainfall in August. In British East Africa Leese (1914) observed that species of *Tabanus* are abundant during and after the rainy season, the numbers falling off greatly as the dry season advances.

TABLE 1.—Data on rainfall and its relation to tabanid incidence

Months	Average for three-year period		Months	Average for three-year period	
	Tabanids	Rainfall in mm.		Tabanids	Rainfall in mm.
January.....	12.3	2.6	July.....	6.6	418.2
February.....	37.0	2.6	August.....	20.6	523.7
March.....	18.6	10.7	September.....	29.3	347.2
April.....	11.3	69.6	October.....	72.6	157.9
May.....	7.3	127.1	November.....	38.0	145.3
June.....	4.0	212.9	December.....	15.2	186.8

TABANUS REDUCENS AND TABANUS STRIATUS IN SURRA TRANSMISSION

Since no records are available that *Tabanus reducens* has been found guilty as a vector of *Trypanosoma evansi*, it seemed desirable to test this horsefly in the laboratory. For comparative purpose, *Tabanus striatus* was also used in the transmission experiments. Guinea pigs and white rats kept in a fly-screened enclosure were utilized. The horseflies used were selected from those collected during the survey. It may be noted here that only a small percentage of the flies could be induced to bite under experimental conditions and could not be kept alive in the laboratory for long periods of time. In one instance, however, a *Tabanus reducens* was maintained in captivity for a period of one month.

The feeding of flies was carried on in small wire baskets applied on surra-infected guinea pigs where the hair had been previously clipped close to the skin. As a rule, the flies were allowed to feed for from 30 seconds to one minute, after which they were transferred to a clean white rat where the hair had also been previously shaved. The intervals between feedings ranged from 20 seconds to one and one-half minutes. In some of the flies four to five interrupted feedings could be carried on before they refused to bite any further.

For convenience, the results are summarized in Table 2. Of four experiments with *Tabanus reducens*, three were positive. With *Tabanus striatus*, only one positive result was recorded

out of the four trials and it was due to the use of eight flies in 32 interrupted feedings. Mitzmain (1914) had practically the same experience with *T. striatus*, for in his experiments he obtained only three positive results out of 16 trials. It thus appears that *Tabanus reducens* is a more efficient transmitting agent of the surra parasite than *Tabanus striatus*. Since the method of transmission is purely mechanical, it is most probably the larger size of the fly and its mouth parts which make it a more dangerous vector. Measurements made from a number of specimens show that *Tabanus reducens* is approximately one-third longer and broader than *Tabanus striatus* and its mouth parts are correspondingly bigger.

TABLE 2.—*Data on the mechanical transmission of surra by T. reducens and T. striatus*

Expt. No.	Density of trypanosome in peripheral blood of surra infected guinea pig per cu. mm.	Species and number of fly used	No. of bite	Clean animal used	Results
1	250,000	<i>T. reducens</i> ----- 2	5	White rat	+
2	150,000	-----do----- 1	4	do	—
3	200,000	-----do----- 2	6	do	+
4	80,000	-----do----- 2	6	do	+
5	300,000	<i>T. striatus</i> ----- 3	10	do	—
6	120,000	-----do----- 2	5	do	—
7	160,000	-----do----- 8	32	do	+
8	100,000	-----do----- 2	5	do	—

With *T. reducens* there are at least 22 species of tabanid flies which have been proven experimentally to transmit *Trypanosoma evansi*. The others, according to the investigations of Sergeant, Ed. and Et. (1905 b and 1906 a), Fraser and Symonds (1908), Mitzmain (1912), Kelsner (1927), Cross and Patel (1922), and Nieschulz (1926, 1927, 1929, and 1941), are: *T. albimidus*, *T. albitriangularis*, *T. bilateralis*, *T. brunipes*, *T. ceylonicus*, *T. fumifer*, *T. griseipalpis*, *T. hilaris*, *T. immanis*, *T. latifacies*, *T. malayensis*, *T. minimus*, *T. nemocallosus*, *T. nemoralis*, *T. partitus*, *T. rubidus*, *T. rufiventris*, *T. striatus*, *T. vagus*, *T. vanecki*, and *T. tropicus*.

SUMMARY

Observations on the monthly prevalence of tabanid flies were made. During a period of a little over 3 years, 854 flies were caught, of which 480 were *Tabanus striatus* and 374 *Tabanus reducens*. The male—female ratio of the former is 1:7.42, the latter, 1:25.71. A large number of males were collected during February and March. The peak of fly-incidence occurred in

October or two months after the heaviest rainfall in August. A subpeak was noted in February following an increase in the rainfall during December.

Positive results were obtained in experiments on surra transmission using *Tabanus reducens* and *Tabanus striatus*. *Tabanus reducens* appeared to be a more efficient vector than *T. striatus*, due probably to its bigger size.

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ILLUSTRATIONS

PLATE 1

- FIG. 1. Female and male *Tabanus reducens*.
2. Female and male *Tabanus striatus*.

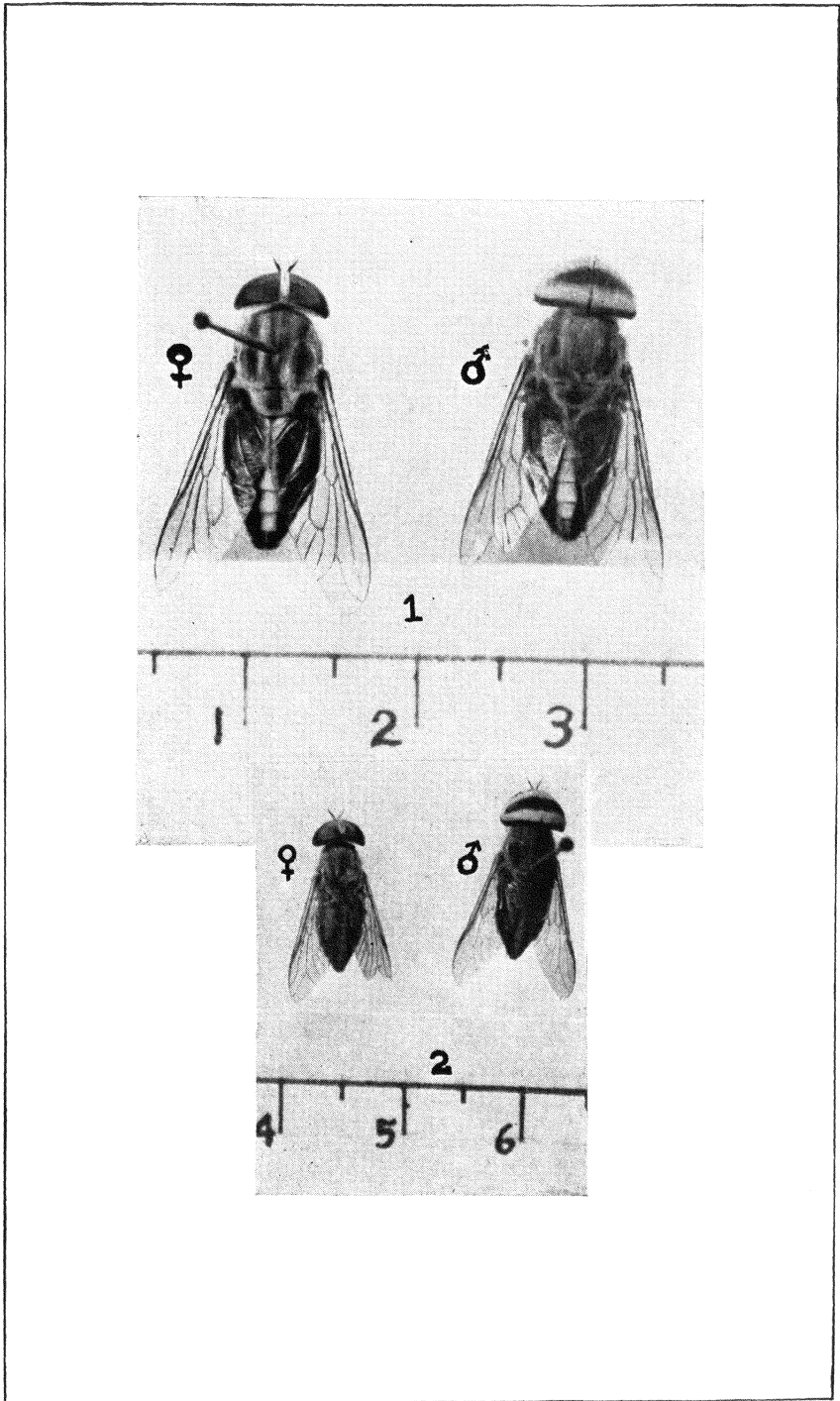


PLATE 1.

ASPIDIACEAE OF NEW GUINEA *

By EDWIN BINGHAM COPELAND
Of the University of California, Berkeley

FORTY-FOUR PLATES

This paper includes material based on work mostly performed from 1939 to 1941, and included in several papers originally submitted for publication in The Philippine Journal of Science. It is recast here, in conformity with classification and nomenclature of my Genera Filicum. When war made the publication of these papers impossible, even after proof had been corrected, and the fate of my manuscripts unknown (all are known now to have been destroyed), I guarded the names of the many novelties by publication of diagnoses in Univ. Calif. Publ. Bot. 18 (1942) 217-226. The descriptions and illustrations, necessary to make these novelties certainly and easily recognizable, appear here for the first time.

Key to Genera of New Guinea Aspidiaceae

Fronds dimorphic.

Veins free.

Not widely scandent, fronds simple 14. *Elaphoglossum*

Rhizome scandent, fronds compound.

Sori distinct 10. *Thysanosoria*

Sporangia covering fertile surface.

Terminal leaflet not articulate 9. *Lomariopsis*

Distal leaflet jointed or suppressed.

Leaves in two rows on rhizome..... 11. *Teratophyllum*

Stipes polyseriate 12. *Arthrobotrya*

Veins anastomosing.

Without included veinlets.

Widely scandent 13. *Lomagramma*

Not scandent.

Rhizome short, fronds clustered 20. *Stenosemia*

Rhizome creeping, fronds remote 8. *Bolbitis*

Included veinlets present.

Rhizome short, fronds clustered 22. *Hemigramma*

Rhizome creeping 8. *Bolbitis*

* This paper is in part a report on the ferns collected by the third Archbold Expedition to New Guinea, in collaboration with the Government of the Netherlands Indies. Previous reports were published in the Philip. Jour. Sci. 73 (1940) 345 and 457; 75 (1941) 347; and 76 (1941) 23; and Univ. Calif. Publ. Bot. 18 (1942) 217.

Fronds not dimorphic or slightly so.

Veins free.

Indusium wanting.

- Sori round 23. *Lastrea*
 Sori elongate 24. *Currania*

Indusium elongate along vein.

- Pinnules articulate, subdimidiate 6. *Didymochlaena*

Indusium ovate, free at apex 2. *Stenolepia*

Indusium round, bursting on top 1. *Diacalpe*

Indusium peltate.

- Pinnae articulate to rachis 5. *Cyclopeltis*

Pinnae not articulate.

Articulate hairs wanting.

- Fronnd dilated at base 7. *Rumohra*

- Fronnd not widened at base 4. *Polystichum*

- Articulate hairs on rachis 17. *Dryopolystichum*

Indusium reniform.

- Nodes of rachis enlarged 3. *Acrophorus*

Nodes not enlarged.

- Axes bearing pluricellular hairs 16. *Ctenitis*

Glabrous, or hairs unicellular.

- Each sinus occupied by a tooth 18. *Pteridrys*

Sinuses not tooth-bearing.

- Minor axes decurrent on major 15. *Dryopteris*

Minor axes not decurrent.

- Fronnd anadromic, base broad 7. *Rumohra*

- Fronnd catadromic 23. *Lastrea*

Fronds anastomosing in regular pairs.

Fronnd not proliferous.

Rachis not spiny.

- Indusium roundish, fixed by sinus 25. *Cyclosorus*

- Indusium oblong, fixed along middle 27. *Sphaerostephanos*

- Rachis spiny, sori linear 30. *Callipteris*

Fronnd proliferous 26. *Ampelopteris*

Veins anastomosing irregularly.

Areolae costular only, costal sori elongate 19. *Heterogonium*

Areolae not all costular, or sori round.

- Free included veinlets present 21. *Tectaria*

Free included veinlets wanting.

- Indusium opening along margin 28. *Athyrium*

- Indusium bursting on top 29. *Diplaziopsis*

1. DIACALPE Blume

D. ASPIDIODES Blume

D. aspidioides Blume, Enum. (1828) 241.

Carr. 14567, Boridi, alt. 1,800 m; *Brass 4115*, Mt. Tafa, alt. 2,300 m.

To India and China.

2. STENOLAPIA Van Alderwerelt Van Rosenburgh

S. TRISTIS (Blume) v.A.v.R.

S. tristis (Blume) v.A.v.R., Bull. Dépt. Agric. Ind. Néerl. No. 27 (1909) 46, Pl. 7.

var. *papuana* C. Chr., Brittonia 2 (1937) 294.

var. *reducta* C. Chr., *ibid.*

Brass 4234, 4329, 4482, Mt. Albert Edward, alt. 3,680 m; Clemens, Mt. Sarawaket.

The species is known elsewhere to be very plastic under the influence of exposure, and var. *reducta* is a stunted form.

The species in Java and Borneo.

3. ACROPHORUS Presl

A. STIPELLATUS (Wallich) Moore

A. stipellatus (Wallich) Moore, Gard. Chron. (1854) 135.

A. stipellatus var. *montana* Ros., Fedde's Repert. 12 (1913) 166.

A. Blumei Ching, Gardens' Bull. 7 (1934) 226.

Brass 10716, Lake Habbema, alt. 2,800 m; 12219, alt. 1,750 m; *Keysser II* 73, II 76 (isotype of var. *montana*), Bolan, alt. 2,400–3,000 m.

Paying some regard to geographic distribution, and judging by specimens I have seen, alive and in herbaria, I feel constrained to construe *Acrophorus* as a genus of one known variable species. It varies in size, and therewith it may be three times or four times pinnate. It varies in size of pinnules, in prickliness, chaffiness and hairiness of the axes, and in size of indusia. But there is not an Indian species characterized by one set of characters, nor a Javan species with another set, which might be the *A. stipellatus* and *A. Blumei* of Ching and Christensen. *Wallich* 359, from Nepal, is fully quadripinnate, with very small ultimate pinnules; its axes are very nearly smooth, and the indusia small; but specimens like it in the four characters mentioned are in hand from Sumatra and Fiji. Borneo and Luzon specimens are most scaly, and this strain extends to Formosa. Judging by material in hand, the species runs small in China, and very large in Fiji.

ACROPHORUS LOXOSCAPHOIDES (Baker) Alston

Acrophorus loxoscapoides (Baker) Alston, Jour. of Bot. (1939) 288.

Polypodium loxoscapoides Baker, Jour. of Bot. 29 (1890) 107.

Dryopteris loxoscapoides C. Chr., Index (1905) 276.

Leucostegia loxoscapoides C. Chr., Suppl. III (1934) 120.

"The type is an exceedingly poor specimen, but this appears to be the correct disposition of it,"—Alston, l. c. I have no other opinion, but would emphasize the word *appears*. The type was collected by MacGregor, "Mount Musgrave and 9,200 ft. on Owen Stanley range."

Dryopteris subdigitata Brause, Engler's Jahrb. 56 (1920) 94, was also treated as *Leucostegia* by Christensen, Suppl. III 98 and 121, with the suggestion that it, and *Davallia Forbesii* Gepp, Journal of Bot. (1923) Suppl. 59, might both be *Leucostegia loxoscaphoides*.

4. POLYSTICHUM Roth

Key to the species

- | | |
|--|------------------------------|
| Fronde over half as broad as long | 1. <i>P. keysserianum</i> |
| Fronde over twice as long as broad. | |
| Pinnules or segments not strongly bullate. | |
| Lamina at least 30 cm long. | |
| Freely tripinnate | 2. <i>P. bamlerianum</i> |
| Only lowest pinnules or none pinnate. | |
| Pinnules acute or aculeate. | |
| Segments of pinnae mostly connected..... | 3. <i>P. aculeatum</i> |
| Pinnules mostly free. | |
| Free pinnules less than 15 pairs. | |
| Sori costal to medial. | |
| Some pinnae over 15 cm long..... | 3. <i>P. aculeatum</i> |
| Pinnae smaller. | |
| Pinnules weakly mucronate..... | 3. <i>P. aculeatum</i> |
| Pinnules very mucronate | 4. <i>P. Archboldii</i> |
| Sori submarginal | 5. <i>P. Brassii</i> |
| Free pinnules about 20 pairs..... | 6. <i>P. bolanicum</i> |
| Pinnules rounded, hardly mucronate. | |
| Pinnules crenate to entire | 7. <i>P. muticum</i> |
| Pinnules incised to subpinnate | 8. <i>P. Myer-Dreesii</i> |
| Lamina usually under 25 cm long. | |
| Stipes conspicuously stout | 9. <i>P. papuanum</i> |
| Stipes slender. | |
| Pinnules acute | 10. <i>P. kinabaluense</i> |
| Pinnules rounded | 11. <i>P. alpinum</i> |
| Pinnules and segments strongly bullate. | |
| Fronde lanceolate | 12. <i>P. cheilanthoides</i> |
| Fronde linear | 13. <i>P. lineare</i> |

1. *P. KEYSSERIANUM* Ros.

P. keysserianum Ros., Fedde's Repert. 10 (1912) 331.

Keysser 60, Sattelberg, alt. 1,600 m, isotype in Herb. Univ. Calif.; also, *Keysser 19*, much less dissected than the type. Endemic.

2. *P. BAMLERIANUM* Ros.

P. bamlerianum Ros., Fedde's Repert. 10 (1912) 330.

Bamler K 10, Cromwell Mountains, alt. 1,600 m, isotype in Herb. Univ. Calif. Our specimen of *Bamler K 10 a*, var. *ferrugineo-paleacea*, a segregate from the type collection, is also tripinnate, but is more ample and more scaly; it is approximately *P. moluccense* (Blume) Moore; but as it does not fit Rosenstock's varietal description, some error is suspected. Endemic.

3. *P. ACULEATUM* (L.) Schott

P. aculeatum (L.) Schott, Genera (1834) Pl. 9, note.

Construed in its usual broad sense, this can include *Brass 12666*, alt. 2,150 m; *13665*, alt. 700 m; and *13384*, alt. 850 m; *Bamler 138* (1914); and *Keysser 203*; these represent a single species. Related to it is *Schlechter 16921*, received as *P. aculeatum* var. *subamoenum* Christ, a doubtful identification. *Keysser 201* is distinct, but is more like the *P. aculeatum* of Europe than is any other New Guinea collection.

Cosmopolitan, as construed.

4. *P. ARCHBOLDII* Copel.

Plate 1.

P. Archboldii Copel., Univ. Calif. Publ. Bot. 13 (1942) 221.

P. gregis *P. aculeati* lamina coriacea rhachi inter alias paleis lanceolatis patentibus onusta; rhizomate adscendente 5–8 mm crasso, paleis atrocastaneis 1 cm longis basibusque stipitum profunde immerso; stipite 30 cm alto, erecto, sordide fusco, paleis variis maximis 13 mm longis 2.5 mm latis apice acicularibus dentibus minutis remotis recte distantibus ciliolatis ornato et furfuraceo; lamina 40 cm longa, 12 cm lata, acuminata, subtripinnata, rhachi paleis 5 mm longis lanceolatis aciculari-acuminatis rectis vel tortis integris vel ciliatis ornata aliisque variis et acicularibus et amorphis dense vestita; pinnis infimis 8 cm longis vix deflexis, sequentibus 9 cm longis breviter (2 mm) pedicellatis, acutis, basi oblique truncatis, rhachibus paleis minoribus vestitis; pinnulis ca. 15-paribus, mucronatis, infimis acroscopicis maximis ca. 17 mm longis, basi obliquis, pinnula secundaria una acroscopica, pinnulis sequentibus auriculatis gradatim apicem brevem incisum versus pinnae decrescentibus, utraque facie pilis paucis debilibus vestitis; soris inframedialibus, indusiis parvis peltatis fugacibus.

Dutch New Guinea: 7 km N-E. of Wilhelmina-top, alt. 3,560 m, *Brass & Myer-Drees No. 9850*. "Subalpine forest; occasional on mossy forest floor; clumps 60–80 cm high; fronds 3 or 4."

5. *P. BRASSII* Copel. sp. nov.

Plate 2.

P. gregis *P. aculeati* tenuiter coriaceum soris submarginalibus; rhizomate ignoto; stipite 30 cm alto, gracile, fusco, deorsum paleis nigro-fuscis 5 mm longis lanceolatis acuminatis appressis vel inflexis sat dense minute denticulato-ciliatis, sursum paleis setiformibus haud dense vestito; lamina 30 cm longa, 12 cm lata, abrupte acuminata, apice 8 cm longo tantum pinnato, alibi bipinnata, rhachi atropureo-fusca paleis 1.5–3 mm longis linearibus contortis castaneis basibus dilatatis hinc inde ramiferis strigosa; pinnis infimis 7 cm longis subdeflexis, sequentibus 8 cm longis falcato-adscendentibus, acuminatis, breviter (1.5 mm) pedicellatis, rhachibus deorsum setoso-paleolatis sursum nudis; pinnulis infra apicem inciso-pinnatifidum pinnae ca. 12, mucronatis, infima acroscopica maxima 1 cm longa, 5–6 mm lata incisa, sequentibus gradatim decreascentibus contiguis interdum oblique rhomboideis argute serratis dentibus minute mucronatis, utraque facie mox glabris, superne fuscis inferne pallide olivaceis; soris submarginalibus parvis, indusio minuto peltato caduco.

Dutch New Guinea: Bele River, alt. 2,300 m; *Brass* No. 10247. "Occasional tufts in forest."

6. *P. BOLANICUM* Ros.

P. bolanicum Ros., Fedde's Repert. 12 (1913) 170.

Bolan, alt. 3,400–3,800 m, *Keysser B* 8 1912, isotype in Herb. Univ. Calif. Perhaps too near to *P. microphyllum* (Blume) Presl.

P. BOLANICUM var. *OVALIFOLIA* Ros.

Bolan, alt. 2,400–3,000 m, *Keysser B* 42, also in Herb. Univ. Calif., bearing the comment "potius spec. propria," with which I agree, although the species and variety are evidently nearly related. Endemic.

7. *P. MUTICUM* Copel.

Plate 3.

P. muticum Copel., Univ. Calif. Publ. Bot. 19 (1942) 221.

Rhizomate erecto, paleis fuscis 2–2.5 cm longis linearibus aciculatis integris dense immerso; stipitibus fasciculatis, 15–18 cm altis, 1.5 mm crassis, ochroleucis, paleis patentibus concoloribus medio brunnescentibus 5 mm longis ovatis oblique acutis nonnullis mucronulatis papyraceis primo integris denique plus minus laceris postquam dejectis cicatrices fuscas relinquentibus ornatis; lamina 35 cm longa, 13 cm lata, acuminata, bipinnata, rhachi quam stipite densius paleis minoribus vestita; pinnis

infirmis 5 cm longis 2 cm latis deflexis, medialibus 7 cm longis basi 2.5 cm alibi 2 cm latis, subfalcatis, obtusis vel breviter mucronulatis, breviter pedicellatis, rhachibus paleolatis sursum nudis; pinnulis ca. 9-paribus, contiguis, oblique oblongis, rotundatis, undulato-crenatis vel fere integris, subcoriaceis, glabris; soris medialibus, e facie superiore laminae expressis, indusio parvo orbiculare sat persistente.

Dutch New Guinea: Bele River, alt. 2,200 m; *Brass 11434*, type, "Numerous clumps on dry face of limestone cliff in forest shade;" *No. 11433*, from the same place, a small juvenile plant, with particularly small paleae, the pinnae with 0-2 basal pinnules.

8. *P. MYER-DREESII* Copel.

Plate 4.

P. Myer-Dreesii Copel., Univ. Calif. Publ. Bot. 18 (1942) 221.

P. mutico affine, paleis rhizomatis atrocastaneis, stipitis rhacheosque castaneis aciculari-lanceolatis, pinnulis paullo majoribus, infimis basi pinnula secundaria una praeseditis, sequentibus pinnatisectis, indusiis magnis interdum excentrice adnatis etenim rarissime orbiculari-reniformibus diversum.

Dutch New Guinea: 7 km N-E. of Wilhelmina-top, alt. 3,560 m. *Brass & Myer-Drees No. 10033*; "Clumped under rocks in subalpine forest."

9. *P. PAPUANUM* C. Chr.

P. papuanum C. Chr., Brittonia 2 (1937) 299.

Brass 9136, Lake Habbema, alt. 3,225 m, "Forming dense clumps 20-30 cm high and up to 1 m in diameter in forest glades;" *Brass & Myer-Drees 10055* and *10112*, Mt. Wilhelmina, alt. 3,950 m. *No. 10055* is "one of the few plants on limestone screes; clumps 20-40 cm high, scattered amongst the rocks." It and *No. 9136* are more or less dwarfed. *No. 10112*, "Under a rock on Alpine grassland," has responded to its more sheltered position by producing somewhat more ample fronds, almost flat pinnules, and longer, paler, less congested paleae on stipe and rachis. The previous collection are *Brass 4350* (type) and *4690*, dwarfed.

10. *P. KINABALUENSE* C. Chr.

P. kinabaluense C. Chr., Gardens' Bull. 7 (1934) 255.

Mt. Albert Edward, alt. 3,680 m, *Brass 5678*, det. Christensen. Borneo.

11. *P. ALPINUM* Ros.

P. alpinum Ros., Fedde's Repert. 12 (1913) 171.

Brass 9483, Lake Habbema, alt. 3,225 m, "under rocks in edge of forest; fronds spreading"; *Brass & Myer-Drees* 9766, 9967, 10333, Mt. Wilhelmina, alt. 3,500–3,800 m. Variable, and none exactly like the type, *Keysser B* 5 (1912), isotype in Herb. Univ. Calif. Judging by its long and comparatively naked stipe, the type grew in a sheltered place, perhaps under a rock. Endemic.

12. *P. CHEILANTHOIDES* Copel.

Plate 5.

P. cheilanthoides Copel., Univ. Calif. Publ. Bot. 13 (1942) 221.

Papuapteris ampla subtripinnata, rhizomate erecto, 2 cm (cum basibus stipitum, 4 cm) crasso, basibusque stipitum paleis primo rufis, deinde atro-fuscis tum demum nigris nitidis usque ad 3 cm longis 3 mm latis aculeato-attenuatis primo integris demum fisso-ciliatis vestitis; stipitibus fasciculatis, 25–30 cm altis 3–5 mm crassis, paleis sursum decrescentibus et variis densis vestitis etiam squamulosis; lamina ca. 35 cm longa, 5–7 cm lata, rhachibus paleis polymorphis et lanceolatis majoribus et ovatis minutis et setiformibus plerisque strigoso-ciliatis sursum pallescentibus ubique dense onustis; pinnis infimis ca. 4 cm remotis paullo reductis haud deflexis, medialibus 5–6 cm longis 1 cm latis, adscendentibus, sessilibus, obtusis; pinnulis infimis usque ad 9 mm longis, pinnatis cum pinnulis secundariis 1–3-paribus, sequentibus rarius pinnatis saepius pinnatifidis, plerisque integris oblongis rotundatis bullatis, coriaceis, superne plus minus decidue crinito-setosis, inferne dense paleatis et strigosis; soris infra paleas et margines revolutos plus minus occultis, indusiis ut videtur nullis, cellulis annulorum ca. 17. sporis oblongis densissime echinatis.

Dutch New Guinea: 11 km N-E. of Wilhelmina-top, alt. 3,400 m; *Brass & Myer-Drees* No. 9801, type, "Grassy bottom of a stream; fronds erect in large clumps;" also, No. 10102, alt. 4,100 m. "Common on rocky grassy slopes; clumps 60 cm high; southern slopes of Mt. Wilhelmina."

I believe that most pteridologists will agree in placing this species in *Polystichum*. In the Orient, it is rather isolated by its strongly bullate pinnules, but this would not be so among Andean species of the genus.

13. P. LINEARE (C. Chr.) Copel., comb. nov.

Papuapteris linearis C. Chr., Brittonia 2 (1937) 300, f. 2.

Brass 4304, Mt. Albert Edward, alt. 3,690–3,980 m; cited also from Owen Stanley Range and Mt. Victoria.

Endemic, and apparently of endemic parentage. Nearly related to the preceding species.

5. CYCLOPELTIS J. Smith

Key to the species

- Pinnae not hastate 1. *C. presliana*
 Pinnae hastate on upper side 2. *C. novoguineensis*

1. C. PRESLIANA (J. Smith) Berkeley

C. presliana (J. Smith) Berkeley, Crypt. Bot. (1857) 517.

Brass 8860, Hollandia, sea level; *Schlechter* 16284, alt. 300 m; *Bamler* 64 (1909), Logaueng; *King* 469, Papua.

Malaya; Philippines. Specimens from the Caroline and Gilbert Islands and Tonkin have been referred to this species.

2. C. NOVOGUINEENSIS Ros.

C. novoguineensis Ros., Fedde's Repert. 10 (1912) 329.

Known locally only by the type collection, *Bamler*, *Rosenstock Fil. novog. exsicc. n. 86*, Logaueng, alt. 300 m; isotype in Herb. Univ. Calif.

Solomon Islands.

6. DIDYMOCHLAENA Desvaux

D. TRUNCATULA (Swartz) J. Smith

Brass 12155, alt. 1,750 m; *Schlechter* 17694, alt. 300 m; *Bamler*, *Rosenstock Fil. novog. exsicc. n. 225*, Sattelberg, alt. 900 m; *King* 484, Papua. All New Guinea specimens represent var. *ozeanica* Ros., Fedde's Repert. 5 (1908) 374, characterized chiefly by small pinnules.

7. RUMOHRA Raddi

Key to the species

- Indusium large, peltate 1. *R. adiantiformis*
 Indusium small, round-reniform to peltate..... 2. *R. aristata*
 Indusium wanting 3. *R. Hasseltii*

1. R. ADIANTIFORMIS (Forster) Ching

R. adiantiformis (Forster) Ching, Sinensia 5 (1934) 70.

Dryopteris discophora Ros., Fedde's Repert. 12 (1913) 172.—
 "Eine durch ihre grossen schildförmigen Indusien sehr auffal-

lende Art." Isotype in Herb. Univ. Calif.; *Clemens s. n.*, Mt. Sarawaket, alt. 3,000–10,000 feet.

All Southern lands.

2. *R. ARISTATA* (Forster) Ching

R. aristata (Forster) Ching, *Sinensia* 5 (1934) 50.

Brass 5177 and 5202, *Bamler* 49p and *Bamler*, *Rosenstock Fil. novog. exsicc. n. 166* are this species, broadly construed. *Carr* 14388 is similar but distinct, but does not well fit Blume's description of *Aspidium appendiculatum*.

India across Polynesia.

3. *R. HASSELTII* (Blume) Ching

R. Hasseltii (Blume) Ching, *Sinensia* 5 (1934) 61.

Bamler 110 (1914), *Sattelberg*, alt. 800–900 m.
Java to Leyte, Formosa and Assam.

8. *BOLBITIS* Schott

Genera (1834) *Plate 14*; Ching, in *C. Chr.*, *Suppl. III* (1934) 47.
Campium Presl.; Copel., *Philip. Jour. Sci.* 37 (1928) 341 *partim*.

Because the formation of fertile fronds is seasonal or occasional, this genus is likely to be passed over by collectors. It seems to be poorly developed in New Guinea, where only 5 species have been reported, in contrast with 15 in the Philippines.

Key to the species

- | | |
|---|--------------------------|
| Apex of frond a leaflet, like lateral pinnae..... | 1. <i>B. heteroclita</i> |
| Apex formed by fusion of decrescent pinnae. | |
| Pinnae shallowly cut. | |
| Lamina over 30 cm long | 2. <i>B. quoyana</i> |
| Lamina smaller. | |
| Main veins evident | 3. <i>B. Taylora</i> |
| Main veins undeveloped | 4. <i>B. parva</i> |
| Pinnae deeply pinnatifid | 5. <i>B. arguta</i> |

1. *B. HETEROCLITA* (Presl) Ching

B. heteroclita (Presl) Ching, in *C. Chr.*, *Suppl. III* (1934) 48.
Campium heteroclitum Copel., *Philip. Jour. Sci.* 37 (1928) 359, *f. 13*.

Idenburg River, alt. 250 m, *Brass* 13242; Papua, *King* 265, 284.

Caroline Islands to China and India.

2. *B. QUOYANA* (Gaud.) Ching

B. quoyana (Gaud.) Ching, *ibid.* 49.
Campium quovanum Copel., *ibid.* 366, *f. 20*.

Schlechter 16236, Kaiser-Wilhelmsland. From Papua, I have four collections by King, all showing a tendency to confine the sporangia to a marginal band, and leave the costal area of fertile pinnae sterile. One of these was named *Leptochilus cuspidatus* (Presl) var., *marginalis* Ros., Fedde's Repert. 9 (1911) 426. They also represent *Heteroneuron Naumannii* Kuhn, described from New Hanover, which I do not regard as distinct.

New Hebrides to Java and Samar.

3. **B. TAYLORI** (Bailey) Ching

B. Taylori (Bailey) Ching, *ibid.* 50.

Campium Taylori Copel., *ibid.* 374.

Brass 12833, "abundant on rocks in a rain-forest stream at 1,150 m alt," 6 km SW. of Bernhard Camp, Idenburg River, is approximately this species. Queensland.

4. **B. PARVA** (Copel.) Ching

B. parva (Copel.) Ching, *ibid.* 49.

Campium parvum (Copel., *ibid.* 375, *Pl. 21* and *f. 28*).

Schlechter 16163, Kaiser-Wilhelmsland, alt. 300 m. *King 269* from Papua, is similar in appearance. A single specimen from Mrs. Clemens, from Morobe, alt. 4,200 feet, looks very distinct, being larger, with few broad pinnae, but may possibly be the same species in ample development.

Endemic.

5. **B. ARGUTA** (Fée) Ching

B. arguta (Fée) Ching, *ibid.* 47.

Heteroneuron argutum Fée, *Acrost.* (1845) 96, *Pl. 25, f. 2*.

Campium argutum Copel., *ibid.* 376, *Pl. 22*.

Brass 13473, "Several tufts on the bank of a rain-forest stream at 800 m alt," 2 km SW. of Bernhard Camp, Idenburg River.

Luzon.

In the Philippines, where they are better known, some *Bolbitis* species are notoriously variable. With the three preceding species represented by a total of 5 collections, of which no two are fully identical, their distinctness and their identity are for the present uncertain.

9. LOMARIOPSIS Fée

Key to the species

Fertile pinnae up to 3 mm wide.

Sterile pinnae lanceolate 1. *L. cochinchinensis*

Sterile pinnae oblanceolate 2. *L. Kingii*

Fertile pinnae 5–10 mm wide..... 3. *L. subtrifoliata*

Fertile pinnae up to 20 mm wide 4. *L. intermedia*

1. *L. COCHINCHINENSIS* Fée

L. cochinchinensis Fée, Acrost. (1845) 68, Pl. 27; Holttum, Gardens' Bull. 5 (1932) 266.

Bamler 50, Bamler, Rosenstock, Fil. novog. exsicc. n. 251, Sattelberg, alt. 300–700 m.

To Indo-China.

2. *L. KINGII* (Copel.) Holttum

L. Kingii (Copel.) Holttum, Gardens' Bull. 5 (1932) 273.

Stenochlaena Kingii Copel., Philip. Jour. Sci. 6C (1911) 80.

Known only by the type collection, *King 285*, from Papua; perhaps not sufficiently distinct from *L. cochinchinensis*.

3. *L. SUBTRIFOLIATA* (Copel.) Holttum

L. subtrifoliata (Copel.) Holttum l.c. 274.

Brass 13882, alt. 120 m, climbing 4–5 m on small trees. Typical except for fewer pinnae, larger sterile pinnae, and less scaly stipe; pinnae sessile.

Southern Philippines.

4. *L. INTERMEDIA* (Copel.) Holttum

L. intermedia (Copel.) Holttum, l. c.

Stenochlaena intermedia Copel., Philip. Jour. Sci. 7C (1912) 67.

Known only by the type collection, *King 370*, from Ambasi, Papua. Very distinct.

10. THYSANOSORIA Gepp

T. PTERIDIFORMIS (Cesati) C. Chr.

T. pteridiformis (Cesati) C. Chr., Suppl. III (1934) 187; Dansk Bot. Arkiv 9 No. 3 (1937) 51.

T. dimorphophylla Gepp, Dutch N. W. New Guinea (1917) 193, Plate 4.

Arfak Peninsula, *Cesati, Gibbs*. Unknown to me.

Local.

11. TERATOPHYLLUM Mettenius

T. ACULEATUM (Blume) Mett.

T. aculeatum (Blume) Mett., in Kuhn, Ann. Mus. Lugd Bat. 4 (1869) 296; Holttum, Gardens' Bull. 5 (1932) 284, Pls. 2, 3, and figs. 38–40.

Werner 64, Damun; also cited by Holttum, 1. c. 289, are *Lam* 424 and 1105.

Malaya; Philippines.

12. ARTHROBOTRYA J. Smith

A. ARTICULATA J. Smith

A. articulata J. Smith, Hist. Fil. (1875) 142.

Brass 12202, Idenburg River, alt. 1,700 m; *Clemens* 11011, Morobe; *King* 490, *Brass* 1468, Papua.

Philippines; Celebes; Solomon Islands.

13. LOMAGRAMMA J. Smith

Key to the species

Sterile pinnae at least 15 mm wide.

Pinnae with winged stalks 1. *L. sinuata*

Pinnae hardly stalked 2. *L. novoguineensis*

Sterile pinnae 8 mm wide 3. *L. angustipinna*

1. *L. SINUATA* C. Chr.

L. sinuata C. Chr., f. *papuana* C. Chr., Brittonia 2 (1937) 302.

Brass 13752, Idenburg River, alt. 75 m; scandent 7–8 m. This is a perfect match for *Brass* 5195, the basis of the *forma*. It is to be observed that the very large pinnae are short-stalked. Holttum, Gardens' Bull. 9 (1937) 216 has noted that the long pedicels of the pinnae, originally a characteristic of the species, are inconstant. The fertile pinnae are 3–4 mm wide.

The species in New Guinea, Celebes, Borneo and Java.

2a. *L. LOMARIOIDES* (Blume) J. Smith?

L. novoguineensis (Brause) C. Chr., Suppl. III (1934) 124.

Leptochilus novoguineensis Brause, Engler's Jahrb. 56 (1920) 117.

Ledermann 9524, alt. 850 m; *Docters van Leeuwen* 9616, Mamberamo River, alt. 50 m.

Endemic. See Holttum, Gardens' Bull. 9 (1937) 209, *Plate* 15.

2a. *L. LOMARIOIDES* (Blume) J. Smith?

Brass 13751, with *L. sinuata*, scandent to 8 m. Pinnae sessile, broadly obliquely cuneate, rather thin, but not satisfactorily distinguishable from the Java plant; fertile pinnae about 2 mm wide.

Brass 12950, alt. 1,200 m, scandent 3–4 m. Pinnae sessile with broad, approximately truncate bases; fertile pinnae 4 mm wide; stipes 10 cm long. Except for the long stipe, this would be more like *L. Brooksii*.

These two specimens are conspecific, whatever the species; and I suspect that they are variants of a species including *No. 13752*. Altogether, there are too few and too imperfect collections in this genus to afford dependable conclusions as to variability. *L. lomarioides* is regarded by Holttum as strictly Javanese.

3. *L. ANGUSTIPINNA* Copel.

Plate 6a.

L. angustipinna Copel., Univ. Calif. Publ. Bot. 18 (1942) 222.

Rhizomate scandente, sicco 5 mm crasso, basique stipitis paleis atrocastaneis 1–2 mm longis late lanceolatis squamulisque amorphis brunneis sparsis; bathyphyllis ignotis; frondis sterilis stipite 14 cm longo, gracile, stramineo; lamina 50 cm longa, 20 cm lata, pinna terminale 7 cm longa non articulata, pinnis lateralibus ca. 30-paribus articulatis, inferioribus decrescentibus, medialibus ca. 10.5 cm longis 8 mm latis, falcato-acuminatis, subsessilibus, basi basiscopice angustissime acropice latius cuneatis, integris, herbaceis, costa inferne decidue paleolatis; venis tenuibus inconspicuis, areolarum seriebus 2 vel 3 irregularibus; rhachi paleis fuscis linearibus ca. 1 mm longis basi interdum dilatatis sparsa; frondis fertilis pinnis breviter (2 mm) stipitulatis, usque ad 9 cm longis et 3 mm latis, sporangiis purpurascensibus.

Dutch New Guinea: 2 km SW. of Bernhard Camp, Idenburg River, alt. 750 m, *Brass 13446*; "Climbing epiphyte abundant on substage trees." Type in Gray Herbarium.

In spite of doubt as to the stability of various characters, and as to the distinctness of species based on them in this genus, I find it impossible to refer this specimen even approximately to any known species. The narrow sterile pinnae are unique in the genus, as is also the combination of thin lamina and inconspicuous venation. The dark-reddish sporangia suggest those occasionally found on more than one species of *Bolbitis*, and on *Teratophyllum Williamsii*.

14. *ELAPHOGLOSSUM* Schott

Key to the species

Small plants, lamina under 5 cm long.

Paleae light-brown, subciliate.

- | | |
|--|---------------------------|
| Stipe of sterile frond under 1 cm long | 1. <i>E. bolanicum</i> |
| Stipe of sterile frond over 2 cm long | 2. <i>E. habbemense</i> |
| Paleae dark, ciliate | 3. <i>E. hellwigianum</i> |

Larger plants.

Fronds clustered or approximate.

Fronds narrowly lanceolate, scaly 4. *E. petiolatum*

Fronds broader or glabrescent.

Margin conspicuously fringed 5. *E. Cumingii*

Margin not fringed.

Stipe conspicuously scaly 6. *E. sordidum*

Stipe glabrescent.

Lamina conspicuously decurrent.

Lamina under 30 cm long 7. *E. novoguineense*Lamina over 40 cm long 8. *E. Archboldii*Lamina acute at base 9. *E. sclerophyllum*

Rhizome elongate, fronds seriate.

Lamina half as wide as long 10. *E. laticuneatum*

Lamina relatively narrow.

Paleae broad, light-brown 11. *E. angulatum*

Paleae narrow and dark.

Base of lamina abruptly narrowed 12. *E. brunneum*

Base cuneate or decurrent.

Rhizome 1.5-2 mm thick 13. *E. repens*Rhizome much stouter 14. *E. fuscum*1. *E. BOLANICUM* Ros.*E. bolanicum* Ros., Fedde's Repert. 12 (1913) 180.Bolan Mts. alt. 2,400-3,000 m, *Keysser* (1912) *B* 62; isotype in Herb. Univ. Calif., including sterile frond.2. *E. HABBEMENSE* Copel.

Plate 7.

E. habbemense Copel., Univ. Calif. Publ. Bot. 18 (1942) 226.

Rhizomate late repente, 1-2 mm crasso, paleis ferrugineis 1-2 mm longis plerisque ovatis subintegris haud dense vestito; stipitibus ca. 1 cm remotis, frondis sterilis ca. 2.5 cm longis, 1 mm crassis, exalatis, paleis iis rhizomatis conformibus sursum decrescentibus vestitis, frondis fertilis brevioris; lamina sterile ca. 2.5 cm longa, 8 mm lata, utrinque acuta, mox glabrescente, rigide coriacea, fusca, margine cartilagineo subdeflexo; lamina fertile conforme sed basi rotundata.

Dutch New Guinea: Lake Habbema, alt. 3,225 m, *Brass No. 9083*, type in Gray Herbarium. "In a cushion of hepatics on exposed branch of tree." Only one plant, with one fertile and several sterile fronds.

A dwarf, perhaps related to *E. laurifolium*, but not to the other dwarfs known in New Guinea.

3. *E. HELLWIGIANUM* Ros.*E. hellwigianum* Ros., Nova Guinea 8 (1912) 731.

Dutch New Guinea: summit of Hellwig Mts., von Roemer 1273. Not seen.

4. *E. PETIOLATUM* (Swartz) Urban

E. petiolatum (Swartz) Urban, Symb. Ant. IV (1903) 61.

Keysser (1910) *K 11*; *Brass 5484*, Mafulu, alt. 1,250 m. I have in hand both of these collections, both determined as *E. Copelandii* Christ. Neither exactly matches that Philippine species, which is a member of the world-wide group of *E. petiolatum*. As an alternative name for the New Guinea plant, I would prefer *E. Blumei* J. Smith.

5. *E. CUMINGII* (Fée) Moore var. *PAPUANUM* C. Chr.

E. Cumingii (Fée) Moore, var. *papuanum* C. Chr., Brittonia 2 (1937) 317.

Mt. Tafa, alt. 2,300 m, *Brass 4112*.

This is a satisfactory match for some Philippine specimens.

6. *E. SORDIDUM* Christ

E. sordidum Christ, Nova Guinea 8 (1909) 156.

Dutch New Guinea: North River, near Geitenkamp, *Versteeg 1432*. Not seen. Brause lists 5 subsequent collections by Ledermann in Kaiser-Wilhelmsland. Christ remarked that this was the first *Elaphoglossum* known in New Guinea.

7. *E. NOVOGUINEENSE* Ros.

E. novoguineense Ros., Fedde's Repert. 10 (1912) 341.

E. Brassii C. Chr., Brittonia 2 (1937) 316.

Sattelberg, *Bamler 67* (1909), isotype in Herb. Univ. Calif.; *ibid.*, *Keysser 226* (1913); Mafulu, alt. 1,950 m, *Brass 5558*, *E. Brassii*; Bele River, *Brass 11498*.

Endemic.

8. *E. ARCHBOLDII* Copel.

Plate 8.

E. Archboldii Copel., Univ. Calif. Publ. Bot. 18 (1942) 226.

Rhizomate breve, crasso, stipitibus radicibusque ubique obsito, etiam paleis sordide fuscis ca. 2 mm longis ovatis integris vestito; stipitibus fasciculatis, basibus (phyllopodiis) castaneis 3-4 cm altis, 3-4 crassis, paleis quam iis rhizomatis longioribus sparsis; frondis sterilis stipite 10-30 cm alto, decurrenti-alato, fusco; lamina 40-50 cm longa, 5.5 cm lata, acuta, coriacea, margine subdeflexo, utraque facie glabrescente, venis manifestis, furcatis; frondis fertilis stipite 30-45 cm alto, sursum brevi-

alato, glabrescente, lamina ca. 30 cm longa, 2–3 cm lata, costa deorsum et margine angusto exceptis sporangiis densissime obtecta.

Dutch New Guinea: 4 km SW. of Bernhard Camp, Idenburg River, alt. 850–900 m, *Brass 13220*, type in Gray Herbarium; *ibidem*, No. 13484.

A large relative of *E. callifolium*, with smaller and darker paleae, the stipe of the sterile frond winged almost to the base.

9. *E. SCLEROPHYLLUM* v.A.v.R.

E. sclerophyllum v.A.v.R., Nova Guinea 14 (1924) 22.

Doorman-top, alt. 3,200 m, *Lam 1793*. Not seen.

10. *E. LATICUNEATUM* Copel.

Plate 9.

E. laticuneatum Copel., Univ. Calif. Publ. Bot. 18 (1942) 226.

Rhizoma te late repente, 2–3 mm crasso, paleis fuscis nigrescentibus ovato-lanceolatis 2–3 mm longis acuminatis irregulariter ciliatis vestito; stipitibus valde remotis, phyllopodiiis obscuris paleaceis 1–1.5 cm altis, frondium sterilium ca. 8 cm altis fusco-stramineis squamulis paucis onustis; lamina sterile 6–8 cm longa, 2.5–4 cm lata, apice rotundata, basi cuneata, coriacea, margine angustissime cartilaginea, utraque facie squamis elongato-triangularibus acuminatis 1 mm longis pauci-ciliatis atris sparsa; frondis fertilis stipite 15 cm alto, lamina 8 cm longa, vix 4 cm lata, sterili conforme.

Dutch New Guinea: 7 km NE. of Wilhelmina-top, alt. 3,560 m, *Brass & Myer-Drees 10032*, type in Gray Herbarium. "One plant in moss of forested cliff."

Related to *E. fuscum*.

11. *E. ANGULATUM* (Blume) Moore

E. angulatum (Blume) Moore, Index (1857) 5.

Lake Habbema region, *Brass 10504, 11036, 11042, 11499*.

New to New Guinea. Java; Borneo; Philippines.

12. *E. BRUNNEUM* Copel.

Plate 10.

E. brunneum Copel., Univ. Calif. Publ. Bot. 18 (1942) 226.

Rhizomate repente, 2.5–4 mm crasso, paleis 3–4 mm longis lanceolatis attenuatis subintegris squarrosis aterrimis nitidis dense vestito; phyllopodiiis indistinctis; stipitibus ca. 1 cm remotis, 10–20 cm altis, fusco-stramineis, basibus exceptis glabrescentibus; lamina sterile ca. 17 cm longa, 4 cm lata, apice acuta, basi abrupte et breviter cuneata, margine anguste carti-

laginea, squamulis minutis amorphis fissis sparsa, superne glabrescente, venis vix conspicuis, lamina fertile ca. 12 cm longa, 2 cm lata, aliter conforme.

Dutch New Guinea: 6 km. SW. of Bernhard Camp, Idenburg River, alt. 1,200 m, *Brass 12808*, type in Gray Herbarium; epiphyte, near the ground, in rain forest.

13. *E. REPENS* Copel.

Plate 11.

E. repens Copel., Univ. Calif. Publ. Bot. 18 (1942) 226.

Rhizomate repente, 1.5 mm crasso, paleis atris 2–3 mm longis lanceolatis attenuatis integris haud densis vestito; stipitibus 0.5–2.0 cm remotis, phyllopodiiis obscuris ca. 1 cm. longis; stipitibus frondium sterilium ca. 4 cm, fertileum 8–14 cm altis, stramineis, mox glabratis; lamina sterile ca. 10 cm longa, 3 cm lata, apice rotundata, basi sensim cuneata, breviter decurrente, margine anguste deflexo cartilagineo, coriacea, glabrescente, venis inconspicuis, lamina fertile minore.

Dutch New Guinea: 15 km SW. of Bernhard Camp, Idenburg River, alt. 1,800 m, *Brass 12124*; frequent low epiphyte in mossy forest.

14. *E. FUSCUM* Copel.

Plate 12.

E. fuscum Copel., Univ. Calif. Cont. Bot. 18 (1942) 226.

Rhizomate repente, 3–4 mm crasso, paleis fuscis nigrescentibus 4–5 cm longis ovatis et lanceolatis acuminatis sparse et irregulariter ciliatis plerisque appressis dense vestito; stipitibus 1–3 cm remotis, phyllopodiiis 1–2 cm altis vix distinctis dense paleatis, frondium sterilium ca. 10 cm altis, 2 mm crassis, sulcatis, stramineis vel fusco-stramineis, paleis sursum decrescentibus sparsis, frondium fertileum 15–30 cm altis; lamina 10–15 cm longa, 2.5–4 cm lata, apice rotundata, basi cuneata vix decurrente, coriacea, sordide fusca, margine angustissime cartilaginea, squamis atris 1 mm longis et amorphis et triangularibus grosse ciliato-dentatis sparsa, superne subglabrescente, lamina fertile conforme.

Dutch New Guinea: Lake Habbema, alt. 3,225 m, *Brass 9088*, type, "plentiful in ground moss of open thickets;" *ibidem*, epiphytic, *Nos. 9354, 9355*; Bele River, 2,200 m, *Nos. 11040, 11071*.

There are several other New Guinea collections of *Elaphoglossum*. In Philip. Jour. Sci. 6C (1911) 92, I reported a doubtful *E. conforme* from Goodenough Bay, *King 212*; it is not that species, nor fit for identification. Better specimens, both apparently new, but left undescribed, are *King 482*, from the

mountains behind Medan; and *Brass* 4772, from Murray Pass, alt. 2,840 m.

15. DRYOPTERIS Dryander

Key to the species

- Pinnae subpinnate 1. *D. paleacea*
 Frond at least tripinnatifid at base.
 Lowest pinnae much enlarged 2. *D. sparsa*
 Lowest and succeeding pinnae similar.
 Sterile pinnules hardly pinnate.
 Fronds uniform 3. *D. bamleriana*
 Fronds somewhat dimorphic 4. *D. pseudoparasitica*
 Pinnules freely compound 5. *D. subarborea*

1. *D. PALEACEA* (Swartz) C. Chr.

D. paleacea (Swartz) C. Chr., Amer. Fern Jour. 1 (1911) 94.

Brass 9138, Lake Habbema, alt. 3,225 m; *No.* 10283, alt. 2,800 m; *No.* 4409, Mt. Albert Edward, alt. 3,680 m.

At major altitudes in Borneo, Philippines, Formosa, Hawaii, India and China, Madagascar, Tropical America.

2. *D. SPARSA* (Ham.) O. K.

D. sparsa (Ham.) O. K., Rev. Gen. Pl. II (1891) 813.

D. papuana C. Chr., see *Brittonia* 2 (1937) 298.

Brass 10248, Bele River, alt. 2,300 m; *Brass* 4128, 4781, Papua, Central Division, alt. 2,100 and 1,900 m. The type of *D. papuana* (*Nephrodium dissitifolium* Baker) was from Mt. Scratchley, alt. 10,000–13,000 feet.

To India.

3. *D. BAMLERIANA* Ros.

D. bamleriana Ros., Fedde's Repert. 10 (1912) 334.

The type is *Bamler* 52, Sattelberg, *Brass* 13053, Idenburg River, alt. 850 m, is too similar to be distinguished, but is apparently without paraphyses. It is an epiphyte, with short-creeping rhizome.

Endemic.

Related to *D. bamleriana*, but distinct, is *Carr* 13386, received from the British Museum (Mr. Alston) as *D. Petelotii*.

4. *D. PSEUDOPARASITICA* v.A.v.R.

D. pseudoparasitica v.A.v.R., Nova Guinea 14 (1924) 19.

Brass 12067, "occasional low epiphyte in mossy forest at 1,800 m." Frond herbaceous; very similar to *D. bamleriana*

except for dimorphism. The type is *Lam 1946*, Doorman-top, alt. 2,480 m.

5. **D. SUBARBOREA** (Baker) C. Chr.

D. subarborea (Baker) C. Chr., Index (1905) 295.

Brause, Engler's Jahrb. 56 (1920) 94, refers to this species 12 collections by Ledermann. Rosenstock, Fedde's Repert. 12 (1913) 173, 174, has described varieties:

attenuata, Keysser S. 134, Sattelberg, alt. 800-1,000 m.

quadripinnata, Keysser B 83 (1912) Bolan, 2,400-3,000 m.

decomposita, Keysser B 52, Bolan, 2,400-3,000 m.

biformis, Keysser 39, 40, Bolan, 2,400-3,000 m.

We have isotypes of vars. *quadripinnata* and *biformis*; also, *Bamler*, *Rosenstock Fil. novog, exsicc. n. 229*, labelled simply *D. subarborea*. I do not believe that these are all one species. *Brass 12107*, "a common low-climbing epiphyte in the mossy forest at 1,800 m;" seems by description to be var. *attenuata*. The group is a difficult one, of more than one confused species in Java (as *D. purpurascens*), in Borneo, and in the Philippines, as well as in New Guinea; commonly represented in herbaria by minor fragments of fronds.

16. **CTENTIS** Christensen

Key to the species

Fronde tripinnatifid or more compound.

Lowest pair of pinnae much enlarged 1. *C. dissecta*

Lower pinnae all similar.

Stipe sparsely hairy.

Lamina over 40 cm long 2. *C. hypolepioides*

Lamina under 15 cm long 3. *C. alpina*

Stipe densely setose and scaly.

Sori dorsal on veinlets.

Fronde tripinnate 4. *C. vilis*

Fronde quinquepinnatifid 5. *C. speciosissima*

Sori terminal on veinlets 6. *C. pulchra*

Fronde bipinnate, stipe brown 7. *C. habbemensis*

Fronde hardly bipinnate, stipe black 8. *C. sagenioides*

1. **C. DISSECTA** (Forster) Copel.

C. dissecta (Forster) Copel., Genera (1946) 124.

Clemens 11422, Morobe, alt. ca. 1,000 m; *Bamler R 16*, Rook Island, alt. 100 m. Reported from Dutch New Guinea by van Alderwerelt van Rosenberg, *Lam 682*, alt. 10 m. I would expect it to be common at minor altitudes.

Polynesia and Malaya.

2. *C. HYPOLEPIOIDES* (Ros.) Copel.

C. hypolepioides (Ros.) Copel., *Genera* (1946) 124.

Dryopteris hypolepioides Ros., *Fedde's Repert.* 12 (1913) 175.

Keysser B 13 (1912), Bolan Mountains, alt. 3,400–3,800 m, isotype in Herb. Univ. Calif; *Brass 9295*, Lake Habbema, alt. 3,225 m, common floor-fern in subalpine forest. The new collection is far more ample than the type, but identical in hairs, paleae, residual roughness, and in having vestigial indusia—which can be detected on some sori of our isotype.

The rhizome is ascending, the stipes contiguous but not crowded. Stipe 55 cm tall, lamina 80 cm long, lower and medial pinnae 25 cm long, 10 cm wide; larger pinnules 6 cm long, 15 mm wide; secondary pinnules many, free, subpinnate with rounded or somewhat cuneate segments, the sterile ones 1.7 mm long by 1.3 mm wide, the fertile considerably contracted and covered by the sori. Except in stature and consequent dissection, the identity is so complete that I believe this must represent in full development the species of which the type collection is an ill developed form. Endemic.

3. *C. ALPINA* (Ros.) Copel.

C. alpina (Ros.) Copel., *Genera* (1946) 124.

Dryopteris alpina Ros., *Fedde's Repert.* 12 (1913) 173.

Keysser B 36, Bolan, alt. 3,600–3,800 m, isotype in Herb. Univ. Calif. This may represent the preceding species, extremely reduced at extreme altitude; if this is the case, the correct name is *C. alpina*.

4. *C. VILIS* (Kunze) Ching

C. vilis (Kunze) Ching, *Bull. Fan Bot.* 8 (1938) 290.

Schlechter 17792, Ibo Mountains, alt. 1,000 m, received as *Dryopteris intermedia* (Blume) O. K., var. *microloba*, from which (the Mindanao varietal type) it differs only in having more acute segments. It is never the original *C. vilis* than are various specimens ascribed to that species in recent years.

5. *C. SPECIOSISSIMA* Copel.

Plate 13.

C. speciosissima Copel., *Genera* (1946) 125.

Dryopteris speciosissima Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 219.

C. gregis *C. vilis* quinquepinnatifida; rhizomate erecto, 1–1.5 cm crasso, apice paleis rufis 1 cm longis 1–2 mm latis integris immerso; stipite ca. 75 cm alta, basi nigro-fusco 8 mm crasso, sursum rufo-fusco 4 mm crasso superne trisulcato, ubique paleis

setiformibus atrocastaneis squarrosis 5 mm longis horrido, et paleis aliquot dejectis basibus nigris relictis aspero; lamina 1 m longa, deltoideo-ovata, rhachibus paleis setiformibus et setis, sursum pilis rubidis nigrescentibus vestitis; pinnis oppositis, infimis 35 cm longis, 15 cm latis, acuminatis, pinnula infima acroscopica 6 cm longa, sequente basiscopica 11 cm longa, 3.5 cm lata acuminata bipinnata, pinnulis tertiariis 3 m longis, 1.5–2 mm latis obtusis inferioribus fere ad costam pinnatisectis, segmentis 0.5 mm latis rotundatis herbaceis costis costulisque pilis sparsis deciduis ornatis; venis in segmentis simplicibus, in pinnulis sequentibus integrioribus vel integris pauci-ramosis; soris ad venulas fere basalibus, indusiis fuscis membranaceis mox plicatis, nonnullis orbiculari-reniformibus, aliis ut videtur semiorbicularibus.

Dutch New Guinea: Bele River, alt. 2,200 m, *Brass 11257*, "in forest undergrowth, one large clump on a limestone cliff."

In its deltoid frond and opposite pinnae, this species resembles the *Peranema-Diacalpe* group of genera. Although very thin, the indusia persist, but are so rolled-up and distorted that it is difficult to be sure of their form.

6. C. PULCHRA Copel.

Plate 14.

C. pulchra Copel., *Genera* (1946) 124.

Dryopteris pulchra Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 219.

Formis dissectis *C. vilis* similis; rhizomate terrestre, repente adscendente, ca. 1 cm crasso, basibusque stipitum paleis atrocastaneis lineari-acicularibus integris 1 cm longis vestitis et furfuraceis; lamina 45 cm alta, deltoideo-ovata, acuminata, basi quadripinnatifida; pinnis infimis ca. 15 cm longis, basi 9 cm latis, basiscopice dilatatis; pinnula infima acroscopica, sequente proxima basiscopica 5.5 cm longa ad costam alatum pinnatisecta segmentis 1 cm longis etiam oblique pinnatisectis segmentis secundariis deltoideo-oblongis obtusis vix 1 mm latis; pinnis sequentibus gradatim angustioribus subsessilibus, oppositis, pinnulis infimis semper basiscopicis ad alam angustam costarum pinnatisectis, segmentis elongato-oblongis plerisque integris membranaceis obscure viridibus glabris, costis pinnularum piluliferis; rhachi frondis conspicue, pinnae inconspicue paleaceis; soris inframarginalibus ad venulas apicalibus, indusiis persistentibus plerisque orbiculari-reniformibus, sororum superiorum interdum athyrioideis.

Dutch New Guinea: 4 km SW. of Bernhard Camp, Idenburg River, alt. 850 m, *Brass 13455*, type; also, *No. 12848*, alt. 1,150 m, frequent on rocks in rain-forest ravines.

In spite of some notable differences, especially in the position of the sori at the ends of the veinlets, this seems to be related to *C. vilis*.

7. *C. HABBEMENSIS* Copel.

Plate 15.

C. habbemensis Copel., Genera (1946) 124.

Dryopteris habbemensis Copel., Univ. Calif. Publ. Bot. 18 (1942) 216.

C. rhizomate erecto, elongato, 5 mm crasso, nigro, apicem versus basibusque stipitum paleis nigro-fuscis ca. 5 mm longis 1 mm latis acuminatis vestitis; stipitibus fasciculatis, 25 cm altis, 2 mm crassis, fuscis, sursum paleis parvis remotis sparsis et minute pubescentibus rhachi inconspicue velutina fere epaleata; lamina 30 cm alta, 5-9 cm lata, brevi-acuminata, bipinnata; pinnis infimis deflexis, 3.5 cm longis, medialibus 4.5 cm longis, 1 cm latis, acutis basi truncatis sessilibus, rhachillis utraque facie pubescentibus; pinnulis 10-12-paribus, 7 mm longis 2 mm latis, obtusis, plerisque adnatis non confluentibus, infimis sessilibus basi lobatis, ceteris obscure crenatis, glabris, firme papyraceis, superne nigro-viridibus inferne obscure olivaceis; venulis 4-5-paribus, simplicibus, plerisque soriferis; soris medialibus, superficialibus, indusiis orbiculari-reniformibus, fuscis, glabris, persistentibus.

Dutch New Guinea: Lake Habbema, alt. 3,225 m, *Brass 9304*, type, "plentifully scattered over mossy floor of forest; tufts \pm 60 cm high." *No. 9217*, same locality, is larger and more lax than the type, the lower pinnules relatively long and narrow, and more deeply cleft or lobed. *No. 11245*; Bele River, alt. 2,300 m, "abundant in openings of ridge forest," is like *No. 9217* except for purplish-black stipes; its suberect caudex is 25-30 cm tall. The type resembles *C. viscosa* in size, shape and color, but is freely bipinnate. This affinity is more unmistakable in the case of *No. 11245*; but specific identity with *C. viscosa* or any of its described forms or relatives, as I understand them, is impossible.

Brass 11895, Idenburg River region, alt. 1,800 m, has the larger pinnae pinnate a third of their length. It is apparently an undescribed relative of *C. viscosa* and *C. habbemensis*.

8. *C. SAGENIOIDES* (Mett.) Copel.

C. sagenioides (Mett.) Copel., Genera (1946) 124.

I mistrust the presence of this species in New Guinea. It is listed by Brause, Engler's Jahrb. 56 (1920) 94, as "var. *Sagenia livida* Mett. msc." *Bamler 103* (1914), received here as *Dryopteris sagenioides*, is *Pteridrys olivacea*.

17. DRYOPOLYSTICHUM Copeland

D. PHAEOSTIGMA (Cesati) Copel.

- D. phaeostigma* (Cesati) Copel., Genera (1946) 126.
Aspidium phaeostigma Cesati, Rend. Ac. Napoli 16 (1877) 26, 29.
Dryopteris phaeostigma C. Chr., Index (1905) 284; Dansk Bot. Arkiv 9 No. 3 (1937) 47.
D. Kingii Copel., Philip. Jour. Sci. 6 C (1911) 73, non C. Chr. (1905)
D. tamatana C. Chr., Suppl. I (1913) 40.
Polystichum lastreoides Ros., Fedde's Repert. 9 (1911) 425.
Dryopteris Ledermanni Brause, Engler's Jahrb. 56 (1920) 90.
D. cyclosorus v.A.v.R., Nova Guinea 14 (1924) 21.

Brass 8839, Hollandia, alt. 50 m; 13855, alt. 175 m; 1422, Aisa River. The most named, and one of the most collected New Guinea ferns.

Endemic.

18. PTERIDRYS Christensen and Ching

P. OLIVACEA (Ros.) Copel.

- P. olivacea* (Ros.) Copel., Genera (1946) 126.
Dryopteris olivacea Ros., Hedwigia 56 (1915) 352.

Sattelberg, alt. 800–900 m, *Bamler* 103 of 1914, received by the University of California as *Dryopteris sagenioides*. It differs from *P. microthecia* (Fée) C. Chr. et Ching by having basal pinnae neither enlarged nor dilated, and by having fewer sinuses obstructed by teeth. Endemic.

19. HETEROGONIUM Presl

H. PROFEREROIDES (Christ) Copel.

- H. profereoides* (Christ) Copel., Univ. Calif. Publ. Bot. 16 (1929) 61.
Aspidium profereoides Christ, Philip. Jour. Sci. 2 C (1907) 156.
A. subaequale Ros., Fedde's Repert. 12 (1913) 176.
Tectaria subaequalis Copel., Philip. Jour. Sci. 9 C (1914) 5.

Known in New Guinea only by Bamler's collection or collections on the Sattelberg. The type of *A. subaequale* was collected in 1912. Our specimen is *Rosenstock, Fil. novog. exsicc. n. 244*, dated April, 1914, labelled "*Aspidium subaequale* Ros. n. sp." It is less dimorphic than the type collection of *H. profereoides*, but otherwise identical. There is no indusium, and the costal sori are oblong.

Mindanao.

20. STENOSEMIA Presl

S. AURITA (Swartz) Presl

- S. aurita* (Swartz) Presl, Tent. (1836) 237.
King 235; *Brass* 5651, Papua. Previously reported. Solomon Islands to India.

21. **TECTARIA** Cavanilles

This is a difficult genus, for natural reasons, because many of its species are ill fixed in the degree of dissection of their fronds, and because the indusia are variable and inconstant within some of the species. It is artificially difficult in reflection of the natural difficulties, because its species have been described in a number of unreal genera. Any present treatment of the New Guinea species is somewhat tentative because the collections are not numerous enough to permit final judgment of the local variation within specific limits.

Key to the species

- Lamina at least bipinnate at base.
 Pinnules at least pinnatifid.
 Areolae along costae and main veins only.
 Pinnules decrescent upward, or few.
 Indusium present.
 Frond green, clear but dark 1. *T. deveza*
 Frond brownish-green 2. *T. Kingii*
 Sori naked.
 Lamina subcoriaceous 3. *T. andaiensis*
 Lamina thin.
 Rachises scaly 4. *T. ferruginea*
 Rachises puberulous 5. *T. gymnocarpa*
 Pinnules numerous and uniform 6. *T. leuzeana*
 Veins anastomosing freely.
 Sori naked 7. *T. irregularis*
 Indusium present.
 Lamina coriaceous, naked 8. *T. Ledermanni*
 Lamina thin, pubescent 9. *T. pubescens*
 Pinnules not pinnatifid.
 Indusium persistent.
 Fertile suprabasal pinnae pinnatifid 10. *T. cesatiana*
 Fertile suprabasal pinnae crenate 11. *T. Barclayi*
 Indusium fugacious 18. *T. melanocaulis*
 Lamina simple to pinnate, not minute.
 Stipe not winged.
 Pinnae normally more than 3 pairs.
 Fronds clustered.
 Sori round.
 Pinnae broad at base.
 Indusium persistent 11. *T. Barclayi*
 Indusium fugacious 19. *T. Weinlandii*
 Pinnae narrow at base.
 Indusium reniform 12. *T. crenata*
 Indusium peltate 13. *T. ternatensis*
 Sori suboblong 14. *T. pleiosora*
 Sori amorphous, exindusiate 15. *T. teratocarpa*

- Rhizome elongate, fronds **seriate**.
- Pinnae 3 cm wide, not forked 16. *T. Menyanthidis*
 Pinnae 2 cm wide, the lower forked..... 17. *T. semibipinnata*
 (Fronnd simple or with 1 to 3 pinnae)
 Fronnd simple or with 1 to 2 pinnae.
- Pinnae pinnatifid 20. *T. pleocnemioides*
 Margin broadly crenate 21. *T. novoguineensis*
 Margin essentially entire.
- Indusium none or inconspicuous.
- Sori scattered.
- Sori minute, somewhat irregular 22. *T. angulata*
 Sori irregularly elongate 23. *T. cristovalensis*
 Sori in paired rows 24. *T. sifolia*
- Indusium conspicuous.
- Sori along main veins 12. *T. crenata*
 Sori submarginal 25. *T. craspedocarpa*
- Rachis and stipe broadly winged.
- Sori in paired rows 28. *T. decurrens*
 Sori scattered 26. *T. beccariana*
- Lamina simple, under 4 cm long 27. *T. minuta*

1. **T. DEVEXA (Kunze) Copel.**

T. devexa (Kunze) Copel., Philip. Jour. Sci 2 C (1907) 415.

Accredited to New Guinea as *Pleocnemia membranacea* Bedd., var. *novoguineensis* Ros., Fedde's Repert. 10 (1912) 338, listed by Brause, Engler's Jahrb. 56 (1920) 116, *Aspidium devexum*, var. *novoguineensis* Ros. We have this plant, *Rosenstock Fil. novog. exsicc. n. 63*. It is positively not *Aspidium membranaceum* Hooker. It is near *T. gigantea* (Blume) Copel., but hardly identical. It is larger than *T. Kingii*, with broader segments, and is dark-green, not brownish-green. I list *T. devexa* because this plant is not to be listed elsewhere, and I do not wish to describe our specimen as new.

Aspidium devexum Kunze was a *nomen nudum*, a substitute for "*Sagenia intermedia* J. Sm. (Cuming. Phil. No. 177),"—also a *nomen nudum*, the more mysterious because 177 was not a Cuming collection number, the plant having none. I construe it by *Aspidium membranaceum* Hooker, Sp. Fil. V 105.

2. **T. KINGII Copel.**

T. Kingii Copel., Philip. Jour. Sci. 9 C (1914) 4.

Known only by the original collection, *King 402*, from Woodlark Island.

3. **T. ANDAIENSIS (Baker) C. Chr.**

T. andaiensis (Baker) C. Chr., Suppl. III (1934) 177; see Dansk Bot. Arkiv 9 No. 3 (1937) 49.

Known only by the original collection, *Herb. Beccari No. 12697*.

4. **T. FERRUGINEA** (Mett.) Copel.

T. ferruginea (Mett.) Copel., Philip. Jour. Sci. 6 C (1911) 76.

Brass 8832, Hollandia, alt. 50 m.

Described from a collection by Zippelius. *King 264*, from Papua, fits Mettenius' description, but differs from his figure in being somewhat more dissected.

Endemic.

5. **T. GYMNOCARPA** Copel.

T. gymnocarpa Copel., Philip. Jour. Sci. 9 C (1914) 4.

Known only by the original collection, *King 401*, from Loana, Papua. Christensen reduces this to *T. ferruginea*, calling my attention to Mettenius' figure. There are resemblance and affinity; but *King 401* and *264* differ essentially in paleae and hairs, carefully described in Mettenius' text, but omitted on his illustration.

6. **T. LEUZEANA** (Gaud.) Copel.

T. leuzeana (Gaud.) Copel., Philip. Jour. Sci. 2 C (1907) 417.

Brass 12938, alt. 1,200 m; *13857*, alt. 130 m.

Common but variable. Rosenstock has described varieties *echinocarpa* and *lobato-crenata*; and a Winkler collection received from Rosenstock as *Aspidium chrysotrichum* Baker, var. can be included here. However, more than one distinct species may already be included.

Polynesia to Asia.

7. **T. IRREGULARIS** (Presl) Copel.

T. irregularis (Presl) Copel., Philip. Jour. Sci. 2 C (1907) 416.

Common. Fiji to Asia.

8. **T. LEDERMANNI** (Brause) C. Chr.

T. Ledermanni (Brause) C. Chr., Suppl. III (1934) 181.

Not seen; known only by the original collection, *Ledermann 9409*, from the Sepik region, alt. 850 m.

9. **T. PUBESCENS** Copel.

Plate 16.

T. pubescens Copel., Univ. Calif. Publ. Bot. 18 (1942) 221.

Rhizomate et parte inferiore stipitis ignotis; stipite 4 mm crasso, facie anteriore trisulcato, brunneo-pupurascente, rhachisque pilis minutis articulatis debilibus sat dense pubescentibus;

lamina ultra 50 cm longa, deltoideo-ovata, basi imo tripinnata; pinnis infimis fere 30 cm longis, pinna infima basiscopica 12 cm longa, ad alam apicem versus latam deorsum contractam pinnatifida, pinnula secundaria libera una, segmentis sequentibus pinnatifide lobatis 13 mm latis, lobis 3-4 mm latis obtusis; pinnis sequentibus 20 cm longis, vix obliquis, deorsum leviter bipinnatifidis; pinnis superioribus pinnatifide lobatis, deinde in apicem sat magnum coadunatis; lamina herbacea, utraque facie pubescente; venis laxe anastomosantibus, utroque latere costae segmenti seriem unam areolarum majorum et hic illuc seriem alteram minorum includentibus; soris parvis irregulariter seriatis, medialibus, aut ad apices venularum inclusarum aut apices versus loborum omnino liberarum, indusio typi persistente, plerumque cordato rarius peltato, glabro.

King 359, Lakekamu, Papua, type,—reported, Philip. Jour. Sci. 6 C (1911) 76, as *T. malayensis*; also, *Bamler, Rosenstock Fil. novog. exsicc. n. 236*, received as *Aspidium coadunatum* Wall. var. *rufovillosa* Ros. n. v., from Logaueng, Kaiser-Wilhelmsland.

A relative of *T. ferruginea*, less dissected, and therefore with more areolae, and indusiate. The Bamler plant is old, and but few indusia can be detected. On the type, but not on the Bamler plant, there are a few narrowly linear paleae 1-5 mm long on the rachises.

As the specimens cited as *T. pubescens* are the only bases for reports of *T. malayensis* and *T. coadunata* in New Guinea, these two species are dropped from the list of New Guinea ferns.

10. *T. CESATIANA* (C. Chr.) Copel.

T. cesatiana (C. Chr.) Copel., Philip. Jour. Sci. 6 C (1911) 76.
Aspidium bamlerianum Ros., Fedde's Repert. 10 (1912) 330.
Tectaria bamleriana C. Chr., Suppl. III (1934) 177.

Brass 13408, alt. 850 m, largest frond 13 cm long, subpinnate; *No. 13442*, alt. 800 m, largest frond 43 cm long, tripinnatifid at base; *No. 13852*, alt. 170 m, up to 50 cm long. More or less dimorphic, usually conspicuously so.

Our specimen of *A. bamlerianum*, received from Rosenstock, and bearing his notation "unicum," is exactly this species.

Throughout New Guinea. Endemic.

11. *T. BARCLAYI* (Carr.) C. Chr.

T. Barclayi (Carr.) C. Chr., Suppl. III (1934) 177.

Carr 11042, 11145, 12334, det. et misit Alston. *Brass 3648* and *5572*, from Papua, det. Christensen as *T. papuana* Copel.,

are this species. The type of *T. papuana* looks distinct, the margin being entire to crenate, the intermediate pinnae broadly rounded at base and not at all pronged; but, so variable in dissection are the species of this genus, it may be only an undissected form. *T. Barclayi* shows affinity to *T. crenata*, which the type of *T. papuana* does not suggest.

New Ireland.

12. *T. CRENATA* Cav.

T. crenata Cav., Descr. (1802) 250.

Brass 12222, alt. 1,800 m; *No. 13834*, deltoid and trifid. In most genera, the latter specimen would be accepted without question as specifically distinct, but even great differences in form and dissection are not by themselves safe criteria in *Tectaria*. Conspecific with this specimen is *Bamler 14* of 1913, received from Rosenstock as *Aspidium grandifolium* Presl, which it is not; it has free, unforked basal pinnae and one pair of almost free lateral pinnae. These specimens may represent a distinct species, but are at any rate near *T. crenata*.

Common. Asia to Polynesia.

13. *T. TERNATENSIS* v.A.v.R.

T. ternatensis v.A.v.R., Bull. Dept. Agric. Ind. Néerl. No. 18 (1908) 9.

Reported by van Alderwerelt, Nova Guinea 14 (1924) 8.

Distinguished by its author from *Aspidium repandum* Willd. by size and by narrower pinnae; from *A. persoriferum* Copel. and *A. pachyphyllum* Kunze by the shape of the indusium. These are all regarded as forms of *T. crenata*, and any real distinction of *A.* or *T. ternatensis* is not evident.

14. *T. PLEIOSORA* (v.A.v.R.) C. Chr.

T. pleiosora (v.A.v.R.) C. Chr., Gardens' Bull. 7 (1934) 260.

To be distinguished from *T. crenata* by having at least a part of the sori oblong instead of round, and fewer, broader pinnae, broader particularly on the basiscopic side. Regarding *T. crenata* as a freely variable species, I mistrust the distinctions. I have seen no New Guinea specimen, but have an authentic one from Borneo.

15. *T. TERATOCARPA* (v.A.v.R.) C. Chr.

T. teratocarpa (v.A.v.R.) C. Chr., Suppl. III (1934) 185.

Known only by the original collection, *Lam 966*, from the Mamberamo River, alt. 100 m; isotype in Herb. Univ. California.

16. *T. MENYANTHIDIS* (Presl) Copel.

T. Menyanthidis (Presl) Copel., Philip. Jour. Sci. 2 C (1907) 414.

Brass 13860, alt. 150 m; *King* 169, 180; *Brass* 975; apparently common.

Philippines; Admiralty and Solomon Islands.

17. *T. SEMIBIPINNATA* (Wall.) Copel.

T. semibipinnata (Wall.) Copel., Sarawak Mus. Jour. 2 (1917) 371.

What is reported from New Guinea is *Aspidium nudum* (Baker) Diels, said to be a synonym of *T. semibipinnata*, its type from Borneo. The resemblance to *T. Menyanthidis* is so close that confusion is possible.

18. *T. MELANOCAULIS* (Blume) Copel.

T. melanocaulis (Blume) Copel., Philip. Jour. Sci. 2 C (1907) 416.

Our only New Guinea specimen is *Bamler, Rosenstock Fil. novog. exsicc. n. 117*, from Wareo, alt. 600 m.

Malaya; Philippines; reported from China.

19. *T. WEINLANDII* (Christ) Copel.

T. Weinlandii (Christ) Copel., Jour. Arnold Arb. 10 (1929) 177.

Central and Eastern New Guinea, at minor altitudes.

Endemic.

20. *T. PLEOCNEMIOIDES* (v.A.v.R.) C. Chr.

T. pleocnemioides (v.A.v.R.) C. Chr., Suppl. III (1934) 183.

Known only by the type collection, *Lam 423*, Mamberamo River, alt. 25 m.

21. *T. NOVOGUINEENSIS* (Ros.) C. Chr.

T. novoguineensis (Ros.) C. Chr., Suppl. III (1934) 182.

Known only by an old collection by Zippelius in the Rijks Herbarium, Leiden, very imperfectly described: "Ab *Aspidium Labrusca* Christ stipitibus pilosis, laminis grosse crenatis, indusio magno, persistente diversum."

22. *T. ANGULATA* (Willd.) Copel.

T. angulata (Willd.) Copel., Sarawak Mus. Jour. 2 (1917) 370.

Brass 8836, Hollandia, alt. 50 m. Previously collected by Schlechter and Bamler.

Malaya; Philippines; Solomon Islands.

23. *T. CRISTOVALENSIS* (C. Chr.) Alston

T. cristovalensis (C. Chr.) Alston, Jour. Bot. (1939) 290.

Brass 13858, Idenburg River, alt. 80 m. Reported from New Guinea as *Dictyopteris pentaphylla* v.A.v.R., *Aspidium quinque-*

foliolatum C. Chr., *Campylogramma pteridiformis* v.A.v.R., and *Tectaria diversisora* Copel.

Solomon Islands. First named *Gymnogramme palmata* Baker.

24. **T. SIFOLIA** (Willd.) Copel.

T. sifolia (Willd.) Copel., Philip. Jour. Sci. 2 C (1907) 414.

Reported from New Guinea, but I have not seen it.
Malaya; Philippines.

25. **T. CRASPEDOSORA** Copel.

T. craspedosora Copel., Jour. Arnold Arb. 10 (1929) 178.

Known only by the type collection, *Brass 557*, Laloki River, alt. 1,500 feet.

26. **T. BECCARIANA** (Cesati) C. Chr.

T. beccariana (Cesati) C. Chr., Suppl. III (1934) 177; see Dansk Bot. Arkiv. 9 No. 3 (1937) 51.

Polypodium ingens Brause, *teste* Christensen, l. c.

Aspidium vastum Blume *forma latius* v.A.v.R., Nova Guinea 14 (1924) 7. *T. vasta* (Blume) Copel., is otherwise unreported from New Guinea.

Mindanao, as *T. Bryanti* Copel.

27. **T. MINUTA** Copel.

T. minuta Copel., Philip. Jour. Sci. 30 (1926) 328.

Known only by the type collection, *King 493*, l. Rev. P. C. Shaw, Mountains behind Taupota.

28. **T. DECURRENS** (Presl) Copel.

T. decurrens (Presl) Copel., Elmer's Leaflets Philip. Bot. 1 (1907) 234.

Brass 12899, 13854, 13855 A, 13853. The last, a single plant, has simple fronds, entire or broadly and irregularly crenate, attenuate to a short, scaly stipe. Found with typical plants of the species, *Nos. 13854* and *13855 A*, it may be regarded with confidence as an abnormal, or probably juvenile, individual. Our specimen of *Lam 1323*, Doorman River, alt. 200 m, reported, Nova Guinea 14 (1924) 13, as approximately *Dictyopteris heterosora* (Baker) Bedd., is *T. decurrens*.

Common. Polynesia to India.

22. **HEMIGRAMMA** Christ

H. **HOLLRUNGII** (Kuhn) Copel.

H. Hollrungii (Kuhn) Copel., Philip. Jour. Sci. 37 (1928) 406.

Besides the original collection, Brause cites *Ledermann 6562, 7781*. This species was described as having pinnatifid fronds.

To it, Christensen, Suppl. III 109, reduces *H. grandifolia* Copel., with pinnate sterile frond, the rachis mostly wingless. This may be correct, as *Hemigramma* is a recent derivative of *Tectaria* with pinnate fronds, and reversions by species with condensed, even with simple and entire fronds, are known to occur. *H. grandifolia* looks like the most primitive element in its genus. The range of the genus is to Java, China and Formosa; and it is in harmony with my theory as to the direction of migration in this region that the most primitive member of a genus with this range should be found in New Guinea. The type of *H. grandifolia* is King 328, from Lakekamu, Papua.

New Britain.

23. LASTREA Bory

Key to the species

Frond tripinnatifid at base or more compound.

Rachises and costae not scaly.

- | | |
|---|--------------------------|
| Stipe smooth | 58. <i>L. setosa</i> |
| Stipe muricate | 59. <i>L. armata</i> |
| Rachises bearing scales and hairs | 60. <i>L. leucolepis</i> |

Frond bipinnate.

Pinnae freely pinnate.

Frond not over 60 cm long.

- | | |
|--|-----------------------------|
| Sori submarginal | 2. <i>L. bipinnata</i> |
| Sori costular | 7. <i>L. conterminoides</i> |
| Frond several meters long | 1. <i>L. marattioides</i> |
| Free pinnules only about 3 pairs | 3. <i>L. platyptera</i> |

Pinnae pinnate at base only or not at all.

- | | |
|---------------------------------|---------------------------|
| Veinlets typically forked | 4. <i>L. flavo-virens</i> |
|---------------------------------|---------------------------|

Veinlets simple.

Lower pinnae gradually dwarfed.

Largest pinnae under 5 cm long.

Rachis sparsely hairy or naked.

- | | |
|---------------------------------|-----------------------|
| Rhizome creeping, slender | 5. <i>L. Beddomei</i> |
| Stem erect, stouter | 6. <i>L. Brassii</i> |

Rachis persistently pubescent.

Pinnae deeply pinnatifid.

- | | |
|-----------------------------------|-----------------------------|
| Sori subcostular | 7. <i>L. conterminoides</i> |
| Sori medial | 8. <i>L. perpubescens</i> |
| Pinnae shallowly pinnatifid | 9. <i>L. petrophila</i> |

- | | |
|---------------------------------|-----------------------|
| Pinnae 10 cm or more long | 10. <i>L. Harveyi</i> |
|---------------------------------|-----------------------|

Lower pinnae abruptly reduced.

Lower pinnae over 20 cm long.

- | | |
|---------------------------------------|--------------------------------|
| Pinnae cut to 1 mm from costa | 11. <i>L. subattenuata</i> |
| Pinnae pectinate to a broad wing..... | 12. <i>L. pseudostenobasis</i> |
| Pinnae about 15 cm long | 13. <i>L. Regis</i> |

Larger pinnae 7-10 cm long.

- Chartaceous, glabrous beneath 14. *L. novoguineensis*
 Herbaceous, glandular beneath 15. *Dryopteris glaucescens*
- Pinnae under 5 cm long.
 Rachis minutely pubescent 16. *L. Finisterrae*
 Rachis hairy and scaly 17. *L. mixta*
- Lower pinnae not or but little reduced.
 Stipe reddish or purplish-black.
 Rachis hairy and paleate.
 Lamina pallid, indusia purplish 18. *L. pallescens*
 Lamina dark, indusia brown.
 Sori about medial 19. *L. viscosa*
 Sori nearer the costule.
 Papyraceous 20. *L. engleriana*
 Coriaceous 21. *Dryopteris villosipes*
- Rachis hairy, not scaly.
 Membranaceous, diaphanous 22. *L. diaphana*
 Thin-chartaceous or herbaceous.
 Indusium naked 23. *L. subnigra*
 Indusium glandular-puberulent..... 24. *Dryopteris oligolepia*
 Coriaceous 25. *L. coriacea*
- Stipe stramineous to brown.
 Sori exindusiate, elongate 26. *Dryopteris stellatopillosa*
- Sori exindusiate, round.
 Sori about medial.
 Veinlets not connivent 27. *L. wariensis*
 Lowest veinlets connivent 47. *L. subdimorpha*
- Sori nearer to costule.
 Sporangia naked.
 Stipe not scaly 28. *L. tuberculata*
 Stipe scaly at base.
 Pinnae up to 5 cm wide..... 29. *L. notabilis*
 Pinnae under 3 cm wide.
 Paleae nigrescent 30. *L. dryopteroidea*
 Basal paleae brown 31. *L. varievestita*
- Sporangia setose.
 Lamina 70 cm long 32. *L. alta*
 Lamina up to 35 cm long.
 Pinnae broad-lanceolate 33. *L. quadriaurita*
 Pinnae narrow-lanceolate 34. *L. ensipinna*
- Sori indusiate.
 Sori supra-medial to marginal.
 Indusium not hairy 36. *L. immersa*
 Indusium hairy.
 Hairs of rachis various 35. *Dryopteris quadriquetra*
 Hairs of rachis uniform.
 Pinnae 4 cm wide 37. *L. keysseriana*
 (Pinnae up to 2 cm wide)
 Pinnae up to 2 cm wide.

- Basal pinnae horizontal..... 38. *L. obliquata*
 Basal pinnae deflexed..... 39. *Dryopteris Peekeli*
- Sori medial.
- Fronde thin.
- Stipe scaly at base only..... 40. *L. gracilescens*
 Stipe subscaly upward..... 41. *L. Lauterbachii*
- Fronde coriaceous.
- Segments 1-2 mm wide..... 42. *Dryopteris stereophylla*
- Segments 3 mm wide.
- Rachis naked beneath..... 43. *Dryopteris rigidifolia*
 Rachis hairy 44. *Dryopteris horizontalis*
- Sori inframedial to costular.
- Lamina thin.
- Rachis hairy 45. *L. calcarata*
 Rachis naked beneath..... 46. *L. fulgens*
- Lamina firm to coriaceous.
- Indusium setulose.
- Rachis pubescent only..... 48. *L. falcatifinnula*
 Rachis hairy and scaly.
- Pinnae 15 mm wide..... 49. *L. echinata*
 Pinnae 3 cm wide..... 50. *L. belensis*
- Indusium naked.
- Pectinate pinnae many.
- Segments 5 mm wide..... 51. *L. costulisora*
 Segments 3 mm wide..... 52. *L. chlamydothora*
- Pinnae up to 10 pairs.
- Rachis pubescent.
- Pinnae coriaceous 53. *L. ophiura*
 Pinnae subcoriaceous 54. *L. crassa*
 Rachis naked beneath 55. *L. wantotensis*
 Pinnae nearly or quite entire..... 56. *L. nephroleptoides*
 Fronde pinnatifid except for basal
 pinnae 57. *L. hunsteiniana*

1. *L. MARATTIOIDES* (Alston) Copel.

Dryopteris marattioides Alston, Jour. of Bot. 78 (1940) 227; Nova Guinea N. S. 4 (1940) 110, Pl. 7, f. 7, 8.

Clemens 4809, type, Morobe, alt. 5,800 feet; 6808, Sambanga, alt. 6,000 feet. Twelve to 14 feet tall. Mrs. Clemens made yet a third collection of this remarkable fern, which may well represent an undescribed genus.

Endemic.

2. *L. BIPINNATA* Copel., comb. nov.

Dryopteris bipinnata Copel., Philip. Jour. Sci. 9 C (1914) 2.

Known only by the type collection, *King* 407, from Loane, Papua.

3. *L. PLATYPTERA* Copel.

Plate 17.

L. platyptera Copel., *Genera* (1946) 139.*Dryopteris platyptera* Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 219.

Rhizomate erecto, basibusque confertis stipitum paleis ovatis acutis integris glabris fuscis nigrescentibus ca. 1 mm longis vestitis; stipite alibi glabro atropurpureo nitente; lamina 30 cm longa, 11 cm lata, sensim acuminata, basi vix angustata, rhachi atropurpurea costisque superne purpureostrigosis, alibi laminaeque glabris; pinnis ca. 13-paribus, inferioribus breviter (1 mm) pedicellatis, infimis paullo abbreviatis vix deflexis, sequentibus ca. 5.5 cm longis 2 cm latis, acuminatis, infra apicem integrum gradatim profundius pinnatifidis, rhachin versus pinnatis; pinnullis ca. 3-paribus, adnatis vel infimis sessilibus, infima acropica inciso-dentata, sequentibus obscure serratis ca. 11 mm longis, 2-3 mm latis, acutis vel obtusis, herbaceis; venis ca. 6-paribus, infimis saepe furcatis ceteris simplicibus; soris infra-medialibus, parvis, indusiis tenuibus, nudis, deciduis.

Dutch New Guinea: Bele River, alt. 2,200 m, *Brass* 11328; "in semi-shade on high rocky bank of stream."

Apparently related to *L. pyrrhorhachis*, and with resemblance but no probable affinity to *Ctenitis sagenioides* and *Lastrea viscosa*.

4. *L. FLAVO-VIRENS* (Ros.) Copel.*L. flavo-virens* (Ros.) Copel., *Genera* (1946) 138.*Dryopteris flavo-virens* Ros., *Fedde's Repert.* 10 (1912) 334.

Bamler, Rosenstock Fil. novog. exsicc. n. 118, Wareo, alt. 600 m; isotype in Herb. Univ. Calif. Peculiar in *Lastrea* because of many forked veinlets.

5. *L. BEDDOMEI* (Baker) Bedd.*L. Beddomei* (Baker) Bedd., *Ferns Brit. India Corr.* II (1870).

Brass 9319, 10888, 10932, alt. 2,620-3,225 m; reported by Gepp from the Arfak Mountains, alt. 7,000 feet.

The *Brass* specimens are identical with those from Java, Luzon, Formosa and Yunnan. Stipe and rachis rather deciduously hairy, hairs more persistent on minor axes; sori submarginal, indusia glandular or glandular-marginate, transient. The typical plant may be represented by *Beddome*, *Ferns of Southern India*, Plate CX, figured with a more hairy rachis, and described as with glabrous indusium. Baker, in publishing the specific name, *Syn. Fil.* (1873) 267, cited *Thwaites C. P. 1287*, but did not mention the rachis or indusium.

6. *L. BRASSII* Copel., comb. nov.

Dryopteris Brassii C. Chr., Brittonia 2 (1937) 295.

Brass 4937, Mt. Tafa, alt. 2,400 m. A young frond of the isotype in Herb. N. Y. Bot. Garden bears glandular-marginate indusia, wanting on older fronds. It still seems distinguishable from the preceding species by its erect, scaly rhizome. The creeping rhizome of *L. Beddomei* is characteristic. But *L. Brassii* grew on the "banks of a small stream flowing over debris of a landslide." If an established plant grew up through any kind of a subsequent deposit, its rhizome would almost have to become erect, for the occasion.

7. *L. CONTERMINOIDES* Copel., comb. nov.

Dryopteris conterminoides C. Chr., Index (1905) 258.

Nephrodium simulans Baker, Jour. Bot. 28 (1890) 106, non (1874) nec (1888).

Known only by the original collection by MacGregor, on Mt. Knutsford. Described as with densely crinite rachis, subcostal sori, and persistent indusium.

8. *L. PERPUBESCENS* (Alston) Copel., comb. nov.

Dryopteris perpubescens Alston, Jour. Bot. 78 (1940) 227; Nova Guinea N. S. 4 (1940) 111, Pl. 8, f. 9, 10.

Clemens 7902c, Morobe District, Kalasa, alt. 1,600 feet. Not seen. Stipe densely puberulous, lamina densely short-pubescent, sori medial, indusia hirsute.

9. *L. PETROPHILA* Copel.

Plate 18.

L. petrophila Copel., Genera (1946) 139.

Dryopteris petrophila Copel., Univ. Calif. Publ. Bot. 18 (1942) 220.

L. rhizomate suberecto, frondibusque, circinnatis paleis fuscis vix 1 mm longis protectis; stipitibus laxe fasciculatis, 5–7 cm altis, gracilibus, brunnescentibus, basi paleis paucis cito caducis fere 2 mm longis ovatis sparsis, mox omnino glabris; lamina 40 cm longa, parte tertia superiore longe attenuata pinnatifida vel apicem versus tantum inciso-serrata, parte tertia inferiore etiam angustata pinnis decrescentibus remotis infimis minutis, parte mediale usque ad 7.5 cm lata subbipinnatisecta, rhachi minute pallide velutino-pubescente; pinnis suboppositis, sessilibus, maximis 4 cm longis 8 mm latis, acutis, basi acroscopice inconspicue auctis, plus minus medio ad costam inciso-lobatis, superne saturate viridibus, costis costulisque minutissime setulosis, inferne pallidis fere (oculo nudo, omnino) glabris; venis

simplicibus, infimis ad sinus conniventibus rarius confluentibus; soris medialibus infimis inframedialibus, plerisque nudis, rarius indusiis vestigialibus fugacibus praeditis.

Dutch New Guinea: Bele River, alt. 2,200 m, *Brass 11326*, "abundant on moist rock faces along a forest stream; fronds spreading."

With *L. Brassii*, this species belongs in a group more diversely developed in the Philippines than, so far as now known, in New Guinea. From its neighbors in this enumeration, it is distinguishable by the shallowly cut pinnae, with consequent occasional anastomosis of the lowest veinlets. *L. nephrolepioides*, with practically entire pinnae, is also a relative.

10. *L. HARVEYI* Carr.

L. Harveyi Carr., *Flora Vitiensis* (1873) 359.

Listed from New Guinea by Brause, but not known to me here. Described from Fiji; reported elsewhere in Polynesia, and from the New Hebrides and Admiralty Islands.

11. *L. SUBATTENUATA* (Ros.) Copel.

L. subattenuata (Ros.) Copel., *Genera* (1946) 1940.

Dryopteris subattenuata Ros., *Fedde's Repert.* 10 (1912) 332.

Known only by the original collection, *Bamler L 37, Rosenstock Fil. novog. exsicc. n. 80*, from Logaueng, alt. 300 m; isotype in Herb. Univ. Calif.

12. *L. PSEUDOSTENOBASIS* Copel.

Dryopteris pseudostenobasis Copel., *Jour. Arnold Arb.* 10 (1929) 176.

Brass 1000, Ihu, Vailala River; known by the single collection; possibly a form of *Cyclosorus alatellus*.

13. *L. REGIS* Copel.

Plate 19.

L. Regis Copel., *Genera* (1946) 140.

Dryopteris Regis Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 220.

L. rhizomate et stipite ignotis; frondis parte visa 120 cm longa, deorwum abrupte contracta, pinnis hic 4-4.5 cm inter se distantibus 6-paribus visis, 1-1.5 cm longis, orbiculari-ovatis rotundatis, lobatis vel pinnatifidis segmentis ca. biparibus 4 mm latis, rhachi 5 mm crassa fusco-plumbeo nudo; pinnis sequentibus permultis oppositis, 3-4 cm remotis, sessilibus et tuberculis subtensis, ca. 15 cm longis, 2.5 cm latis, acuminatis, basi paullo dilatatis, ad alam 1 mm latam costae suboblique pectinatis, costis superne velutinis inferne glabris; segmentis ca. 13 mm longis 4 mm latis, rotundatis, integris, papyraceis, glabris;

venis ca. 8-paribus, simplicibus, infimis ad marginem supra sinum currentibus; soris multis, parvis, subcostularibus, indusiis invisis, sporangiis in vetustat enudis.

Papua: Mountains behind Medan, *Rev. Copland King 486*.

The specimen consists of 120 cm of the upper part of a frond, wanting the base. The absence of an indusium may be due to age.

13a. *DRYOPTERIS MUNDA* Ros.

Dryopteris munda Ros. Meded. Rijks Herb. No. 31 (1917) 5.

"Nova Guinea: Atasrip 1903." Not seen. So far as the very incomplete description shows, this may resemble *L. Regis* except for having hairy axes.

14. *L. NOVOGUINEENSIS* (Brause) Copel.

L. novoguineensis (Brause) Copel., Genera (1946) 139.

Dryopteris novoguineensis Brause, Engler's Jahrb. 49 (1912) 26.

Brass 12849, alt. 1,200 m. The type is *Schlechter 17719*, Kani Mountains, alt. 100 m. *Bamler, Rosenstock Fil. novog. exsicc. n. 227*, distributed as this species, fits better the description of *Dryopteris glaucescens*.

Endemic.

15. *DRYOPTERIS GLAUDESCENS* Brause.

Dryopteris glaucescens Brause, Engler's Jahrb. 56 (1920) 85.

Sepik region, alt. 1,400–1,500 m, *Ledermann 13034*.

This and the preceding species seem to be very similar.

16. *L. FINISTERRAE* (Brause) Copel.

L. Finisterrae (Brause) Copel., Genera (1946) 138.

Dryopteris Finisterrae Brause, Engler's Jahrb. 49 (1912) 20.

Schlechter 18134, Finisterre Mountains, alt. 1,000 m; *Bamler 116* (1914), Sattelberg.

Endemic.

17. *L. MIXTA* (Ros.) Copel., comb. nov.

Dryopteris mixta Ros., Fedde's Repert. 12 (1913) 172.

Known only by the type collection, *Keysser S 141*, Sattelberg, alt. 800–1,000 m; not seen.

18. *L. PALLESCENS* (Brause) Copel., comb. nov.

Dryopteris pallescens Brause, Engler's Jahrb. 56 (1920) 88.

Known only by the type, *Ledermann 9146*, Sepik region, alt. 850 m; not seen. Two meters tall.

19. *L. VISCOSA* J. Smith

L. viscosa J. Smith, Jour. Bot. 3 (1841) 412 nomen.

Nephrodium viscosum Baker, Syn. Fil. (1867) 264.

Brass 13294, alt. 900 m, common ground fern in *Agathis* forest. Except that few glands can be detected, this is perfectly typical.

Philippines; Borneo; and (not quite typical) Fiji.

This is a variable species or a closely related group. Christensen has reduced to it two which seemed distinct species to me; and they are indeed reducible if one construe it broadly. If this policy be adopted, I mistrust the specific identity of all of the following six "species."

20. *L. ENGLERIANA* (Brause) Copel.

L. engleriana (Brause) Copel., *Genera* (1946) 138.

Dryopteris engleriana Brause, *Engler's Jahrb.* 49 (1912) 19.

The type, not seen, is *Schultze 330*, from the Sepik region. We have received with this name *Keysser 181*, Sattelberg Hinterland; also, as var. *hirta* C. Chr., *Brittonia* 2 (1937) 296, *Brass 5032* and *4104*. *Brass 10281*, Lake Habbema, alt. 2,800 matches these well. All have persistent indusia; the species was described as exindusiate. They are also alike in having nigrescent stipe-bases, not provided in the description.

21. *DRYOPTERIS VILLOSIPES* Gepp.

Dryopteris villosipes Gepp. in Gibbs, *Dutch N. W. New Guinea* (1917) 70.

Gibbs 5627, Arfak Mountains, alt. 7,000–8,000 feet; not seen. Epiphytic. Without other comparison, Gepp remarks: "The plant differs in every respect from *D. viscosa*."

22. *L. DIAPHANA* (Brause) Copel., comb. nov.

Dryopteris diaphana Brause, *Engler's Jahrb.* 56 (1920) 80.

Ledermann 8903, Sepik region, alt. 850 m; collected but once.

23. *L. SUBNIGRA* (Brause) Copel.

L. subnigra (Brause) Copel., *Genera* (1946) 140.

Dryopteris subnigra Brause, *Engler's Jahrb.* 56 (1920) 82.

Ledermann 11962, type, not seen, Sepik region, alt. 2,170 m, epiphytic in masses of moss; *Clemens 41020*, Morobe, alt. 1,800 m. *Brass 12038*, alt. 1,750 m, a single specimen, epiphytic with pendent fronds, is like *L. subnigra* in most respects, but the nether surface is minutely pubescent.

24. *DRYOPTERIS OLIGOLEPIA* v.A.v.R.

Dryopteris oligolepia v.A.v.R., *Nova Guinea* 14 (1924) 17.

Typified by *Lam 1977*, Doorman-top, alt. 2,520 m, epiphytic; not seen. Because of relative nakedness of stipe and rachis, *Brass 9062*, Lake Habbema, alt. 3,225 m, may be identified as this species.

Between *L. subnigra* and *D. oligolepia*, there are differences in description which may be diagnostic of species. Thus, the paleae are described as "grosse dentatis" on the former, "integerimis" on the latter. On *Brass 9062*, they are mostly entire, but a few have marginal outgrowths. The indusium of the former is "glabrum," of the latter "in juventute minutissime glanduloso-puberulum." Some globose unicellular glands can be detected on the margin of the indusium of the Brass plant. I do not suppose that the differences are real, but have not been an authentic specimen of either species.

25. *L. CORIACEA* (Brause) Copel., comb. nov.

Dryopteris coriacea Brause, Engler's Jahrb. 56 (1920) 83.

Known only by Ledermann's collections from the Sepik region, *No. 10965*, alt. 1,350 m (type), and *No. 11291*, alt. 1,300 m (var. *elata*).

25a. *L. KLOSSII* Ridley

L. Klossii Ridley, Trans. Linn. Soc. Bot. 9 (1916) 257.

Carstenz Expedition, alt. 5,500 feet.

This may be an older name for *L. subnigra*, but the description is inadequate for its recognition.

L. erubescens (Wall.) Copel. is reported by Ridley in the paper just cited; it is otherwise unknown in New Guinea.

26. *L. STELLATO-PILOSA* (Brause) Copel., comb. nov.

Dryopteris stellato-pilosa Brause, Engler's Jahrb. 56 (1920) 96.

Known only by the type collection, *Schlechter 16853*, Mt. Gati, alt. 600 m. It is a small *Leptogramma*, having few elongate naked sori.

27. *L. WARIENSIS* Copel.

L. wariensis Copel., Genera (1946) 140.

Dryopteris wariensis Copel., Philip. Jour. Sci. 6 C (1911) 73.

Collected only once,—*King s. n.*, Waria River, Papua.

28. *L. TUBERCULATA* (Ces.) Copel.

L. tuberculata (Ces.) Copel., Genera (1946) 140.

Nephrodium tuberculatum Cesati, Atti Acad. Napoli 7 (1877) 29; see C. Chr., Dansk Bot. Arkiv 9 No. 3 (1937) 48.

Dryopteris Schlechteri Brause, Engler's Jahrb. 49 (1912) 16, f. 1 E.

Dryopteris schizophylla v.A.v.R., Nova Guinea 14 (1924) 19.

Brass 13656, alt. 700 m; *13835*, alt. 150 m; *Schlechter 16188*, type of *D. Schlechteri*, Kelel, alt., 200 m; *16811*, var. *djamuensis* Brause, Djamu, alt. 350 m, isotypes in Herb. Univ. Calif.; *Lam 1185*, *1296*, cotypes of *D. schizophylla*, of which the type, not

seen, is *Lam 772*. Remarkable for the absence of permanent paleae on the base of the stipe.

Endemic.

29. *L. NOTABILIS* (Brause), Copel.

L. notabilis (Brause) Copel., *Genera* (1946) 139.

Dryopteris notabilis Brause, *Engler's Jahrb.* 56 (1920) 91.

Ledermann 11663 and *14991*, Sepik region, alt. 2,070 m, not seen. *Brass 11233*, alt. 2,200 m, is referable to this species. The stipe has a densely scaly base, conforming to Brause's German text, and is elsewhere aculeate, conforming to the Latin. The largest pinna is 30 cm long, 6.5 cm wide.

Endemic.

30. *L. DRYOPTEROIDEA* (Brause) Copel.

L. dryopteroidea (Brause) Copel., *Genera* (1946) 138.

Alsophila dryopteroidea Brause, *Engler's Jahrb.* 56 (1920) 70.

Cyathea atrispora Domin, *Acta Bohem.* 9 (1930) 95.

Dryopteris atrispora C. Chr., *Brittonia* 2 (1937) 296.

Brass 10931, Lake Habbema, alt. 2,800 m, "Small tree-fern, trunk 70 cm tall, 6 cm in diameter; fronds few, \pm 1.5 m long." The type, not seen, is *Ledermann 11897*, Sepik region, alt. 2,070 m. *Brass'* specimen conforms to the incomplete description. Its stipe is 65 cm long, sharply aculeate throughout, with black mostly curved spines, densely clothed in the lower part with narrow, chestnut-black, mostly appressed scales up to 1 cm long; sporangia naked. Like Brause, I have detected a sporangium with the annulus passing the pedicel; but it is exceptional practically all being of the polypodioid type.

Endemic.

31. *L. VARIEVESTITA* (C. Chr.) Copel.

L. varievestita (C. Chr.) Copel., *Genera* (1946) 140.

Dryopteris atrispora var. *varievestita* C. Chr., *Brittonia* 2 (1937) 296.

Brass 4996, Mt. Tafa, Central Division, Papua, alt. 2,400 m, in Herb. N. Y. Bot. Garden. As noted by Christensen, this is distinguished by the trichomes of the frond, and by not having veinlets connivent at the sinuses. The complete frond of *L. dryopteroidea* reveals more conspicuous differences, the stipe being much more spiny, and bearing on the lower part denser, narrower and much darker paleae.

32. *L. ALTA* (Brause) Copel., comb. nov.

Dryopteris alta Brause, *Engler's Jahrb.* 56 (1920) 86.

Ledermann 11497, Sepik region, alt. 1,300 m; otherwise unknown.

33. *L. QUADRIAURITA* (Christ) Copel.

L. quadriaurita (Christ) Copel., Genera (1946) 139.

Dryopteris quadriaurita Christ, Philip. Jour. Sci. 2 C (1907) 209.

King 220, Papua; *Schlechter 17759*.

Philippines.

The published description should be amplified to show that the paleae are setulose, the lamina sparsely or deciduously setulose above, the pinnae pinnate at the very base only, and the sporangia setulose. The King specimen is typical; that of *Schlechter* is nearly enough so (the pinnae are nowhere pinnate).

34. *L. ENSIPINNA* (Brause) Copel.

L. ensipinna (Brause) Copel., Genera (1946) 138.

Dryopteris ensipinna Brause, Engler's Jahrb. 56 (1920) 84.

Brass 12929, 13362, alt. 1,200 and 850 m. I have not seen the type, *Ledermann 12773*, nor *Ledermann 12533*, var. *acuminata*, but *Brass'* collections fit the description. In minutiae, they are like *L. quadriaurita*, but have longer and narrower pinnae and more numerous segments. I suppose that the identification of *Schlechter 17759* is by Brause, and cannot but wonder that he failed to mention the resemblance.

Endemic.

35. *DRYOPTERIS QUADRIQUETRA* v.A.v.R.

Dryopteris quadriquetra v.A.v.R., Nova Guinea 14 (1924) 16.

Known only by the type collection, *Lam 542*, Mamberamo River, alt. 10 m. Not seen. Stipes glabrescent; fronds dimorphic, subchartaceous.

36. *L. IMMERSA* (Blume) Moore

L. immersa (Blume) Moore, Index (1857)

Carr 14299, Boridi, alt. 4,000 feet; previously reported.

To Luzon and the Malay Peninsula; reported from Polynesia to India.

37. *L. KEYSSERIANA* (Ros.) Copel.

L. keysseriana (Ros.) Copel., Genera (1946) 139.

Dryopteris keysseriana Ros., Fedde's Repert. 10 (1912) 333.

Brass 12928, alt. 1,200 m. Described from Sattelberg, alt. 1,600 m, *Bamler 23* (1911); distributed as *Rosenstock Fil. novog. exsicc. n. 121 1. Bamler*. Remarkable for very long-caudate pinnae with oblique bases. *Bamler 82c*, received from *Rosenstock* under a manuscript name, is a juvenile plant of this species.

Endemic.

38. *L. OBLIQUATA* (Mett.) Copel.

L. obliquata (Mett.) Copel., *Genera* (1946) 139.

Aspidium obliquatum Mett., *Ann. Sc. Nat.* IV 15 (1861) 75.

Another species listed by report. *Goadby 27*, from New Britain, is similar but not identical.

New Caledonia.

39. *DRYOPTERIS PEEKELI* v.A.v.R.

Dryopteris Peekeli v.A.v.R., *Bull. Dept. Agric. Ind. Néerl.* No. 18 (1908) 7.

Known only by the type collection, *Peekel 44*, not seen. Evidently very similar to the preceding species.

40. *L. GRACILESCENS* (Blume) Hooker

L. gracilescens (Blume) Hooker (as to the name), *Jour. Bot.* 9 (1857) 338.

Brass 12217, alt. 1,750 m. "On ground in a rain-forest ravine; rhizome purple when cut." New to New Guinea.

To India and China.

41. *L. LAUTERBACHII* (Brause) Copel.

L. Lauterbachii (Brause) Copel., *Genera* (1946) 139.

Dryopteris Lauterbachii Brause, *Engler's Jahrb.* 49 (1912) 18.

Brass 12127, alt. 1,800 m. The type is *Schultze 273*, Sepik region. Rhizome erect; stipes dark and densely scaly at base; scales sparse upward, caducous on rachis.

Endemic.

42. *DRYOPTERIS STEREOPHYLLA* v.A.v.R.

Dryopteris stereophylla v.A.v.R., *Nova Guinea* 14 (1924) 17.

Known only by the type, *Lam 1785*, Doorman-top, alt. 3,200 m; not seen.

43. *DRYOPTERIS RIGIDIFOLIA* v.A.v.R.

Dryopteris rigidifolia v.A.v.R., *Nova Guinea* 14 (1924) 18.

Lam 1481, 1560, 1562, 1890, Doorman Mountains, alt. 1,420–1,450 m; not seen. This and the preceding species were to be expected in the Archbold Expedition collections, but I do not recognize them.

44. *DRYOPTERIS HORIZONTALIS* v.A.v.R.

Athyrium horizontale Ros., *Nova Guinea* 8 (1912) 722.

Dryopteris horizontalis v.A.v.R., *Bull. Buit.* II No. XI (1913) 10.

Hellwig-Gebirge, alt. 1,350–1,600 m, *v. Roemer 1136*; not seen. Except that it is described as "subcoriaceo-chartaceous," this would seem very near to *L. gracilescens*.

45. *L. CALCARATA* (Blume) Moore

L. calcarata (Blume) Moore, Index (1858) 87.

Known from New Guinea by *Ledermann 11740*, det. Brause. Java to India, common and plastic; not known in the Philippines.

46. *L. FULGENS* (Brause) Copel., comb. nov.

Dryopteris fulgens Brause, Engler's Jahrb. 56 (1920) 89.

Known only by the type collection, *Ledermann 11004*, Hunstein Peak, alt. 1,300 m; not seen. A large relative of *L. falcatipinnula*.

47. *L. SUBDIMORPHA* Copel.

Plate 20.

L. subdimorpha Copel., Genera (1946) 140.

Dryopteris subdimorpha Copel., Univ. Calif. Publ. Bot. 18 (1942) 220.

L. rhizomate horizontale 1 cm crasso, basibusque stipitum confertorum paleis fuscis integris plerisque 2-3 mm longis lanceolatis nonnullis 5 mm longis linearibus vestitis; stipite frondis sterilis ca. 25 cm alto, frondis fertillis altiore, brunneo, paleis parvis linearibus sparso, sursum rhachique pubescentibus parce paleolatis; lamina sterile 30 cm vel ultra longa, 20-25 cm lata, subcoriacea, faciebus glabris, apice acuminata pinnatifida, basi truncata; pinnis infimis subdeflexis 13 cm longis 3.5 cm latis, pedicellis 1 cm longis protensis, apicibus integris breviter acuminatis, basibus rotundatis, segmento infimo acroscopico obsolete, basicopico abbreviato, alibi ad alam 5 mm latam costae suboblique pinnatifidis, segmentis 6 mm latis obtusis integris margine leviter cartilagineo-incrassatis; costis utraque facie setulosis etiam inferne paleis paucis minutis obscuris sparsis; costulis nudis, venis ca. 10-paribus, infimis ad vel infra sinus conniventibus, infima basicopica a costula remota e costa egrediente; lamina fertile minore laxiore; soris medialibus, exindusiatis sporangiis nudis.

Dutch New Guinea: 2 km SW. of Bernhard Camp, Idenburg River, alt. 700 m, *Brass 13666*; "rain-forest undergrowth; few tufts on crests of ridges."

Near enough to be conspecific is *Brass 5155*, from Mafulu, Papua, alt. 1,250 m, in Herb. N. Y. Bot. Garden, identified by Christensen as *D. crassifolia* var. *purpureo-lilacina* C. Chr. Its pinnae are more numerous, smaller and in particular narrower, at most 23 mm wide, and the lowest are somewhat deflexed. The type of *L. subdimorpha* is mature, and I can only say of it that no indusia are present; but *Brass 5155* has an immature fertile frond, and sori without any mature sporangia are exin-

usiate. I do not adopt Christensen's varietal name, because uncertain of identity with the Bornean varietal type; also, it is too long a name.

The most immediate affinity seems to be to *L. motleyana* (Hooker) Copel., whether that be a distinct species, or, as Ching, Bull. Fan. Bot. 6 (1936) 286, regards it, a variety of *L. crassifolia*. The pinnae of *L. subdimorpha* are more deeply cut. There is some uncertainty as to the indusia of *L. crassifolia* and *L. motleyana*. My specimens of *L. crassifolia* suggest no dimorphism.

48. *L. FALCATIPINNULA* Copel.

L. falcaticinnula Copel., Genera (1946) 138.

Dryopteris falcaticinnula Copel., Philip. Jour. Sci. 6 C (1911) 74.

King 114, Papua, in lowlands (1908). We have a larger and more perfect specimen than the type,—*Rosenstock Fil. novog. exsicc. n. 199*, supposed to be a part of the original collection, but dated 1911.

49. *L. ECHINATA* (Mett.) Copel.

L. echinata (Mett.) Copel., Genera (1946) 138.

Aspidium echinatum Mett., Ann. Lugd. Bat. 1 (1864) 230.

Dryopteris echinata C. Chr. See Gardens' Bull. 4 (1929) 386.

Listed by Brause, Engler's Jahrb. 56 (1920) 81. I have a New Guinea specimen collected by Zahn, Sattelberg, alt. 900 m, received with this name, but misidentified.

50. *L. BELENSIS* Copel.

Plate 21.

L. belensis Copel., Genera (1946) 138.

Dryopteris belensis Copel., Univ. Calif. Publ. Bot. 18 (1942) 220.

L. gregis *L. crassifoliae*, rhizomate erecto crasso, inter bases stiptum radicumque paleis fuscis ovatis 1.5 mm longis dense setuliferis vestito; stiptibus caespitosis, 40 cm altis, fuscis, basi paleis parvis sat dense vestitis et hic solummodo tuberculatis, sursum rhachibusque paleis lanceolatis et linearibus ciliatis 1–2.5 mm longis sparsis et minute setuliferis, rhachibus infra bases pinnarum glanduliferis; lamina 45 cm longa, 25 cm lata, acuminata, bipinnatifida, fusca, tenuiter coriacea; pinnis typi 13-paribus, sessilibus, infimis vix abbreviatis haud deflexis, sequentibus 15 cm longis, 3 cm latis, caudato-acuminatis, basi rotundatis, ad alam 2 mm latam costae pinnatifidis, costis superne sulcatis utraque facie setulis brunneis haud densis obsitis; segmentis erecto-patentibus plus minus falcatis, infimis plerumque modo reductis, sequentibus 2 cm longis, basi 5 mm latis, acutis, integris, decidue ciliolatis, superne glabris inferne

ad costulas sparse et decidue setuliferis; venis usque ad 18-paribus, simplicibus, infimis ad vel infra sinus conniventibus vix anastomosantibus, venula infima basiscopica a costula remota e costa oriente; soris costularibus, indusiis parvis setulosis, deciduis.

Dutch New Guinea: Bele River, alt. 2,200 m, *Brass 11509*, "on a limestone cliff in forest; not common;" also, *No. 11327*, same place, an older, somewhat larger specimen, the indusia gone, the sori plainly marked by minute depressions on the upper surface.

This species might be responsible for the report of *L. echinata* in New Guinea, being like that species in connivent veins and slightly scaly rachis. It is more like *L. Hallieri*, but has less setulose costae and costules. Its acute segments are peculiar in the group.

51. *L. COSTULISORA* Copel.

L. costulisora Copel., *Genera* (1946) 138.

Dryopteris basisora Copel., *Philip. Jour. Sci.* 6 C (1911) 73, *non* Christ (1909).

Brass 12465, alt. 2,150 m. The type is *King 304*, from Papua, distributed as *Rosenstock Fil. novog. exsicc. n. 198*, but misdated 1911. *Keysser 23p*, Sattelberg Hinterland, received indet. from Dr. Rosenstock, is also this species. This is a member of the group of *L. crassifolia*, its lowest veins connivent at the sinus, with a raised (on the lower surface) line running from the sinus between them. Rhizome stout, short-creeping, beset with firm, brown densely setuliferous paleae 5 mm long; indusia dark, naked, firm and persistent. *L. wariensis*, to which Christensen, *Suppl. I* 30. thought this might be reduced, is not a near relative; it is exindusiate, and the lowest veinlets run to the margin above the sinus.

Endemic.

52. *L. CHLAMYDOPHORA* (Ros.) Copel.

L. chlamydophora (Ros.) Copel., *Genera* (1946) 138.

Dryopteris chlamydophora Ros. C. Chr., *Gardens' Bull.* 4 (1929) 384.

Brass 3808, Papua, alt. 500 m; see *Brittonia* 2 (1937) 297. Celebes to Burma.

53. *L. OPHIURA* Copel.

Plate 22.

L. ophiura Copel., *Genera* (1946) 139.

Dryopteris ophiura Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 220.

L. rhizomate erecto, valido, paleis fuscis minute setuliferis 4 mm longis dense vestito; stipitibus approximatis, 15 cm altis,

1 mm crassis, basi imo paleatis, alibi rhachibusque minute pallide pubescentibus stramineis; lamina 20 cm longa, ca. 10 cm lata, acuminata, basi truncata, coriacea, costis superne minute antrorso-strigosis exceptis glabra, bipinnatifida; pinnis ca. 7-paribus, infimis vix reductis haud deflexis, superioribus 1-2-paribus sat abrupte diminutis et integrescentibus, medialibus ca. 6 cm longis, 14 mm latis, in caudas 2 cm longas rectas falcatas vel sinuosis protractis, subsessilibus; segmentis infimis reductis rarius liberis, infimo basiscopico interdum tantum vestigiale; segmentis medialibus ca. 8 mm longis, 2-3 mm latis, subfalcatis, integris margine subdeflexis, obtusis vel oblique acutis; venulis usque ad 10-paribus, immersis, infimis supra sinus terminantibus; soris inframedialibus, indusiis coriaceis persistentibus glabris.

Dutch New Guinea: 18 km SW. of Bernhard Camp, Idenburg River, alt. 2,150 m, *Brass 12471*, small clumps on open rock-slide. There is an evident, but not salient, gland on the rachis under the insertion of each pinna.

54. *L. CRASSA* Copel.

Plate 23.

L. crassa Copel., *Genera* (1946) 138.

Dryopteris crassa Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 220.

L. rhizomate repente 1 cm crasso, paleis fuscis 1-2 mm longis lanceolatis minutissime setulosis vestito; stipitibus approximatis, 60 cm altis, 3 mm crassis, brunneis, basi imo paleatis alibi glabris; lamina 20-30 cm longa, 15-20 cm lata, acuminata, basi truncata, rhachi et deorsum costis minute purpureo-strigosis, alibi glabra, rigide coriacea, bipinnatifida; pinnis infimis vix diminutis haud deflexis, segmentis infimis reductis; pinnis medialibus frondis maximae 11 cm longis, basi truncatis 2 cm latis, caudato-acuminatis; segmentis 1 cm longis, 3-3.5 mm latis, plerisque subfalcatis, obtusis, margine deflexis, integris; venulis ca. 12-paribus, conspicuis, infimis paullo supra sinus terminantibus; soris subcostularibus, indusiis obscuris nudis fugacibus. Specie praecedente (*L. ophiura*) differt: rhachi costisque inferne glabris, indusia deciduis.

Dutch New Guinea: 9 km N. E. of Lake Habbema, alt. 2,650 m, *Brass 10878*, type; *ibidem* No. 10934.

Because it grew on a rock-slide, I do not trust the erect rhizome of *L. ophiura* as a fixed character. It and *L. crassa* rook much alike. The darker stipe and rachis, less caudate tips of the pinnae, and slightly greater stature of *L. crassa* may not be essential differences, but the naked axes and transient indusia

should be diagnostic. I am loath to describe these two coriaceous species while two others, *D. stereophylla* and *D. rigidifolia*, from the same region, are unknown to me, but am unable to reconcile the differences in description.

55. *L. WANTOTENSIS* Copel.

Plate 24.

L. wantotensis Copel., Genera (1946) 140.

Dryopteris wantotensis Copel., Univ. Calif. Publ. Bot. 18 (1942) 220.

Clemens 11013 bis, Morobe; known by the one collection.

56. *L. NEPHROLEPIOIDES* (C. Chr.) Copel.

L. nephrolepioides (C. Chr.) Copel., Genera (1946) 139.

Dryopteris nephrolepioides C. Chr., Brittonia 2 (1937) 295, Fig. 1 (p. 268) c, d.

Known only by the type collection, *Brass 5354*, Mafulu, Papua, alt. 1,700 m.

57. *L. HUNSTEINIANA* (Brause) Copel.

L. hunsteiniana (Brause) Copel., Genera (1946) 139.

Dryopteris hunsteiniana Brause, Engler's Jahrb. 56 (1920) 79.

Brass 12372, alt. 1,500 m, "on shaded bank of stream; fronds glaucous beneath." The type is from Hunstein Peak, alt. 1,350 m, not seen but unmistakable from the description. *Brass'* plant has the lowest pinnae enlarged and incised, the second pair like the segments above, only free, and remote by about 5 mm.

Endemic.

58. *L. SETOSA* Presl

L. setosa Presl, Epim. (1849) 40.

Cheilanthes setigera Blume, Enum. (1828) 138.

Lastrea setigera Bedd., Ferns Brit. India, Corr. II (1870), non Moore.

Dryopteris setigera O. K., Rev. Gen. Pl. II (1891) 813.

Common at minor altitudes. Polynesia to India.

59. *L. ARMATA* Copel.

Plate 25.

L. armata Copel., Genera (1946) 138.

Dryopteris spinosa Copel., Univ. Calif. Publ. Bot. 18 (1942) 219.
non *Lastrea spinosa* Newman.

L. leucolepidi similis, paleis basalibus castanesis ovatis glabris axibus minoribus minute puberulis distincta; stipite 75 cm alto basi 1 cm sursum (sicco) 4 mm crasso, stramineo, deorsum paleis castaneis 1-2 cm longis 4-5 mm latis acutis vel acuminatis glabris haud ciliatis vestito, sursum rhachique sparse minutissime puberulis ubique spinis 0.5-1.0 mm longis horridis; lamina

80 cm alta, ovata, acuminata, tripinnata, firme papyracea, fuscescente, superne (etiam in sulcis axium) glabra, rhachibus inferne spinulis sursum minutis armatis, minute obscure debiliter pubescentibus; pinnis infimis 15 cm, medialibus 25 cm longis, 6 cm latis, acuminatis, breviter pedicellatis; pinnulis subsessilibus, recte patentibus, acuminatis, basi 1 cm latis pinnatis, alibi fere ad costam pinnatifidis, segmentis et pinnulis secundariis usque ad 12-paribus infra apicem inciso-serratum, majoribus crenato-dentatis; soris laminam omnino tegentibus, indusiis nullis.

Dutch New Guinea: 9 km N. E. of Lake Habbema, alt. 2,800 m, *Brass 10751*. "Gregarious in young second growth on a native clearing." This is not the place to expect a new species; it is a typical place for *L. setosa* and *L. leucolepis*, both of which enter abandoned clearings in the Philippines like weeds. This species is like them in dissection, and thus in general aspect, but most distinct in its nakedness.

60. *L. LEUCOLEPIS* Presl

L. leucolepis Presl, Epim. (1849) 39.

Brass 12462, alt. 2,150 m; *Carr 12339*, Ronna, alt. 1,400 feet; probably common. In naming Carr's specimen, Alston has agreed with others who call this *Dryopteris uliginosa* (Kunze) C. Chr.; for some synonyms under that name, see Christensen, Suppl. III 100. Maxon, Proc. Biol. Soc. Washington 36 (1923) 170, has interpreted *Aspidium uliginosum* as *D. setigera*, *L. setosa* of this enumeration. Backer and Posthumus, Varenflora voor Java, p. 42, treat *D. leucolepis* as a synonym of *D. uliginosa*, Christensen, Suppl III 90, Dansk Bot. Arkiv 9 No. 3 (1937) 44, treats *D. leucolepis* as distinct, and cites New Guinea synonyms, *Cheilanthes gigantea* Ces., *Polypodium cheilanthoides* Baker, and *Dryopteris brunneo-villosa* C. Chr. The original description of *A. uliginosum* Kunze does not show whether it is *L. setosa* or *L. leucolepis*; it is almost certainly one or the other, and its name has priority. Unable to settle the question, I follow Maxon; but compare still Christensen, Engler's Jahrb. 66 (1933) 46.

Polynesia to India and Japan.

24. *CURRANIA* Copeland

C. *OYAMENSIS* (Baker) Copel.

C. oyamensis (Baker) Copel., Philip. Jour. Sci. 6 C (1911) 147.
Dryopteris genuflexa Ros., Fedde's Repert. 12 (1913) 175.

Keysser B 56 Bolan, alt. 2,400–3,000 m; isotype of *D. genuflexa* in Herb. Univ. Calif.

Japan; China.

25. CYCLOSORUS Link

Hort. Berol. (1833) 128; Ching, Bull. Fan Bot. 8 (1938) 162; Copeland, Genera (1946) 140.

Cyclosorus is so intimately related to *Lastrea* that its separation is justified only by convenience, both being very large genera. New Guinea may be regarded as the center of evolution of *Cyclosorus*.

Key to the species

Sori round.

Only one pair of veinlets anastomosing.

Fronds under 5 cm broad.

Fronnd practically naked 1. *C. roemerianus*

Fronnd strigose.

Fronnds uniform 2. *C. Warburgii*

Fertile fronds contracted 66. *C. canescens* var.

Fronnd finely pubescent 3. *C. obtusifolius*

Fronnds 7–10 cm broad.

Pinnæ subentire 8. *C. mutabilis*

Pinnæ sharply serrate 9. *C. cataractorum*

Pinnæ lobed $\frac{1}{2}$ to costa 4. *C. adenostegius*

Pinnæ incised over half-way to costa 5. *Dryopteris repandula*

Fronnds comparatively large.

Margin of pinnæ entire to serrate.

Indusium naked.

Fronnds uniform 9. *C. Cataractorum*

Fronnds dimorphic 6. *C. dimorphus*

Indusium setulose 7. *Dryopteris sepikensis*

Pinnæ pectinate.

Basal pinnæ not reduced.

Veins setose beneath.

Pinnæ under 15 cm long.

Caudex erect 11. *C. albociliatus*

Rhizome creeping 12. *C. parasiticus*

Pinnæ 25 cm long 13. *C. distinctus*

Veins naked beneath 14. *C. alatellus*

Basal pinnæ gradually reduced.

Segments 2–2.5 mm wide.

Fronnd about 50 cm tall 15. *Dryopteris perpili-fera*

Fronnd over 1 meter tall 16. *Dryopteris hispiduliformis*

Segments 4–5 mm wide.

Glaucous beneath.

Lamina membranaceous 17. *C. austerus*

- Lamina chartaceous 18. *C. farinosus*
 Not glaucous.
 Lamina setulose 19. *Dryopteris hirto-pilosa*
 Lamina naked 42. *C. truncatus*
 Basal pinnae abruptly reduced.
 Lamina setulose above.
 Yellowish-gray beneath 18. *C. farinosus*
 Greenish beneath.
 Saudex erect.
 Veins naked above 20. *C. suprastrigosus*
 Veins setose above 21. *C. vestigiatus*
 Rhizome creeping 22. *C. oblongus*
 Lamina naked above.
 Lamina over 1 meter long 23. *C. superbus*
 Lamina smaller 24. *C. heterocarpus*
 More than the lowest veinlets anastomosing.
 Basal pinnae abruptly reduced.
 Margin cut at least one-fourth costa.
 Lamina naked above.
 Sori strictly costular 25. *C. supraspinigerus*
 Sori inframedial or medial.
 Nether surface setulose.
 Pinnae alternate 26. *C. paraphysatus*
 Pinnae opposite 27. *C. paripinnatus*
 Nether surface naked.
 Pinnae opposite.
 Pinnae dilated at base 28. *C. deltipteris*
 Pinnae not dilated 29. *C. subappendiculatus*
 Pinnae alternate 30. *C. sogerensis*
 Sori extramedial 31. *C. extensus*
 Lamina setulose above.
 Veins densely setose beneath 32. *C. megaphylloides*
 Veins almost naked beneath 32. *A. C. sp.*
 Margin entire or shallowly toothed.
 Pinnae numerous.
 Subcoriaceous or thinner.
 Pinnae opposite 29. *C. subappendiculatus*
 Pinnae alternate.
 Setose above 33. *C. Atasripii*
 Glabrous or nearly so.
 Veins 3 or 4 pairs 34. *Dryopteris tamiensis*
 Veins about 6 pairs.
 Pinnae truncate at base 35. *C. arfakianus*
 Pinnae cuneate 36. *C. gregarius*
 Coriaceous 37. *C. unitus*
 Pinnae few—3-6 pairs 61. *C. micans*
 Basal pinnae gradually reduced.
 Upper surface naked or glabrescent.
 Pinnae 15 cm long or longer.

- Pinnae lobed.
 Indusia hairy 40. *Dryopteris pilosissima*
- Indusia not hairy.
 Pinnae cut one-fourth to costa..... 41. *C. megaphyllus*
 More deeply cut..... 42. *C. truncatus*
 Pinnae crenate to entire..... 35. *C. arfakianus*
- Pinnae hardly exceeding 10 cm.
 Apparently exindusiate.
 Paleae naked 43. *C. rigidus*
 Paleae hairy 44. *C. multiauriculatus*
- Evidently indusiate.
 Pinnae under 15 mm wide.
 Pinnae cuneate 53. *C. riparius*
 Truncate at base.
 Sori about medial.
 Rhizome creeping 38. *C. aridus*
 Rhizome \neq erect 45. *C. protectus*
 Sori subcostular 39. *C. Archboldii*
 (Pinnae 2 cm wide)
 Pinnae 2 cm wide.
 Pinnae gradually narrowed..... 46. *C. amboinensis*
 Pinnae abruptly narrowed..... 47. *C. terrestris*
- Upper surface setulose.
 Pinnae opposite 29. *C. subappendiculatus*
 Pinnae alternate.
 Upper surface sparsely hairy.
 Pinnae up to 1 cm wide..... 39. *C. Archboldii*
 Pinnae 15 mm wide..... 48. *C. confertus*
- Upper surface freely hairy.
 Pinnae 15 mm wide..... 49. *C. dichrotrichus*
 Pinnae up to 11 mm wide.
 Auricles on stipe remote.
 Pinnae linear-lanceolate 50. *C. hispidulus*
 Pinnae broadly lanceolate..... 51. *C. albosetosus*
 Auricles crowded 52. *C. strigosissimus*
- Basal pinnae not reduced.
 Pinnae over 30 cm long..... 54. *C. imponens*
 Pinnae much shorter.
 Pinnae less than 2 cm wide.
 Sori restricted to lobes..... 55. *C. interruptus*
 Sori not so restricted.
 Lamina setose beneath..... 56. *C. invisus*
 Lamina naked.
 Costae naked 57. *C. gongyloides*
 Costae setulose 10. *C. aquatilis*
- Sterile pinnae over 2 cm wide.
 Lamina glandulose beneath..... 58. *C. glandulosus*
 Lamina not glandulose.
 Pinnae abruptly caudate..... 59. *C. cuspidatus*
 Pinnae not caudate 60. *C. urophyllus*

Sori elongate, or basal ones confluent.

Pinnae numerous.

Base of frond gradually narrowed.

Base of pinna auriculate..... 62. *C. hastato-pinnatus*

Base of pinna cuneate-rounded..... 63. *C. morobensis*

Base of frond truncate. (Ampelopteris)

Pinnae about 5 pairs, all small..... 67. *C. lanceolus*

Pinnae 1-3 pairs, fairly large.

Margin entire or nearly so..... 64. *C. triphyllus*

Margin lobed 65. *C. pentaphyllus*

Frond simple or with few reduced pinnae.

Body of frond inciso-lobate..... 66. *C. canescens*

Body of frond more or less entire..... 68. *C. beccarianus*

1. *C. ROEMERIANUS* (Ros.) Copel.

C. roemerianus (Ros.) Copel., Genera (1946) 139.

Dryopteris roemeriana Ros., Nova Guinea 8 (1912) 723.

Brass 11497 (?), Bele River, alt. 2,200 m, "abundant on limestone cliffs in forest." The type, not seen, is *von Roemer* 1025, in mountain forest, alt. 1,350 m, also in Dutch New Guinea. Brass' plant presents inconsistencies with the description, most essentially in having one perfectly regular row of sori on each side of the costa, and in having elongate fronds, about 30 cm long (length not stated by Rosenstock, but shortness indicated by stated shape); but there are so many points of agreement that I am unwilling to describe it as distinct from the unseen species of the same region. The veinlets do not anastomose on the basiscopic side of the pinnae, not anywhere on the smaller pinnae; but on the acroscopic side of the larger ones, the lowest veinlets of several veins regularly anastomose, with "radio calloso in sinum excurrente." The probable affinity is not to *Cyclosorus*, but to *Lastrea nephrolepioides* and *L. petrophila*. Endemic.

2. *C. WARBURGII* (Kuhn and Christ) Wagner and Grether

C. Warburgii (Kuhn and Christ) Wagner and Grether.

Aspidium Warburgii Kuhn and Christ, Monsunia 1 (1900) 81.

Bamler 131 (1914) Sattelberg (type locality of *C. Warburgii*), alt. 400 m, received as *Dryopteris debilis* (Mett.) C. Chr., is more exactly *C. Warburgii*, distinguished by persistent, setose indusia. *Clemens* 6522, Morobe, alt. 1,700 feet, has broader, less densely hirsute pinnae.

Admiralty Ids.; Guam (as *Dryopteris depauperata* Copel.).

3. *C. OBTUSIFOLIUS* (Ros.) Copel.

C. obtusifolius (Ros.) Copel., *Genera* (1946) 143.

Dryopteris obtusifolia Ros., *Fedde's Repert.* 10 (1912) 336.

Known only by the type collection, *Bamler 115*, Sattelberg, alt. 700 m; isotype in Herb. Univ. Calif.

4. *C. ADENOSTEGIUS* Copel.

Plate 6b.

C. adenostegius Copel., *Genera* (1946) 142.

Dryopteris adenostegia Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 220.

C. rhizomate brevi-repente 5 mm crasso; stipitibus approximatis, frondis sterilis 10 cm, fertilis 30 cm altis, fuscis, basi paleis paucis fuscis minutis praeditis, alibi cinereo-velutinis vel sursum rhachibusque potius dense setulosis; lamina ca. 30 cm longa, 8-9 cm lata, acuminata, basi angusta; pinnis inferioribus deflexis paucis sensim diminutis, infimis 8 mm longis 5 mm latis oblique deltoideis; pinnis medialibus 4-4.5 cm longis, 12 mm latis, obtusis vel acutis, basi truncatis inconspicue auriculatis, ca. one-third ad costam incisus, segmentis 2-2.5 mm latis, subcoriaceis, costis sparse costulisque sparsius strigosis, venis superne sparsissime setosis, facie superiore laminae sed conspicue setulosa; venis ca. 5-paribus, infimis anastomosantibus, sequentibus 1-paribus ad sinus conniventibus; soris inframedialibus, indusiis glandulis globosis aurantiacis cinctis, sporangiis glabris.

Dutch New Guinea: 9 km N.-E. of Lake Habbema, alt. 2,800 m, terrestrial in forest, *Brass 10282*; type in Gray Herbarium.

This may resemble *Dryopteris repandula* v.A.v.R., the description of which is more elaborate than clear; it (*C. adenostegius*) seems to be distinguished by absence of paleae above the base of the stipe, less deeply incised pinnae, inframedial sori, and gland-bordered indusia.

5. *DRYOPTERIS REPANDULA* v.A.v.R.

Dryopteris repandula v.A.v.R., *Nova Guinea* 14 (1924) 20.

Known only by the type, *Lam 1058*, Mamberamo River, alt. 90 m; not seen.

6. *C. DIMORPHUS* (Brause) Copel., comb. nov.

Dryopteris dimorpha Brause, *Engler's Jahrb.* 56 (1920) 100.

Known positively only by the type, *Ledermann 12622*, Sepik region, alt. 1,400-1,500 m, not seen. *Carr 15531*, sent to me as this species, has meniscioid venation, which cannot be reconciled with Brause's "Nervis . . . infimis anastomosantibus;" and there are other discrepancies.

From *C. alatellus*, which likewise is commonly dimorphic, *C. dimorpha* seems to be distinguished by very reduced lower pinnae, and by normal pinnae less contracted toward the rachis.

7. **DRYOPTERIS SEPIKENSIS** Brause

Dryopteris sepikensis Brause, Engler's Jahrb. 56 (1920) 101.

Known by the original collections, *Ledermann 12053* and 11183, Sepik region, alt. 2,070 and 1,300 m, not seen. Judging by description only, this seems suspiciously like the preceding species. Christensen, Suppl. III 97, reduces it to *D. arfakiana* (No. 35), which is hard to reconcile with Brause's description.

8. **C. MUTABILIS** (Brause) Copel.

C. mutabilis (Brause) Copel., Genera (1946) 143.

Dryopteris mutabilis Brause, Engler's Jahrb. 56 (1920) 97.

Brass 13047, alt. 850 m, on flood-swept river bank. The type is *Ledermann 9745*, Kaiserin-Augusta River, alt. 200–400 m, isotype in Herb. Univ. Calif. The narrowness of the pinnae is responsible for the mostly free veinlets.

9. **C. CATARACTORUM** Wagner and Grether

C. cataractorum Wagner and Grether, Pterid.

Rook Island, *Bamler R 14*, reported by Rosenstock as "prope *D. aquatilem* Copel.", which is correct as far as it goes. It is distinguished from *C. aquatilis* by sharply toothed pinnae more narrowly cuneate at the base, and by a single pair of anastomosing veinlets.

Admiralty Ids., along lowland streams.

10. **C. AQUATILIS** Copel.

C. aquatilis Copel., Genera (1946) 142.

Dryopteris aquatilis Copel., Philip. Jour. Sci. 6 C (1911) 75.

Known only by the type collection, *King 182*, Papua, below the flood level of creeks.

C. Warburgii, *C. mutabilis*, *C. aquatilis* and *C. riparia* (No. 53) are all stream-bank plants, similar in adaptation to this habitat, and all probably related.

11. **C. ALBOCILIATUS** Copel.

C. albociliatus Copel., Genera (1946) 142.

Dryopteris albociliata Copel., Jour. Arnold Arb. 10 (1920) 177.

The type is *Brass 566*, Basiatabu, Papua, alt. 1,500 feet. To this species I now refer *King 405*, from Loane; it is somewhat larger than the type, with broader instead of more numerous segments, and with the same mixture of pale bristles.

Endemic.

12. *C. PARASITICUS* (L.) Farwell

C. parasiticus (L.) Farwell, Amer. Midland Nat. 12 (1931) 258.

Carr 11645, Veiya, Papua, at sea level, received as *Dryopteris didymosora* (Parish) C. Chr. This identification seems correct, but I can see no detail of difference from the plant I have from Fokien and Tonkin, which is *C. parasiticus* as of late strictly construed. The rhizome is long-creeping. This species, or *C. amboinensis*, may be responsible for the listing of *Dryopteris mollis* (Jacq.) Hieron. as a New Guinea species.

Westward to India.

13. *C. DISTINCTUS* Copel.

Plate 26.

C. distinctus Copel., Genera (1946) 142.

Dryopteris distincta Copel., Univ. Calif. Publ. Bot. 18 (1942) 220.

C. rhizomate ignoto; stipite deorsum fusco, paleis fuscis membranaceis glabris usque ad 12 mm longis basi 1–1.5 mm latis vestito, sursum rhachique brunneis sparsius et decidue paleatis, paleis dejectis spinulis parvis nigris sparsis; lamina grande, herbacea, bipinnatifida, apice breviter acuminata, basi late truncata; pinnis infimis horizontalibus ca. 25 cm longis, 3 cm latis, acuminatis, basi modo angustatis subsessilibus, sequentibus sessilibus basi utroque latere dilatatis, aliter cum basalibus conformibus, ad alam 1.5–2.0 mm latam costae pectinatis, segmentis permultis patentibus subfalcatis obtusis vel subacutis integris usque ad 2 cm longis 2.5–3.0 mm latis; costa superne strigosa, inferne costulisque venisque setulosis, facie inferiore laminae minutissime setulosa; venis ca. 17-paribus, infimis anastomosantibus, sequentibus non conniventibus, soris inframedialibus, indusiis nullis vel vestigialibus, sporangiis setiferis.

New Guinea, present mandated territory: Wareo, alt. 150–180 m, *Bamler W 11* (March, 1914), in Herb. Univ. Calif. No. 391441, type; alt. 600 m, *Bamler, Rosenstock Fil. novog. exsicc. n. 243*.

This is *Dryopteris longissima* (Brack.) var. *novoguineensis* Ros., Hedwigia 56 (1915) 351, the type collection of which was published as *Bamler 132*; it was presumably the collection distributed as *Fil. novog. exsicc. n. 243*. As a complete description was needed, and the varietal name could not serve as specific, I chose as the type our more perfect specimen. I have observed before, Bull. B. P. Bishop Museum No. 93 (1932) 38, that *C. longissimus* is endemic in Tahiti, and this New Guinea fern is far too distinct to justify their association. As they are not particularly related, the effect of treating the New Guinea species

as a variety is to present false evidence of floristic affinity between New Guinea and Polynesia.

14. *C. ALATELLUS* (Christ) Copel.

C. alatellus (Christ) Copel., *Genera* (1946) 142.

Nephrodium and *Aspidium alatellum* Christ (1901).

Dryopteris stenobasis C. Chr., *Index* (1905) 294; older synonyms here.

D. logavensis Ros., *Fedde's Repert.* 10 (1912) 332.

? *D. pseudostenobasis* Copel., *Jour. Arnold Arb.* 10 (1929) 176.

First collected in New Guinea by Weinland, but described from the Schuman and Lauterbach collection. In hand are: *Schlechter 18038*, Finisterre Mountains, alt. 800 m; *Bamler 34* and *35*, the latter being *Rosenstock Fil. novog. exsicc. n. 78*, *D. logavensis*, the description of which is based on *No. 35*; *Zahn ss. nn.*, Sattelberg, alt. 900 m, purporting to be determined by Christ as *Nephrodium echinatum* and *N. pteroides*, but without resemblance to either; *Bamler, Rosenstock Fil. novog. exsicc. n. 230*, also from *Logaueng*, and recognized as *D. alatella*; *Brass 5140*, Mafulu, alt. 1,250 m.

The fertile frond and pinnae of this species may or may not be contracted. Christ noted the dimorphism of the Weinland collection. Rosenstock distinguished his *D. logavensis* by its not being dimorphic,—which is most remarkable, because *Bamler 34*, Rosenstock's *forma minor*, is the contracted form. Both are present on the Zahn collection received as *D. pteroides*. Both are also present on my isotype of *D. stenobasis*, *Cuming 327*; less distinct on *Ramos, Bu. Sci. 17600*, from Samar; and as somewhat different pinnae on the same frond of *Elmer 13555 A*, from Mindanao. It is a variable species in other respects also,—in the width of its uncontracted segments, and in the indusium, which is more or less fugacious. Because I now recognize this as a variable species, I mistrust the distinctness of *D. pseudostenobasis*, which has no trace of an indusium, and has one or two (perhaps casually) reduced lower pinnae.

Central and Southern Philippines; Celebes.

15. *DRYOPTERIS PERPILIFERA* v.A.v.R.

Dryopteris perpilifera v.A.v.R., *Bull. Jard. Bot. Buitenzorg* No. XI (1913) 12.

Known only by the original collection, *Lauterbach 68*, from Finschhafen.

16. *DRYOPTERIS HISPIDULIFORMIS* C. Chr.

Dryopteris hispiduliformis C. Chr., *Suppl. III* (1934) 88.

D. hispida Brause, *Engler's Jahrb.* 56 (1920) 102, non O. K.

Authentically known only by the original collections, *Ledermann 11758* and *11709*, Sepik region, alt. 2,070 m. See No. 31 A of this list.

17. **C. AUSTERUS** (Brause) Copel., comb. nov.

Dryopteris austera Brause, Engler's Jahrb. 56 (1920) 108.

Known only by the type collection, *Ledermann 11750*, Sepik region, alt. 2,070 m. Basal pinnae gradually reduced to rudiments; sori exindusiate.

18. **C. FARINOSUS** (Brause) Copel., comb. nov.

Dryopteris farinosa Brause, Engler's Jahrb. 56 (1920) 111.

Known only by the type collection, *Ledermann 12103*, Sepik region, alt. 2,070 m. Not too evidently distinct from *C. austerus* from the same locality, which is described as larger and thinner.

19. **DRYOPTERIS HIRTO-PILOSA** Ros.

Dryopteris hirto-pilosa Ros., Meded. Rijks Herb. No. 31 (1917) 7.

Carr 11113, 11727, Papua, near sea level, det. Alston.

The type is *Merrill 7671*, which I have not, from the Philippines. The Carr specimens conform to what there is of a description.

20. **C. SUPRASTRIGOSUS** (Ros.) Copel.

C. suprastrigosus (Ros.) Copel., Genera (1946) 143.

Dryopteris suprastrigosa Ros., Fedde's Repert. 10 (1912) 335.

Bamler 37, 4, Sattelberg, distributed as *Rosenstock Fil. novog. exsicc. n. 234*, in Herb. Univ. Calif.; *Brass 5158*, Mafulu, alt. 1,250 m. Described as having medial pinnae 4 cm long; but our specimen, probably *Bamler 4* before distribution, has them up to 9 cm long. It differs from *C. heterocarpus* in having smaller segments and minutely but densely setulose upper surface.

21. **C. VESTIGIATUS** Copel.

Plate 27.

C. vestigiatus Copel., Genera (1946) 143.

Dryopteris vestigiata Copel., Univ. Calif. Publ. Bot. 18 (1942) 220.

C. rhizomate erecto vel adscendente, basibusque stipitum fasciculorum paleis castaneis lanceolatis ca. 4 mm longis sparsis; stipite 50 cm alto, 4 mm crasso, fusco sursum glabro vel glabrescente vestigiis nonnullis omnino inconspicuis pinnarum praedito; lamina 1 m alta vel altiore, 30-35 cm lata, sensim acuminata, basi (absque vestigiis pinnarum) truncata, bipinnatifida, rhachi minutissime pubescente; pinnis ultra 40-paribus, brevi-pedicellatis, infimis aut deflexis aut horizontalibus, rhachin versus angustatis, medialibus basi truncatis, usque ad 18 cm

longis 2 cm latis, caudato-acuminatis, alibi ad alam 2 mm latam costae pinnatifida, herbacea, segmentis 3.5–4 mm latis, obtusis, superne costis ochroleuco-strigosis venis sparse et decidue albo-setosis lamina minutissime decidue setulosa, inferne costis glabrescentibus aliter glabris; venis ca. 9-paribus, infimis anastomosantibus, sequentibus ad marginem supra sinus rotundum attingentibus; soris medialibus, indusiis fugacibus vel nullis, sporangiis nudis.

Dutch New Guinea: 15 km S.W. of Bernhard Camp, Idenburg River, alt. 1,600 m, *Brass 12317*, "Plentiful in undergrowth of rain-forest gullies; fronds somewhat over 2 m long, spreading from a slender stock up to 60 cm long."

Apparently related to *C. alatellus* and *C. heterocarpus*; nearest to *C. oblongus* of the several similar species described by Brause. There seems to be hardly a limit to the number of similar but distinguishable species in this group.

22. *C. OBLONGUS* (Brause) Copel., comb. nov.

Dryopteris oblonga Brause, Engler's Jahrb. 56 (1920) 109.

Known only by the type collection, *Ledermann 10100*, Sepik region, alt. 1,000 m. Epiphytic; distinguished from *C. austereus* by abrupt contraction of base of frond, and more deeply cut pinnae.

23. *C. SUPERBUS* (Brause) Copel., comb. nov.

Dryopteris superba Brause, Engler's Jahrb. 56 (1920) 105.

Known only by the original collections, *Ledermann 11733* and *11848*, Sepik region, alt. 2,070 m. Terrestrial; lamina 125 cm long; medial pinnae 17 cm long; lower pinnae rather abruptly reduced to rudiments.

24. *C. HETEROCARPUS* (Blume) Ching

C. heterocarpus (Blume) Ching, Bull. Fan Bot. 8 (1938) 180.

Reported, as *Dryopteris heterocarpa*, *Ledermann 11601*. The only New Guinea specimen I have seen under this name was misidentified.

Cyclosorus sp., *King 404*, from Ambasi, apparently undescribed, is a member of the preceding group, with a few lowest pinnae abruptly reduced to rudiments, costae naked beneath, and indusia fugacious or none.

25. *C. SUPRASPINIGERUS* (Ros.) Copel.

C. supraspinigerus (Ros.) Copel., Genera (1946) 143.

Dryopteris supraspinigera Ros., Hedwigia 56 (1915) 353.

Bamler 91 (1913), Sattelberg, alt. 900 m; isotype in Herb. Univ. Calif. Not again collected.

26. *C. PARAPHYSATUS* Copel.

C. paraphysatus Copel., Genera (1946) 143.

Dryopteris paraphysata Copel., Philip. Jour. Sci. 6 C (1911) 74.

King 306, Papua. With this may probably be identified *Brass* 13836 and 13837, Idenburg River, alt. 150 m, in a rocky ravine on lower mountain slopes. These specimens show moderate dimorphism, and it is the fertile frond which is like the single frond of the type. Sterile pinnae reach 23 cm in length and 3.5 cm in width, cut one-third of the way to the costa. The rhizome is stout, creeping, clothed at the apex with fuscous pubescent paleae.

27. *C. PARIPPINATUS* Copel.

Plate 28.

C. paripinnatus Copel., Genera (1946) 143.

Dryopteris paripinnata Copel., Univ. Calif. Publ. Bot. 18 (1942) 220.

C. rhizomate erecto, apice basibusque stipitum haud congestorum paleis fuscis membranaceis integris glabris lanceolatis vix 1 cm longis vestitis; stipite usque ad 1 m alto, fusco, glabrescente, sursum rudimentis nonnullis remotis pinnarum praedito; lamina ca. 80 cm alta, basi truncata, pinnis oppositis, sursum in segmenta apicis acuminati sensim transeuntibus, infimis expansis et medialibus ca. 20 cm longis, 2-2.5 cm latis, in apices acuminatos integros subfalcatos protractis, subsessilibus basibus paullo angustatis, subcoriaceis, costas versus ultra medium pinnatifidis, segmentis rotundatis ca. 5 mm latis; rhachi fulvo-setosa, costis utrinque leviter setosis, costulis superne nudis inferne venisque breviter sparse setosis, lamina superne glabra inferne minute sparse setulosa; venis usque ad 9-paribus, infimis anastomosantibus, sequentibus 1-paribus conniventibus et plerisque anastomosantibus, ceteris secus marginem curvis; soris inframedialibus, indusiis glabris, sporangiis non spinuliferis.

Dutch New Guinea: 15 km S.W. of Bernhard Camp, Idenburg River, alt. 1,700 m, *Brass* 12435, type, "a large clump-fern common in rain-forest gullies;" *No.* 12156, *ibidem*.

Remarkable for its height and its rather remote, strictly opposite pinnae. It differs from *C. appendiculatus* in much firmer texture, pinnae contracted at base, and in other details. Other *Cyclosorus* species with opposite pinnae are *C. biauritus* in India, *C. malodorus* in the Solomons, *C. pennigerus* in New Zealand, none evidently related to *C. paripinnatus*. Affinity to the group of *C. crassifolius* is likewise not apparent.

Carr 10202 represents a related species, with few, relatively broad pinnae less deeply lobed, its veins sparsely setose above.

28. *C. DELTIPTERUS* Copel.

Plate 29.

C. deltipterus Copel., *Genera* (1946) 142.*Dryopteris deltiptera* Copel., *Univ. Calif. Bot.* 18 (1942) 220.

C. paripinnato affinis, pinnis basi dilatatis et facie inferiore glabra distinctus; rhizomate adscendente, apice basibusque stipitum confertorum paleis fuscis membranaceis nudis integris ca. 1 cm longis vestitis; stipite ca. 60 cm alto, brunneo, sursum in sulca strigoso alibi glabro, rudimentis nonnullis pinnarum praedito; lamina usque ad 1 m longa, apice breviter acuminato inciso deltoideo basi truncato; pinnis oppositis, remotis, inferioribus sterilibus 15 cm longis acutis basi 3.5 cm latis truncatis sessilibus, subcoriaceis, $\frac{1}{2}$ — $\frac{1}{8}$ ad costas incisis, segmentis rotundatis integris; rhachi costisque superne strigosis, inferne cum facie tota glabris; venis ca. 14-paribus, quorum ca. 6-paribus anastomos-antibus, liberis in marginem angustum cartilagineum curvis; fronde fertile modo contracta, pinnis profundius incisis, venis ca. 10-paribus fere omnibus soriferis; soris inframedialibus, indusiis persistentibus glabris.

Dutch New Guinea: Bele River, alt. 2,200 m, *Brass 11260*, type in Gray Herbarium, "large ground fern, common in flood-plain forest."

A relative of *C. paripinnatus*, most conspicuously distinguished by the form of the pinnae, uniformly narrowed from the broad truncate base to the apex.

29. *C. SUBAPPENDICULATUS* Copel.

Plate 30.

C. subappendiculatus Copel., *Genera* (1946) 143.*Dryopteris subappendiculata* Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 220.

C. rhizomate ignoto; stipite ad vestigia infima pinnarum 10 cm, ad pinnas normales 35 cm alto, basi nigro paleis paucis brunneis 6 mm longis praedito, alibi rhachique fuscis setis obscuris brevibus vestitis; lamina 90 cm longa, 30 cm lata, subdimorpha, basi truncata, segmento apicale 15 cm longo integro-acuminato deorsum inciso-lobato, alibi pinnata; pinnis ca. 16-paribus normalibus, oppositis, remotis, inferioribus 18 cm longis, 2.5–3 cm altis, acuminatis, basi truncatis vix dilatatis, sterilibus incisco-crenatis lobis 5 mm latis 1.5 mm longis truncatis, papyraceis, costis superne appresso-strigosis, inferne glabris, costulis venis et lamina glabris; venis 4–6-paribus plerisque anastomosantibus; pinnis infimis 6-paribus abrupte in auriculas triangulari-hastatas 1 cm longas reductis; pinnis fertilibus lobatis, lobis 5 mm latis 2–3 mm longis falcato-truncatis; soris medialibus vel infra-

medialibus, indusio inconspicuo brunneo setis paucis ornato, sporangiis nudis.

Dutch New Guinea: 15 km S.W. of Bernhard Camp, Idenburg River, alt. 1,700 m, *Brass 12247*; "Several clumps in undergrowth of rain-forest gully; fronds dimorphous, ± 1 m long."

Near *C. deltipterus*, distinguished by longer, narrower pinnae, with parallel and less incised margins, the rudimentary pinnae below the base of the normally developed frond larger and conspicuous.

29a. *C. APPENDICULATUS* (Blume) Copel.

C. appendiculatus (Blume) Copel., *Genera* (1946) 142.

Reported from New Guinea. I have seen no specimen, and suspect wrong identification.

30. *C. SOGERENSIS* (Gepp) Copel.

C. sogerensis (Gepp) Copel., *Genera* (1946) 143.

Dryopteris sogerensis Gepp, *Jour. Bot.* 61 (1923) Suppl. 61.

Described from collections by Forbes at Sogere, Papua, alt. 1,700–2,500 feet; pinnae 15–19 cm long, 1.5–2 cm wide; not well distinguished by description from *C. paraphysatus*. But, identified as this species, comes *Carr 14667*, Boridi, alt. 3,500 feet, pinnae 30 cm long, 3–3.5 cm wide, distinguishable in many ways. Identical with this specimen is *King 411*, from Mamba, Papua.

Endemic.

31. *C. EXTENSUS* (Blume) Ching

C. extensus (Blume) Ching, *Bull. Fan Bot.* 8 (1938) 182.

Aspidium extensum Blume, *Enum.* (1828) 156.

Schlechter 16349, alt. 180 m. Our specimen of this collection might not be identified, but bears this name, and it may well be correct.

Supposed to range from New Caledonia to Africa.

31a. *CYCLOSORUS* sp.

Brass 5197, in Herb. N. Y. Bot. Garden as *Dryopteris hispidualiformis* (No. 16), has the lower pinnae abruptly reduced, 1 or 2 anastomosing veinlets above the lowest pair, and lamina setulose beneath. It is near *C. tadavensis* of Mindanao, but not identical.

32. *C. MEGAPHYLLOIDES* (Ros.) Copel.

C. megaphylloides (Ros.) Copel., *Genera* (1946) 143.

Dryopteris megaphylloides Ros., *Fedde's Repert.* 12 (1913) 174.

Keysser 120, Sattelberg, alt. 800–1,000 m. Our specimen is labelled as *Bamler 120*, almost surely a mistake. Also (var.

glabrescens Ros.) *Rosenstock Fil. novog. exsicc. n. 233*. *King 487*, mountains behind Medan, is approximately this species, more setose than the type, and with broader lobes.

32a. **CYCLOSORUS** sp.

Carr 14202, Boridi, alt. 5,000 feet, received as *D. megaphylloides* and conforming reasonably to the description, is really no near relative; it is probably undescribed.

33. **C. ATASRIPII** (Ros.) Copel.

C. Atasripui (Ros.) Copel., *Genera* (1946) 142.

Dryopteris Atasripui Ros., *Meded. Rijks Herb. No. 31* (1917) 6;

C. Chr., Brittonia 2 (1937) 298.

Brass 13844, Idenburg River, alt. 85 m, frequent on lower forested slopes; *Bamler 51* (1912) Logaueng, alt. 400 m, det. Rosenstock; *Brass 5153*, det. Christensen, and the subject of the first adequate description of the species. Here belongs also *Schlechter 16855*, alt. 500 m, received as *D. sagittifolia*. It thus occurs at minor and middle altitudes throughout the island. Endemic.

34. **DRYOPTERIS TAMIENSIS** Brause

Dryopteris tamiensis Brause, *Engler's Jahrb. 49* (1912) 23.

Known only by the sterile type, *Schultze (33) 86*, from the interior of Kaiser-Wilhelmsland, alt. 1,600 m.

35. **C. ARFAKIANUS** (Baker) Copel.

C. arfakianus (Baker) Copel., *Genera* (1946) 142.

Dryopteris arfakiana (Baker) *C. Chr., Index* (1905) 253; *Dansk Bot. Arkiv 9 No. 3* (1937) 50.

King 483, and (?) 485, from mountains behind Medan; *Carr 12021*, Koitake, Papua, alt. 1,500 feet. So far as my specimen shows, *Carr 15531*, Isuarava, alt. 4,500 feet, is the same species. Here also *Schlechter 17743* and *17746*, Kani Mountains, alt. 1,000 m, and *Bamler, Rosenstock Fil. novog. exsicc. n. 231*, Sattelberg, alt. 900 m, all received as *Dryopteris arbuscula*, but with little resemblance to the fern properly so called. Christensen regards *D. sepikensis* as a small form of this species. *King 483* has an erect caudex 20 cm tall; the paleae are puberulent. Endemic.

36. **C. GREGARIUS** Copel.

Plate 31.

C. gregarius Copel., *Jour. Arnold Arb. 24* (1943) 440.

Known only by the type collection, *Brass 6759*, from the upper Fly River, alt. 80 m.

36A. *C. CYATHEOIDES* (Kaulfuss) Farwell

C. cyatheoides (Kaulfuss) Farwell, Amer. Midland Nat. 12 (1931) 258.

Reported from New Guinea, but probably in error; so far as I know it, this species is endemic in Hawaii.

37. *C. UNITUS* (L.) Ching

C. unitus (L.) Ching, Bull. Fan Bot. 8 (1938) 196.

Brass 11587, 13250, probably 2,200 and 850 m; the former altitude is notable for this species, but the location was grassland, formerly cultivated.

Common, to Polynesia and East African islands.

38. *C. ARIDUS* (Don) Ching

C. aridus (Don) Ching, Bull. Fan Bot. 8 (1938) 194.

Papua, *King* 172, 403; *Brass* 1407; Kaiser-Wilhelmsland, *Schlechter* 16777.

To India and Fiji.

39. *C. ARCHBOLDII* (C. Chr.) Copel.

C. Archboldii (C. Chr.) Copel., Genera (1946) 142.

Dryopteris Archboldii C. Chr., Brittonia 2 (1937) 297.

Papua: Mt. Tafa, alt. 2,400 m, *Brass* 4875. Collected only once.

40. *DRYOPTERIS PILOSO-SQUAMATA* v.A.v.R.

Dryopteris piloso-squamata v.A.v.R., Bull. Agric. Ind. Ind. Néerl. III (1908) 4.

Described from a cultivated plant in the Buitenzorg Garden, originally from Skroe, New Guinea.

41. *C. MEGAPHYLLUS* (Mett.) Ching

C. megaphyllus (Mett.) Ching, Bull. Fan Bot. 8 (1938) 225.

Unknown to me in New Guinea. Cited are *Ledermann* 7553, 8316, and, as var. *abbreviata* Ros., *Keysser* 262.

To the Philippines and Africa.

42. *C. TRUNCATUS* (Poiret) Farwell

C. truncatus (Poiret) Farwell, Am. Midland Nat. 12 (1931) 259.

Brass 12221, 12273, alt. 1,750 m; *Bamler*, *Rosenstock Fil. novog. exsicc. n.* 235; *Brass* 5144, Papua, alt. 1,250 m.

To India.

43. *C. RIGIDUS* (Ridley) Copel., comb. nov.

Goniopteris rigida Ridley, Trans. Linn. Soc. Bot. II 9 (1916) 258.

Cyclosorus Wollastonii (v.A.v.R.) Copel., Genera (1946) 143.

The original description of this species was very inadequate; However, it has a type, of which Mr. Alston has been good

enough to send me a photograph. *Brass 10287, 10826*, Lake Habbema, alt. 2,800 m, resemble it just enough so that I do not care to give them a new name. Because the identification is doubtful, I will not correct and amplify the description, more than is done in the key to the species.

44. *C. MULTIAURICULATUS* Copel.

Plate 32.

C. multiauriculatus Copel., *Genera* (1946) 143.

Dryopteris multiauriculata Copel., *Univ. Calif. Bull. Bot.* 18 (1942) 221.

C. caudice stricte erecto, stipitibus et radicibus exclusis 1 cm diametro, apice stipitibusque paleis rufo-ferrugineis ca. 7 mm longis lanceolatis pubescentibus vestitis; stipitibus 5–10 cm longis, caudici appressis; frondibus subdimorphis, acuminatis, deorsum longe gradatim usque ad apicem caudicis angustatis; fronde sterile 80–100 cm alta, 20 cm lata, rhachi fusco-setosa; pinnis permultis, alternantibus, sessilibus, basi truncatis, acutis, medialibus 10 cm longis, basi leviter dilatatis 1.5 cm latis, integris vel obscure crenulatis, firme papyraceis, costis superne sparse inferne densius setulosis, alibe setulosis setulis caducis; venis 4–5-paribus, plerisque anastomosantibus; pinnis superioribus in segmenta apicis sensim transeuntibus; fronde fertile paullo minore, venis 3–4-paribus omnibus soriferis, soris medialibus, primo orbicularibus deinde nonnullis elongatis, infimis saepe more Meniscii confluentibus, tum demum faciem inferiorem omnino tegentibus, indusiis invisibilibus, sporangiis nudis.

Dutch New Guinea: 6 km SW. of Bernhard Camp, Idenburg River, alt. 1,150 m, *Brass 12850*, type, "common ground fern in rain-forest gullies; fronds dimorphous, spreading from an erect stock up to 40 cm in length;" also, *No. 13054*, alt. 850 m.

Similar, and probably related, to *C. hastato-pinnatus*, *No. 62*, which has a symmetrical entire terminal leaflet, and erecto-patent lateral pinnae pronged on the upper side, with the surface probably naked from the start; they are alike in the gradual shortening of the crowded lower pinnae, the lowest broadly triangular.

45. *C. PROTECTUS* Copel.

Plate 33.

C. protectus Copel., *Genera* (1946) 143.

Dryopteris protecta Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 221.

C. caudice erecto, 10–12 mm diametro, apice dense et stipitibus sparsius paleis fuscis 7–10 mm longis late lanceolatis minutissime decidue puberulentibus vestitis; stipitibus ad vestigia infima pinnarum 5–10 cm altis; lamina 70–80 (basi contracta exclusa ca. 50 cm) alta, 14 cm lata, apice pinnatifida acuminata, basi

sensim vel subabrupte contracta, pinnis infimis remotis ad vestigia vix manifesta reductis, rhachi ferrugineo-setulosa; pinnis medialibus alternantibus, subsessilibus, 7.5 cm longis, 13 mm latis, acutis, basi truncatis, one-fourth to one-third ad costam incisis, segmentis 2.5 mm latis, subcoriaceis, costis breviter strigosis, costulis venisque sparse setulosis, lamina glabra; venulis ca. 5-paribus, bipolaribus plerumque anastomosantibus; soris inframedialibus (haud costularibus), indusiis persistentibus setulosis.

Dutch New Guinea: 9 km N.-E. of Lake Habbema, alt. 2,800 m, *Brass 10933*, type; "Abundant in thin secondary forest on an old landslip; leaves spreading from a semi-erect slender stem 40-50 cm high;" *No. 11246*, Bele River, alt. 2,300 m; *No. 12470*, on an open rock-slide, alt. 2,150 m, fronds only 45 cm long and hardly 10 cm wide.

46. *C. AMBOINENSIS* (Willd.) Copel.

C. amboinensis (Willd.) Copel., *Genera* (1946) 142.

C. subpubescens (Blume) Ching, *Bull. Fan Bot.* 8 (1938) 211.

Both of these species, as well as *Dryopteris mollis* which has been used as a name of both, have been reported from New Guinea. *Carr 11635*, from Veiya, Papua, comes as *C. subpubescens*.

C. dentatus (Forsk) Ching, which, broadly construed, can include all of these, is then pantropic.

47. *C. TERRESTRIS* Copel.

Plate 34.

C. terrestris Copel., *Genera* (1946) 143.

Dryopteris terrestris Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 221.

C. rhizomate brevi-repente, basibusque stipitum paleis atrofuscis ca. 4 mm longis microscopice setuliferis vestitis; stipitibus approximatis, usque ad vestigia infima pinnarum 10-15 cm, usque ad pinnae normales 30 cm altis, rhachibusque minute appresso-setosis; lamina (basi contracta exclusa) ca. 45 cm longa, 15 cm lata, apice 15 cm longo pinnatifido acuminato; pinnis infimis paucis remotis ad vestigia reductis, infimis normalibus deflexis, 5-6 cm longis, media longitudine quam basi latioribus; medialibus 7-8 cm longis 2 cm latis, alternantibus, sessilibus, basi recte truncatis, abrupte falcato-acuminatis et hic integris, alibi serratis vel inciso-serratis, papyraceis, microscopice sparse setulosis oculo nudo glabris; venulis 5-paribus, plerisque anastomosantibus et soriferis; soris medialibus, indusiis et sporangiis setuliferis.

Dutch New Guinea: 2 km S.-W. of Bernhard Camp, Idenburg River, alt. 700 m, *Brass 13660*; "Rain forest; common ground

fern on steep slopes;" The illustration, *Plate 35*, shows the peculiar form of the pinnae, better than is possible with words.

48. **C. CONFERTUS** (Brause) Copel.

C. confertus (Brause) Copel., *Genera* (1946) 142.

Dryopteris conferta Brause, *Engler's Jahrb.* 49 (1912) 22, f, 1 F.

Kani-Gebirge, alt. 700 m, *Schlechter 17846*, isotype in Herb. Univ. Calif. *Brass 3849*, Dieni, Central Division, Papua, alt. 500 m, is superficially similar, but is long-stipitate, and has minute indusia and naked sporangia. Brause's figure of the whole frond gives little idea of its appearance.

Endemic.

49. **C. DICHROTRICHUS** Copel.

C. dichrotrichus Copel., *Genera* (1946) 142.

Dryopteris dichrotricha Copel., *Philip. Jour. Sci.* 6 C (1911) 74.

Papua, *King 294, 219*; otherwise unknown. This species and *D. dichrotrichoides* v.A.v.R., a Philippine species, are reversed by Christensen, *Suppl.* III 84.

50. **C. HISPIDULUS** (Dec.) Copel.

C. hispidulus (Dec.) Copel., *Genera* (1946) 142.

Aspidium hispidulum Decaisne, *Nouv. Ann. Mus. Paris* 3 (1834) 346.

Dryopteris angusta Copel., *Philip. Jour. Sci.* 9 C (1914) 3.

King 408, type of *D. angusta*, from Papua *Schlechter 16805*, alt. 300 m; *Bamler, Rosenstock Fil. novog. exsicc. n. 232*, alt. 800 m. *Dryopteris perpilifera* v.A.v.R., No. 15 of this list may be another synonym.

Malaya; Samoa.

51. **C. ALBOSETOSUS** Copel.

Plate 35.

C. albosetosus Copel., *Genera* (1946) 142.

Dryopteris albosetosa Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 221.

C. rhizomate brevi-repente, 3 mm crasso, basibusque stipitum paleis atrocastaneis ovatis minute ciliatis vestitis; stipitibus approximatis, usque ad vestigia infima pinnarum ca. 5 cm (ad laminam expansam 10–15 cm) altis, sursum rhachibusque breviter cinereo-setosis et pulverulentibus; lamina (pinnis infimis ca. 6-paribus subabrupte reductis exclusis) 20–25 cm longa, 7 cm lata, sursum in apicem acuminatum pinnatifidum 7–9 cm longum sensim angustata; pinnis infimis normalibus paulo abbreviatis vix deflexis, medialibus alternantibus subsessilibus, 4 cm longis, 1 cm latis, obtusis vel subacutis, basi truncatis, inciso-dentatis dentibus 3 mm latis margine deflexis, subcoriaceis, superne ubique albosetosis; venulis 5–6-paribus quarum 3-paribus anastomosantibus; soris medialibus, indusiis et sporangiis setosis.

Dutch New Guinea: Bele River, alt. 2,200 m, *Brass 11435*; "Abundant in small clumps on dry face of a limestone wall in forest shade."

Related to *C. confertus*, but pinnae smaller, more incised and more setose.

52. *C. STRIGOSISSIMUS* Copel.

Plate 36.

C. strigosissimus Copel., *Genera* (1946) 143.

Dryopteris strigosissima Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 221.

C. rhizomate erecto, breve, stipitibusque paleis atrofuscis ovatis acuminatis minute pubescentibus usque ad 8 mm longis vestitis; stipitibus fasciculatis, 2-4 cm longis; lamina 40 cm longa, 10 cm lata, apice acuminato 2 cm et pinnatifido 4 cm longo, basi angustata et deinde in crus 10 cm longum contracta, pinnis hic contiguis vel imbricatis sursum 1 cm longis triangulari-hastatis deorsum sensim ad vestigia diminutis, rhachi dense fulvo-tomentosa; pinnis medialibus alternantibus sessilibus, acuminatis, basi paullo dilatatis 8-10 mm latis fere contiguis, dentatis dentibus 1 mm longis 2 mm latis, papyraceis, facie superiore ubique densissime breviter pallide setosa; venulis ca. 5-paribus, 3-paribus anastomosantibus; soris medialibus, indusiis magnis persistentibus dense setosis, sporangiis glabris.

Dutch New Guinea: Bele River, alt. 2,200 m., *Brass 11436*. "A few tufted plants on dry face of a limestone cliff in forest shade."

It will be observed that this and the preceding species were collected together and look much alike. Two superficially similar Mexican species grow on shaded limestone cliffs.

53. *C. RIPARIUS* Copel.

Plate 37.

C. riparius Copel., *Genera* (1946) 143.

Dryopteris riparia Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 221.

C. rhizomate adscendente, 4 mm crasso, basibusque stipitum paleis paucis fuscis ovatis subglabris 2 mm longis vestitis; stipitibus confertis, usque ad pinnae infimas remotas vestigiales 5-12 cm altis, pube decidua et paleolis paucis caducis praeditis; lamina 40 cm longa, 7-9 cm lata, apice acuminato pinnatifido breve, basi sensim vel abrupte contracta pinnis reductis paucis, rhachi superne strigosa, inferne setulosa vetustate glabrescente; pinnis medialibus alternantibus subsessilibus, 5.5 cm longis, vix 1 cm latis acutis basi cuneatis interdum subauriculatis, $\frac{1}{3}$ ad costam inciso-serratis dentibus 3 mm latis 1.5 mm longis, subcoriaceis, costis superne strigosis, aliter glabris; venulis biparibus anastomosantibus, 2 3-paribus liberis; soris medialibus, indusiis persistentibus sporangiisque glabris.

Dutch New Guinea: 4 km S.W. of Bernhard Camp, Idenburg River, alt. 800 m, *Brass 13048*. "Very abundant on steep, shaded, flood-swept bank of river."

There is some resemblance to the Philippine *C. philippinensis*, but this may be due wholly to the common habitat. Typically flood-swept species look alike, the world over.

54. *C. IMPONENS* (Ces.) Copel.

C. imponens (Ces.) Copel., *Genera* (1946) 142.

Dryopteris imponens (Cesati) C. Chr.; see *Dansk Bot. Arkiv* 9 No. 3 (1937) 50.

D. armata Ros. *Hedwigia* 56 (1915) 351.

D. muricata Brause, *Engler's Jahrb.* 56 (1920) 106.

Brass 12948, 13269, 13728, alt. 800–1,200 m; *Carr 15410*, Isuarava, alt. 4,500 feet; *Bamler 111*, Sattelberg, alt. 700–800 m, distributed as *Rosenstock Fil. novog. exsicc. n. 242*, both in *Herb. Univ. Calif. King 455* is near this species, not identical.

D. muricata is reduced by description. Brause distinguished it from *D. armata*:

1. By the basal paleae. In this respect, *Brass 12948*, his only specimen with stipe base, fits Brause's description. Our stipe base of *Bamler 111* is that of a small frond, certainly of the same species.

2. By the spacing of the pinnae, described by Brause as "subcontiguus." They are contiguous on the upper part of the frond of *Bamler 111*, but are rather remote toward the base of specimens showing the base; *Brass 12948* shows both base and apex. Brause's specimen was evidently incomplete,—"*Folia usque ad 2 m (e scida) longa.*" *Brass'* note on No. *13269* shows a total height of 4 meters.

3. By elongate sori, especially the lower ones. This is more or less evident on all specimens.

Endemic.

55. *C. INTERRUPTUS* (Willd.) Ching

C. interruptus (Willd.) Ching, *Bull. Fan Bot.* 8 (1938) 184.

Aspidium pteroides Sw., non *Polypodium pteroides* Retz.

Carr 11123, 11722, Papua, at sea level.

To India and China; and reported from Queensland and Polynesia.

56. *C. INVISUS* (Forster) Copel.

C. invisus (Forster) Copel., *Genera* (1946) 142.

Polypodium invisum Forster, *Prod.* (1786) 81.

Brass 5538, Mafulu, Papua, alt. 1,250 m; previously reported. Polynesia, Philippines.

57. *C. GONGYLODES* (Schkuhr) Link

C. gongyloides (Schkuhr) Link, Hort. Berol. II (1833) 128.

Brass 14076, alt. 50 m. "Massed in floating grass of deep, open marshes; common." It should be common in wet meadows, but seems not to have been reported before in New Guinea.

All warm lands; New Zealand.

58. *C. GLANDULOSUS* (Blume) Ching

C. glandulosus (Blume) Ching, Bull. Fan Bot. 8 (1938) 227.

Reported from New Guinea but I have seen no specimen. Malaya; Philippines; Solomon Islands.

59. *C. CUSPIDATUS* (Blume) Copel.

C. cuspidatus (Blume) Copel., Genera (1946) 142.

Meniscium cuspidatum Blume, Enum. (1828) 114.

I have seen no specimen; Brause cites *Ledermann* 9743 as *Dryopteris urophylla*, var. *cuspidata*.

Malaya; Philippines.

60. *C. UROPHYLLUS* (Wall.) Copel.

C. urophyllus (Wall.) Copel., Genera (1946) 143.

King 258, Papua; *Bamler*, *Rosenstock Fil. novog. exsicc. n.* 174, Sattelberg, alt. 900 m. There is also var. *peraspera* v.A.v.R., *Lam* 677, not seen.

Asia to Australia and Fiji.

60a. *DRYOPTERIS RUFO-PILOSA* Brause

Dryopteris rufo-pilosa Brause, Engler's Jahrb. 56 (1920) 106.

Goniopteris rudis Ridley. Trans. Linn. Soc. Bot. II 9 (1916) 259.

A photograph of the type, kindly sent by Mr. Alston, shows the pinnae to be alternate, the veinlets up to 11 pairs, the soti medial,—all contrary to the description. I do not see why it is not *C. urophyllus*.

61. *C. MICANS* (Brause) Copel.

C. micans (Brause) Copel., Genera (1946) 143.

Dryopteris micans Brause, Engler's Jahrb. 56 (1920) 98.

Brass 12900, 13392, alt. 850 and 1,150 m. Described from *Ledermann* 12468 and 11278. Endemic.

62. *C. HASTATO-PINNATUS* (Brause) Copel.

C. hastato-pinnatus (Brause) Copel., Genera (1946) 142.

Dryopteris hastato-pinnata Brause, Engler's Jahrb. 56 (1920) 112.

Brass 13419, alt. 850 m, "scattered in the stony bed of a rain-forest stream." Described from *Ledermann* 8237, 7047.

Suggestive of *C. aquatilis* and *C. riparia*, in adaptation to the common habitat.

Endemic.

63. *C. MOROBENSIS* Copel.

Plate 38.

C. morobensis Copel., *Genera* (1946) 143.

Dryopteris morobensis Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 221.

Pseudomeniscium trunco arboreo 150 cm alto (teste lectore); stipite 20 cm alto 6 mm crasso, fusco, basi paleis fuscis appressis integris membranaceis 1 cm longis vestito, alibi glabrescente asperulo; lamina ultrametrale subdimorpha, pinnata, basi sensim longe angustata, rhachi glabra ad basin pinnae quaeque aerophoro praedita; frondis sterilis pinna apicale obscure crenata aliter ceteris conforme, pinnis inferioribus gradatim reductis et remotis, infimis vix 5 mm longis et latis; pinnis medialibus permultis alternantibus, erecto-patentibus, 20–25 cm longis, 1.5–2 cm latis, sensim acuminatis, subsessilibus, basi acroscopica cuneata basiscopica rotundata, integris vel sinuatis, subcoriaceis, glabris; venulis 3- 4-paribus oblique anastomosantibus, 1-2-paribus brevibus liberis; frondis fertilis partibus omnibus minoribus, pinnis ca. 12 cm longis 8 mm latis, crenatis, venulis ubique soriferis, soris nudis confluentibus paginam inferiorem dense dententibus.

New Guinea: Morobe, Finongan, alt. 1,400 m, *Clemens s. n.*, "in mossy mountain bush; trunk 5–6 feet."

This seems much like *C. dimorphus* (No. 6), but the description of that species is explicit, "nervis . . . infimis anastomosantibus," and "das unterste Paar anastomosierend." The sori are not merely crowded as the sporangia mature; they are somewhat indefinite, more or less elongate along the veinlets, and with border-sporangia on the "parenchyma."

64. *C. TRIPHYLLUS* (Sw.) Copel.

C. triphyllus (Sw.) Copel., *Genera* (1946) 143.

Meniscium triphyllum Swartz, *Schrader's Journal* (1801) 16.

Papua: *King 322; Carr 11983.*

Queensland to India.

65. *C. PENTAPHYLLUS* (Ros.) Copel.

C. pentaphyllum (Ros.) Copel., *Genera* (1946) 143.

Dryopteris pentaphylla Ros., *Fedde's Repert.* 12 (1913) 529.

Known only by the type collection, *Keysser 186* (1913) Hinterland des Sattelbergs, 1,400–1,500 m; isotype in Herb. Univ. Calif.

66. C. CANESCENS (Blume) Copel.

C. canescens (Blume) Copel., Genera (1946) 142.

Dryopteris canescens var. *novo-guineensis* Brause, Engler's Jahrb. 49 (1912) 22.

Brass 12210, alt. 1,750 m. "Bank of a forest stream; common on rocks and on ground." The varietal type is *Schlechter 18844*, Bismarck Mountains; isotype in Herb. Univ. Calif.

The variety is endemic, and would better be regarded as a species, as I have treated nearly related Philippine members of the group. It is distinguished from the supposedly typical *C. canescens* by some degree of dimorphism and by having only the lowest veinlets anastomosing.

67. C. LANCEOLUS (Christ) Copel.

C. lanceolus (Christ) Copel., Genera (1946) 142.

Dryopteris lanceola (Christ) Copel., Philip. Jour. Sci. 56 (1935) 102.

Keysser II 85 (1912), Bolan, alt. 2,400–3,000 m, received as *D. canescens* var. *nephrodiiformis* Christ; fertile frond only, exactly like Philippine fertile fronds.

Philippines.

68. C. BECCARIANUS (Ces.) Copel.

C. beccarianus (Ces.) Copel., Genera (1946) 142.

Meniscium beccarianum Cesati, Rend. Ac. Napoli 16 (1877) 27.

Dryopteris cesatiana C. Chr., Index (1905) 257.

D. oblanceolata Copel., Philip. Jour. Sci. 9 C (1914) 3.

D. canescens var. *incana* Ros., in herb.

Brass 12199, 13050, alt. 1,750 and 850 m.

Throughout New Guinea, evidently common.

Fiji.

SPECIES NOT PLACED:

Dryopteris mamberamensis v.A.v.R., Bull. J. B. Buitenzorg II No. 24 (1917) 3.

26. AMPELOPTERIS Kunze**A. PROLIFERA (Retz.) Copel.**

A. prolifera (Retz.) Copel., Genera (1946) 144.

Hemuinitis prolifera Retz., Obs. VI (1791) 38.

Dryopteris prolifera C. Chr., Index 286, and other recent writers.

Brass 8875, 13936, swampy places near sea level; *Lam* 1105, 1141, same region and habitat; *King* 128, *Carr* 12285, Papua. Polynesia to Africa.

27. SPHAEROSTEPHANOS J. Smith**S. POLYCARPA (Blume) Copel.**

S. polycarpa (Blume) Copel., Univ. Calif. Publ. Bot. 16 (1929) 60.

King 159, 410, 413; Brass 544, all from Papua; *Bamler, Rosenstock Fil. novog. exsicc. n. 81*, Logaueng, alt. 300 m. Larger than known elsewhere, but not otherwise distinguishable.

Malaya. The generic range includes the Solomon Islands.

27A. CYSTOPTERIS Bernhardt

C. TENUISECTA (Blume) Mett.

C. tenuisecta (Blume) Mett.

Ledermann 858 is reported as this species, but it is misplaced in *Cystopteris*.

To Formosa and India.

28. ATHYRIUM Roth

Key to the species

Veins free.

Fronde tripinnatifid or more dissected.

Small ferns, mostly under 20 cm tall.

Paleae and lamina brownish..... 1. *A. minutum*
Entire plant blackish 15. *A. squamuligerum*

Size moderate,—up to 60 cm tall.

Axes light-brown.

Pinnae obtuse to acute..... 2. *A. setiferum*
Pinnae acuminate 3. *A. Myer-Dreesii*
Axes dark-brown..... 4. *A. scotinum*

Large ferns.

Fully tripinnate.

Secondary pinnules incised.

Sori elongate 7. *A. Huttoni*
Sori short, basal 9. *A. decompositum*

Secondary pinnules entire.

Rachises furfuraceous 8. *A. latilobum*
Rachises naked except at nodes..... 6. *A. pedicellatum*

Tripinnatifid.

Sori short.

Segments 4 mm wide..... 10. *A. woodwardioides*
Segments 2–3 mm wide..... 11. *A. sylvaticum*

Sori elongate.

Indusium lacerate.

Veins nearly all simple..... 12. *A. Blumei*
(Forked veins not rare)

Forked veins not rare.

Pinnules 25 mm wide..... 13. *D.* Nymani*
Pinnules 15 mm wide..... 14. *D. Schraderi*

Indusium entire.

Segments 12 by 3.6 mm..... 15. *D. Schlechteri*
Segments 10 by 5 mm..... 16. *D. Schultzei*

Fronde bipinnate, not nearly tripinnate.

Lamina thin.

Sori short 2. *A. setiferum*

* This key "D" stands for *Diplasium*.

- Sori elongate 5. *A. morobense*
- Lamina firm.
- Small fern, mostly under 20 cm tall..... 17. *A. squamuligerum*
Much larger.
- Pinnules cut two-thirds to costa..... 18. *D. opacifolium*
Pinnules cut one-third or one-half to costa.
- Pinnules up to 6 cm long.
- Lamina over 50 cm long..... 19. *A. nitens*
Lamina under 30 cm long..... 5. *A. morobense*
Pinnules commonly 12 cm long..... 20. *A. davaoense*
Pinnules more shallowly toothed.
- Pinnules over 10 cm long..... 21. *A. maximum*
Pinnules 3-5 cm long..... 22. *A. cyatheifolium*
- Pinnae pinnate at base, elsewhere subpinnate.
- Paleae of stipe elongate, short-ciliate..... 23. *A. uncidens*
Most paleae reduced to tufts of hairs..... 24. *A. Keysseri*
- Pinnae deeply pinnatifid.
- Stellate paleae present.
- Indusium linear 25. *A. protensum*
Indusium wanting 26. *D. asterothrix*
- Stellate paleae absent.
- Stipe and rachis dark.
- Pinnae about 2.5 cm wide..... 27. *A. sorsogonense*
Pinnae 6 cm wide..... 28. *A. Archboldii*
Axes stramineous or greenish..... 29. *A. japonicum*
- Pinnae icised or lobed.
- Pinnae subcordate.
- Lacerate squamules present 30. *A. Weinlandii*
Lacerate squamules wanting 31. *A. serrato-crenatum*
- Pinnae truncate or cuneate at base.
- Sori elongate 32. *A. bulbiferum*
Sori horse-shoe-shaped 33. *A. Ledermanni*
- Pinnae serrate 34. *A. pallidum*
- Pinnae crenate-sinuate or entire.
- Pinnae about 1 cm wide.
- Stipe and rachis stramineous..... 35. *A. flavoviride*
Stipe and rachis black, scaly..... 36. *A. acrocarpum*
Pinnae much wider 39. *A. frazinifolium*
- Veins anastomosing.
- Fronnd bipinnate 37. *A. esculentum*
- Fronnd pinnate or simple.
- Base of pinnae cuneate.
- Axes brown, naked 38. *A. frazinifolium*
Axes black, scaly 39. *A. Cumingii*
Fronnd usually simple, base cordate..... 40. *A. cordifolium*

1. *A. MINUTUM* Copel.

Plate 39.

A. minutum Copel., Univ. Calif. Publ. Bot. 18 (1942) 221.

A. nanum, rhizomate brevi-repente, paleis linearibus 5 mm longis integris olivaceo-ferrugineis vestito; stipitibus fascicu-

latis, gracilimis, ca. 5 cm longis, fuscis, parce et decidue squamulatis; lamina 3-5 cm longa, basi 2.5 cm lata, subacuta, tripinnatifida; rhachi filiforme, superne angustissime alata, parce decidue strigilosa; pinnis ca. 8-paribus, inferioribus stipitulatis, apice rotundatis, infimis maximis 8 mm latis, herbaceis, glabris; pinnulis usque ad 4-paribus, infimis pedicellatis, truncato-orbicularibus, profunde incisus segmentis 2-4, segmentis majoribus et pinnulis minoribus apice pauci-dentatis; soris ad pinnulas vel segmenta semper basalibus, saepe solitariis, brevibus, indusio lato, stramineo, integro vel eroso, persistente.

Dutch New Guinea: Northern slope of Mt. Wilhelmina, alt. 3,950 m, *Brass et Myer-Drees 10107*, in a rock-hole on grassland; *No. 10340*, alt. 3,800 m, among mosses in wet limestone cave.

A relative of *A. setiferum*, distinguished by non-acuminate frond, ovate pinnae, dissected pinnules, and position of sori.

2. A. SETIFERUM C. Chr.

A. setiferum C. Chr., Index (1905) 146; Brittonia 2 (1937) 293.

Brass et Myer-Drees 9857, Mt. Wilhelmina, alt. 3,560 m, in tufts in ground moss in subalpine forest; *Brass 4392, 4481*, Mt. Albert Edward, alt. 3,680 m,—see Brittonia, 1. c.

Himalayas. Represented in Borneo by *A. atropurpureum* Copel.; in Luzon and Formosa, by *A. Oreopteris* Copel.

3. A. MYER-DREESII Copel.

A. Myer-Dreesii Copel., Univ. Calif. Publ. Bot. 18 (1942) 222.

A. rhizomate erecto, paleis ferrugineis fuscescentibus integris anguste lanceolatis attenuatis 7 mm longis vestito; stipitibus fasciculatis, 30 cm altis, gracilibus, stramineis brunnescentibus, deorsum sparse paleatis sursum nudis; lamina 20 cm longa 10 cm lata, subtripinnata, apice valde attenuata, glabra, papyracea (sicca); pinnis infimis 8.5 cm longis 15 mm latis, sensim acuminatis, pedicellis 3 mm longis; pinnulis majoribus brevipedicellatis, rhomboideis, 10 mm longis 5 mm latis, apice rotundatis, subpinnatis segmentis 0.6-1.2 mm latis apice 1-3-dentatis; pinnis sequentibus gradatim minoribus; soris ad segmenta plerisque basalibus; indusiis latis, plerisque rectis, brunneis, integris vel eroso-crenatis.

Dutch New Guinea: 7 km N.E. of Wilhelmina-top, alt. 2,560 m, *Brass et Myer-Drees 9851*, in ground moss of subalpine forest. Type in Gray Herbarium.

One of the group of *A. nigripes*, more immediately related to *A. setiferum*.

4. A. SCOTINUM (Ros.) Copel., comb. nov.

Diplazium scotinum Ros. Fedde's Repert. 12 (1913) 169.

The type is *Kyesser B* (or *II*) 44, Mt. Bolan, alt. 3,400–3,800 m; isotype in Herb. Univ. Calif. Rosenstock, 1. c., distinguished also vars. *platyloba*, *Keysser B* 61 (not seen), and *microloba*, *Keysser B* 41, collected at the same place; the latter needs no distinguishing name. There is also var. *contracta* Hieron., Engler's Jahrb. 56 (1920) 143.

Endemic.

5. A. MOROBENSE Copel., sp. nov.

Plate 40.

A. rhizomate adscendente, 3 mm crasso, paleis atris lanceolatis 3 mm longis vestito; stipitibus congestis, basin versus nigris paleatis, sursum rhachibusque atroviridibus glabris; lamina 20–25 cm longa, 12 cm lata, bipinnata, acuminata; pinnis erecto-patentibus, pedicellatis, basi conspicue obliquis, acutis; pinnulis infimis acroscopicis maximis 15 mm longis, 7 mm latis, obliquis, latere acroscopico incisus lobis paucis, alibi cum pinnulis caeteris tantum serrulatis, papyraceis, glabris; soris majoribus 2 mm longis, plerisque unilateralibus, indusiis angustis obscuris.

New Guinea: Morobe: Boana, alt. 800–1,400 m, *Clemens* 41537, anno 1940.

This species suggests the group of *A. Williamsii*, which is better developed in the Philippines.

6. A. PEDICELLATUM Copel.

Plate 41.

A. pedicellatum Copel., Univ. Calif. Publ. Bot. 18 (1942) 222.

A. rhizomate adscendente, 5 mm crasso, atro-fusco, apice paleis 1–2 mm longis ferrugineis vestito, glabrescente; stipite 10–15 cm alto, 1.5 mm crasso, nigrescente, glabro; lamina 25 cm longa vel majore, ovata, tripinnata (plantarum minorum laminis jam soriferis tantum tripinnatifidis), ad insertionem quamque pinnae vel pinnulae palea plerumque solitaria ornata, aliter glabra, rhachibus atroviridibus, pinnulis et pinnulis fere recte distantibus pedicellatis; pinnulisⁱⁱ oblongis, ca. 4 mm longis et 2 mm latis, integris vel apice denticulatis, herbaceis, venulis simplicibus; soris usque ad 2 mm longis, fere omnibus unilateralibus infimis rarius diplazioides, indusio firmo, secus venulam nigro alibi laete brunneo.

New Guinea: Morobe: Boana, alt. 800–1,400 m, *Clemens* 41566; anno 1944.

Related to *A. latilobum*, which has the same peculiar paleae at the nodes of the axes, but is distinguished by pubescent axes.

7. A. HUTTONI (Baker) Copel., comb. nov.

Asplenium Huttoni Baker, *Annals of Bot.* 5 (1891) 311.

Athyrium australe var. *papuanum* C. Chr., *Brittonia* 2 (1937) 293.

Diplazium cyatheifolium Ros. et al. in herb., non Presl.

Brass 13848, alt. 130 m; *Brass* 3863, Diene, Papua, alt. 500 m, type of var. *papuanum*; *Carr* 14945, Boridi, Papua, alt. 1,200 m; *Clemens* (sent as host of a fungus), Morobe; from the same region, *Schlechter* 16800, *Bamler* 92a and 136, *Bamler*, *Rosenstock Fil. novog. exsicc. n. 221*. The species thus occurs at minor altitudes throughout New Guinea. It might hardly be identified as this species except by comparison with the type; I construe it by the Carr collection, received with this name from the British Museum (Mr. Alston). It was originally described from a specimen from the "Malay Isles," received by Baker from Messrs. Veitch.

8. A. LATILOBUM Copel.

Plate 42.

A. latilobum Copel., *Univ. Calif. Publ. Bot.* 18 (1942) 222.

A. silvatico (Blume) Milde affine, rhizomate breve adscendente, apice paleis nigrescentibus triangulari-ovatis acutis usque ad 9 mm longis basi 3 mm latis vestito; stipitibus fasciculatis, 30–35 cm altis 4 mm crassis, deorsum sparse appresso-paleatis alibi rhachibusque minute furfuraceis nigro-fuscis; lamina 65 cm longa, 40–45 cm lata, subtripinnata, pinnis infimis paullo diminutis interdum deflexis, medialibus 20–25 cm longis, 8–10 cm latis, acuminatis, basi pedicellatis (vix 1 cm) paullo angustatis, sursum per pinnas pinnatas pinnatifidas serratas et integras ad apicem brevum acuminatum transeunte; pinnulis pinnarum medialium vix contiguis, 4–5 cm longis, ca. 16 mm latis, plerisque obtusis rarius acutis, basi truncatis pedicellatis (1.5–3 mm), deorsum pinnatis sursum profunde pinnatifidis; pinnulisⁱⁱ sessilibus et segmentis sequentibus decurrenti-confuentibus late oblongis, 4–5 mm latis, falcato-truncatis, integris vel maximis infimis rarius late crenatis, atroviridibus, herbaceis vel siccis tenuiter papyraceis; venis in segmentis pinnatis, venula infima acroscopica solummodo plerumque furcata; soris, infimo acroscopico saepe excepto, simplicibus, 2 mm longis, indusio fusco stramineo-marginato nigrescente.

Dutch New Guinea: Idenburg River, alt. 850 m; *Brass* 13420, type, "A large clump on shady bank of stream in rain forest; stipes and rachis black." Also, *Nos.* 12893, alt. 1,100 m, and 12270, alt. 1,700 m.

The larger pinnules of the medial pinnae have usually a single pair of sessile secondary pinnules, sometimes a pair of adnate pinnules, then about 4 pairs of similar but confluent segments. No. 12270 is a more lax specimen, the only one with acute pinnules, and up to 7 pairs of segments and secondary pinnules.

This might be suspected of being *Diplazium opacifolium* v.A.v.R., Nova Guinea 14 (1924) 14, which I know by description only; but that species is described as less compound, with narrower pinnules, and subcoriaceous; and texture is usually a group characteristic among these ferns.

9. A. DECOMPOSITUM (Ros.) Copel.

Plate 43.

A. decompositum (Ros.) Copel., Univ. Calif. Publ. Bot. 18 (1942) 222.

Brachysorus, stipite ultra 60 cm alto, fusco, spinuloso, sparse furfuraceo; pinna infima unica visa 32 cm longa, 20 cm lata, quadripinnatisecta, papyracea, rhachi fusca superne furfuracea aliter glabra, pedicello 15 mm longo; pinnulis imbricatis, medialibus 12 cm longis 3.5 cm latis, acuminatis, pedicellatis, recte patentibus vel recurvis, pinnulis inferioribus paulo minoribus; pinnulis secundariis approximatis, infimis sessilibus, ceteris adnatis fere omnibus ala costale confluentibus, acutis, majoribus $\frac{2}{3}$ costam versus incisus, segmentis multis 1 mm latis falcatis acutis; venis usque ad 4-paribus; soris costularibus (ad bases venarum), brevibus, indusio fusco parvo lacero.

New Guinea: Sattelberg, alt. 800 m, *Bamler 128* (1914), type in Herb. Univ. Calif.; received from Dr. Rosenstock as "*Diplazium brevisorum* J. Sm var. *novoguineensis* Ros. n. v., = *Athyrium silvaticum* Bl. f. *decomposita* Ros. n. f., an spec. nov." This would give a correct idea of the affinity of the plant. However, the confusion is remarkable. "*D. silvaticum* Bl. var. *novoguineensis* Ros.", *Hedwigia* 56 (1915) 351, typified by *Bamler 56* is segregate of *D. silvaticum* (Bory) Sw., correctly placed by Hieronymus, *Engler's Jahrb.* 56 (1920) 134; it is No. 32 A of this enumeration.

10. A. WOODWARDIOIDES (Presl) Christ

A. woodwardioides (Presl) Christ, Verh. Nat. Ges. Basel 11 (1895) 233.

Brachysorus woodwardioides Presl. Epim. (1849) 70.

Schlechter 16618 (alt. 300 m), 19114; *Bamler, Rosenstock Fil. novog. exsicc. n. 222*, as *Diplazium brevisorum* J. Sm. I have no Cuming specimen for comparison and am not quite certain of the identification, made by Hieronymus for the

Schlechter specimen. It is not in the Brause enumeration, apparently prepared, as to this genus, by Hieronymus.

Philippines.

11. *A. SYLVATICUM* (Blume) Milde

A. sylvaticum (Blume) Milde, Bot. Zeit. 24 (1866) 376.

Bamler 130, Sattelberg, alt. 800 m. This again bears label as var. *novoguineensis* Ros., n. v. It is quite identical with Java specimens.

Java. Further range uncertain because our specimens are poor.

12. *A. BLUMEI* Copel.

A. Blumei Copel., Philip. Jour. Sci. 3 C (1908) 294.

Diplazium polypodioides Blume, Enum. (1828) 194.

Athyrium fimbriatægium Copel., Philip. Jour. Sci. 9 C (1914) 5.

King 386 (type of *A. fimbriatægium*), *459*, Papua; *Keysser 44*; *Zahn s. n.*, Sattelberg. Hieronymus omits this species from Brause's enumeration, but describes 5 new species, "Subspecies *D. polypodioidis*" or "e turma *D. polypodioidis*." I have no authentic specimens of any of them, and can list them only for what they may be worth. Of these great ferns, such criteria as size of pinnule always vary from part to part of a single frond, and the forking of the veins varies with the size of the segment. The indusium of specimens I recognize as *A. Blumei* is fimbriate in Java and in New Guinea; it is entire on specimens so named from Indo-China and Assam.

13. *DIPLAZIUM NYMANI* Hieron.

Diplazium Nymani Hieron., Engler's Jahrb. 56 (1920) 136.

The type is *Nyman 698*, Sattelberg, alt. 900 m. *Carr 15712*, from Papua, comes with this name from the British Museum, and fits the description.

14. *DIPLAZIUM SCHRADERI* Hieron.

Diplazium Schraderi Hieron., Engler's Jahrb. 56 (1920) 141.

The type is *Ledermann 12076*, Schraderberg, alt. 2,070 m.

15. *DIPLAZIUM SCHLECHTERI* Hieron.

Diplazium Schlechteri Hieron., Engler's Jahrb. 56 (1920) 138.

The cited specimens are *Ledermann 11032*, *11867*, *11942*; *Nyman 432*; *Schlechter 14339*; *Hellwig 609*, *613*, *617*, all from Kaiser-Wilhelmsland, alt. 900-2,070 m.

16. *DIPLAZIUM SCHULTZEI* Hieron.

Diplazium Schultzei Hieron., Engler's Jahrb. 56 (1920) 140.

Schultze 260; Ledermann 12882; Warburg s. n. Brass 5165, Mafulu, Papua, alt. 1,250 m is identified as this species by Christensen; it does not fit the description, but may have been named by comparison with an authentic specimen.

16A. *DIPLAZIUM NAUMANNI* Hieron.

Diplazium Naumannii Hieron., Engler's Jahrb. 56 (1920) 137.

Described from a collection by the Gazelle Expedition at Mac Cluer Bay.

Diplazium prolongatum Ros., Meded. Rijks Herb. No. 31 (1917) 5.

"A praecedente recedit pinnis secundariis haud acuminatis, segmentis s. pinnis tertiariis margine serratis, non rotundato-crenatis." The preceding species is *D. pseudocyatheifolium*, which has not acuminate pinnules, nor any secondary segments or pinnules, and is nowhere round-crenate. Comparison with something else may have been intended, but, as published, *D. prolongatum* is essentially a *nomen nudum*.

Diplazium asperum var. *subpolypodioides* v.A.v.R. [*D. subpolypodioides* v.A.v.R., Bull. Jardin Buit. No. XX (1915) 11] is listed by Hieronymus, p. 136, but I find no explicit authority for its occurrence elsewhere than in Sumatra.

17. A. *SQUAMULIGERUM* (Ros.: Hieron.) Copel.

A. squamuligerum (Ros.: Hieron.) Copel., Jour. Arnold Arb. 10 (1929) 178.

Asplenium varians var. *squamuligera* Ros., Fedde's Repert. 12 (1913) 528.

Asplenium squamuligerum Hieron., Hedwigia 61 (1919) 5; Engler's Jahrb. 56 (1920) 147.

Athyrium Ramosii Copel., Philip. Jour. Sci. 38 (1929) 140.

A. geophilum var. C. Chr., Suppl. III (1934) 41 (overlooking p. 38).

The assignment of this plant to a genus has made more than enough trouble. The latest instance is by Christensen, Brittonia 2 (1937) 293, "The referring of *Asplenium squamuligerum* Hieron. to *Athyrium* by Copeland is very problematical." This does not appear in Suppl. III p. 41, under *A. geophilum*, and my type sheet of *A. Ramosii* is annotated by Christensen as "certainly an *Athyrium*." Still, its relatives are plants which he still prefers to call *Diplazium*. With the fine new New Guinea material in hand, I must conclude that *A. Ramosii* is the same species. *A. geophilum*, however, is distinct, being without the characteristic paleae on the axes.

Keysser 228, Sattelberg Hinterland, alt. 1,400–1,500 m, type;
Brass 12209, 12832, 13635, alt. 850–1,750 m, Idenburg River;
Clemens, Morobe, alt. 900 m.

Mindanao.

18. *DIPLAZIUM OPACIFOLIUM* v.A.v.R.

Diplazium opacifolium v.A.v.R., Nova Guinea 14 (1924) 14.

Lam 1048, Mamberamo River, alt. 90 m; not seen.

A collection by Zahn, Sattelberg, alt. 900 m, received with a manuscript name by Christ, fits the description of *D. opacifolium* in most respects, but the largest pinnules of the complete frond are less than 2 cm long by 8 mm wide. If it were a Philippine specimen, it might be *A. atratum*.

19. *A. NITENS* (Ros.) Copel., comb. nov.

Diplazium nitens Ros., Fedde's Repert. 5 (1908) 373.

Werner 62, Danum, alt. 500 m; isotype in Herb. Univ. Calif.;
Bamler, Rosenstock Fil. novog. exsicc. n. 161, Logaueng, alt. 400 m;
Schlechter 17647, Kani Mountains, alt. 600 m.

Endemic.

20. *A. DAVAOENSE* Copel.

A. davaoense Copel., Philip. Jour. Sci. 3 C (1908) 295.

Bamler, Rosenstock Fil. novog. exsicc. n. 189, Sattelberg, alt. 800 m;
Carr 13018, 14471, Boridi, Papua, alt. 1,400 m; all received as *Diplazium cyclolobum* (Christ) Ros., a name which I have not located.

Philippines.

21. *A. MAXIMUM* (Don) Copel.

A. maximum (Don) Copel., Philip. Jour. Sci. 3 C (1908) 295.

Both *Diplazium maximum* (Don) C. Chr. and *D. latifolium* Moore have been reported from New Guinea. I have no local specimen, and, as both names have been used for groups of species, do not know at all exactly what were (or is) meant.

22. *A. CYATHEIFOLIUM* (Rich.) Milde

A. cyatheifolium (Rich.) Milde, Bot. Zeit. 28 (1870) 353.

King 331; Brass 603, 3805; Papua.

Endemic, so far as definitely known.

23. *A. UNCIDENS* (Ros.) Copel.

A. uncidens (Ros.) Copel., Univ. Calif. Publ. Bot. 12 (1931) 394.
Dryopteris uncidens Ros., Fedde's Repert. 10 (1912) 337.

Brass 12894, alt. 1,100 m; *Frau Bamler 3*, Sattelberg, isotype in Herb. Univ. Calif.; *Keysser 179p*, *ibid.*, alt. 1,400–1,500 m; *Clemens*, Morobe District. Exindusiate.

Endemic.

24. A. KEYSSERI Copel., nom. nov.

Diplazium atropurpureum Ros., Fedde's Repert. 12 (1913) 528, non *Athyrium atropurpureum* Copel.

Keysser 179, Sattelberg Hinterland, alt. 1,450 m; isotype in Herb. Univ. Calif.; *Brass 5044*, Mt. Tafa, Papua, alt. 2,400 m. Endemic.

25. A. PROTENSUM (Ros.) Copel., comb. nov.

Diplazium protensum Ros., Fedde's Repert. 12 (1913) 169.

Keysser 106, 108 (as published), Sattelberg, alt. 800–1,000 m; not certainly seen; but we have, from Dr. Rosenstock, *Keysser II 118*, slightly smaller but otherwise as described, probably different in number because of error. Most sori are exindusiate, but a few narrow indusia can be detected. Like the preceding species in its paleae and prior in name, but apparently distinct in other respects.

26. DIPLAZIUM ASTEROTHRIX C. Chr.

Diplazium asterothrix C. Chr., Brittonia 2 (1937) 292.

Brass 3848, Dieni, Central Division, Papua, alt. 500 m. *Schlechter 16853*, received as *Dryopteris africana*, is probably an ill developed form of the same species.

This is like the two preceding species in its stellate paleae, and like *A. uncidens* in being exindusiate. I suspect that it is more perfectly developed specimen of *A. protensum*.

27. A. SORSOGONENSE (Presl) Milde

A. sorsogonense (Presl) Milde, Bot. Zeit 28 (1870) 354.

Brass 8945, Cyclops Mountains, alt. 500 m; *13655*, Idenburg River, alt. 700 m; *King 329*; *Carr 12071, 12545*, Papua.

I have not seen *Diplazium mamberamense* v.A.v.R., Suppl. Corections (1917) 55, but suspect it to be an ill developed *A. sorsogonense*, distinguished by pinnae cut only half-way to the costae.

To India; but slightly different beyond the Malay Peninsula.

28. A. ARCHBOLDII Copel.

Plate 44.

A. Archboldii Copel., Univ. Calif. Publ. Bot. 18 (1942) 222.

A. rhizomate adscendente, paleis brunneis anguste lanceolatis 17 mm longis primo integris tum demum margine fibrilloso-

deliquescente vestito; stipite 40 cm alto, sicco 4 mm crasso, superne trisulcato fusco, rhachique paleis nigris rigidis recurvis angustis 1–2 mm longis ornatis; lamina 75 cm longa, bipinnatifida; pinnis infimis 11 cm longis, 5 cm latis; medialibus 18 cm longis, 6 cm latis, acuminatis, basi truncatis vel abrupte paullo angustatis, breviter (1 mm) pedicellatis, deorsum $\frac{2}{3}$ ad costam pinnatifidis, apices versus tantum serratis, subcoriaceis, segmentis serrulatis acutis; pinnis superioribus etiam 15 cm longis ca. 3 cm latis vix $\frac{1}{2}$ ad costam incisus lobis rotundatis; apice frondis pinnis coadunatis composito ca. 15 cm longo; venis plerisque furcatis; soris segmentorum majorum usque ad 10-paribus, ca. 6 mm longis, margine remotis, infimis diplazioideis, indusio fusco angusto integro.

Dutch New Guinea: 15 km S.W. of Bernhard Camp, Idenburg River, alt. 1,700 m, *Brass 12272*; "Common ground fern in a rain forest; leaves somewhat fleshy."

The upper part of the frond suggests *A. maximum*, but the lower part is utterly different. It is probably a relative of *Diplazium pseudoshepherdoides*, but the lower and medial pinnae are twice as broad, and very short-stalked; by description, that species seems much like *A. polycarpum* Copel., of Borneo.

29. *A. JAPONICUM* (Thunb.) Copel.

A. japonicum (Thunb.) Copel., Philip. Jour. Sci. 3 C (1908) 290.

Brass 9303, Lake Habbema, alt. 3,225 m, very large; *Clemens Morobe*, host of a fungus No. 6735, not quite identical.

New Zealand (native?) to Japan and India.

30. *A. WEINLANDII* (Christ) Copel., comb. nov.

Diplazium Weinlandii Christ, Bull. Boiss. II 1 (1901) 452.

D. bamlerianum Ros., Fedde's Repert. 10 (1912) 329.

Bamler (No. 40), *Rosenstock Fil. novog. exsicc. n. 220*, Sattelberg, alt. 600 m, isotype in Herb. Univ. Calif.

Endemic.

31. *A. CRENATO-SERRATUM* (Blume) Milde

A. crenatum-serratum, (Blume) Milde, Bot. Zeit. 28 (1870) 353.

King 344, 446.

Malaya; Philippines.

32. *A. BULBIFERUM* (Brack.) Copel.

A. bulbiferum (Brack.) Copel., Bishop Museum Bull. No. 59 (1929) 53.

Brass 8826, Hollandia, alt. 50 m. Common and variable. Most New Guinea specimens are notably large. Fiji to Mauritius.

32A. *DIPLAZIUM NOVOGUINEENSE* (Ros.) Hieron.

Diplazium novoguineense (Ros.) Hieron., Engler's Jahrb. 56 (1920) 134.

Bamler 56 bis, Sattelberg, alt. 600 m, isotype in Herb. Univ. Calif., reissued as *Rosenstock Fil. novog. exsicc. n. 219*. This is the most over-grown development of *A. bulbiferum*, the pinnae up to 25 cm long and 4.5 cm wide, and very shallowly cut. It looks distinct enough for specific recognition, but probably intergrades with plants of more normal size.

Local.

33. *A. LEDERMANNI* Hieron.

A. Ledermanni Hieron., Engler's Jahrb. 56 (1920) 133.
Ledermann 11906, alt. 2,070 m. Not seen.

34. *A. PALLIDUM* (Blume) Milde

A. pallidum (Blume) Milde, Bot. Zeit. (1870) 354.

King 365, Papua; *Bamler, Rosenstock Fil. novog. exsicc. n. 187*, Wareo, alt. 600 m.

Malaya; Philippines; Queensland; New Hebrides.

35. *A. FLAVOVIRIDE* Alston

A. flavoviride Alston, Jour. Bot. 78 (1940) 226.

Clemens 7037, Sambanga, Morobe, alt. 5,000–6,000 feet. Not seen.

36. *A. ACROCARPUM* (Ros.) Copel., comb. nov.

Diplazium acrocarpum Ros., Fedde's Repert. 10 (1912) 328.

Asplenium acrocarpum Hieron., Hedwigia 61 (1919) 32; Engler's Jahrb. 56 (1920) 148.

Brass 12036, alt. 1,750 m, common ground fern in rain forest. Described from the Sattelberg, *Keysser 27*, isotype in Herb. Univ. Calif.; reported also as *Ledermann 11853*.

Endemic.

Report of *A. Merrillii* in New Guinea may be due to confusion with this species. The Philippine *A. longissimum* Copel. has far more numerous, smaller pinnae. The Bornean *A. fuliginosum* has a long pinnatifid apex. These are all nearly related, and with several relatives pinnatifid throughout, might constitute a small segregate genus.

37. *A. ESCULENTUM* (Retz.) Copel.

A. esculentum (Retz.) Copel., Philip. Jour. Sci. 3 C (1908) 295.

Brass 13646, alt. 850 m. Common at minor altitudes throughout New Guinea, always with only the lower veinlets anastomosing. This form has been named *Asplenium vitiense* Baker and *A. dietrichianum* Luerssen, thus occupying the eastern end of the range of the species in which it is here included. The typical form, with half or more of the veinlets anastomosing, is found in Hawaii, but is probably not native there.

To India.

38. A. **FRAVINIFOLIUM** (Presl) Milde

A. fraxinifolium (Presl) Milde, Bot. Zeit. 28 (1870) 353.

Brass 13881, alt. 120 m; *Bamler 30*, Logaueng; *King 377, 414*, Papua. *Schlechter 17793* bears this name, but is distinct. Also reported from New Guinea as *Diplazium bantamense*. Report of *D. alternifolium* may be based on this or the following species.

To India and Formosa.

39. A. **CUMINGII** (Presl) Milde

A. Cumingii (Presl) Milde, Bot. Zeit. 28 (1870) 353.

Brass 12274, alt. 1,750 m; *Bamler 121*, Wareo, distributed as *A. fraxinifolium*; *Brass 5444*, Papua, alt., 1,450 m. New Guinea specimens are less scaly than the Philippine type, but clearly nearer to it than to *A. fraxinifolium*.

Philippines; Celebes.

40. A. **CORDIFOLIUM** (Blume) Copel.

A. cordifolium (Blume) Copel., Philip. Jour. Sci. 3 C (1908) 300.

Brass 12250, 13418, 13740, alt. 570–1,750 m. Common.

To the Malay Peninsula.

29. **DIPLAZIOPSIS** Christensen

D. **JAVANICA** (Blume) C. Chr.

D. javanica (Blume) C. Chr., Index (1905) 227.

Brass 12939, alt. 1,200 m.

Samoa to Formosa and India.

30. **CALLIPTERIS** Bory

Key to the species

Fronde simply pinnate 1. *C. prolifera*
 Fronde bipinnate 2. *C. spinulosa*

1. C. **PROLIFERA** (Lam.) Bory

C. prolifera (Lam.) Bory, Voy. I (1804) 283.

Athyrium accedens (Blume) Milde, Bot. Zeit. 28 (1870) 353.

Brass 13799, alt. 160 m; probably common, certainly conspicuous, at minor altitudes throughout New Guinea.

Fiji to Africa.

2. *C. SPINULOSA* (Blume) J. Smith

C. spinulosa (Blume) J. Smith, Jour. Bot. 3 (1841) 409.

Diplazium spinulosum Blume, Enum. (1828) 193.

Diplazium paradoxum Fée, Genera (1850-1852) 214.

Asplenium smithianum Baker, Syn. Fil. (1867) 245; Christ, Ann. Jar. Buit. 15 (1904) 122.

Bamler 66, Sattelberg, alt. 800 m; *Carr* 14526, 15688, Papua. Rosenstock, *Hedwigia* 56 (1915) 351, distinguished two varieties or forms by name, and entered a third name on one of our labels; all may apply to parts of a single frond.

The apparent distribution of this species, unknown between Celebes and Ceylon, is remarkable.

ILLUSTRATIONS

[Photographs of types, except Plates 6 and 29, which are photographs of fragments of types.]

- PLATE 1. *Polystichum Archboldii* Copel.
2. *P. Brasii* Copel.
3. *P. muticum* Copel.
4. *P. Myer-Dreesii* Copel.
5. *P. cheilanthoides* Copel.
6a. *Lomagramma angustipinna* Copel.
6b. *Cyclosorus adenostegius* Copel.
7. *Elaphoglossum habbemense* Copel.
8. *E. Archboldii* Copel.
9. *E. laticuneatum* Copel.
10. *E. brunneum* Copel.
11. *E. repens* Copel.
12. *E. fuscum* Copel.
13. *Ctenitis speciosissima* Copel.
14. *C. pulchra* Copel.
15. *C. habbemensis* Copel.
16. *Tectaria pubescens* Copel.
17. *Lastrea platyptera* Copel.
18. *L. petrophila* Copel.
19. *L. Regis* Copel.
20. *L. subdimorpha* Copel.
21. *L. belensis* Copel.
22. *L. ophiura* Copel.
23. *L. crassa* Copel.
24. *L. wantotensis* Copel.
25. *L. armata* Copel.
26. *Cyclosorus distinctus* Copel.
27. *C. vestigiatus* Copel.
28. *C. paripinnatus* Copel.
29. *C. deltipterus* Copel.
30. *C. subappendiculatus* Copel.
31. *C. gregarius* Copel.
32. *C. multiauriculatus* Copel.
33. *C. protectus* Copel.
34. *C. terrestris* Copel.
35. *C. albosetosus* Copel.
36. *C. strigosissimus* Copel.
37. *C. riparius* Copel.
38. *C. morobensis* Copel.
39. *Athyrium minutum* Copel.
40. *A. morobense* Copel.
41. *A. pedicellatum* Copel.
42. *A. latilobum* Copel.
43. *A. decompositum* Copel.
44. *A. Archboldii* Copel.



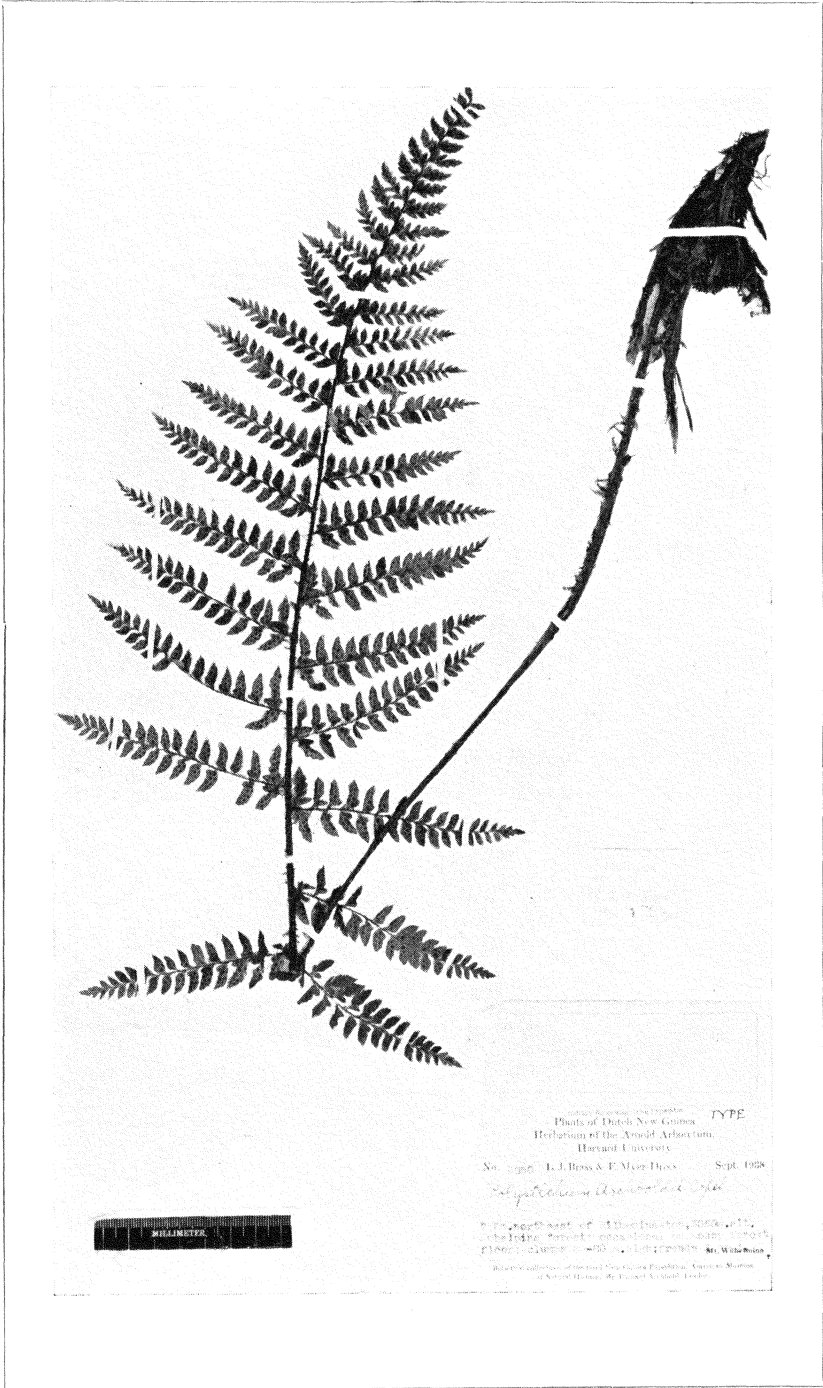


PLATE 1.

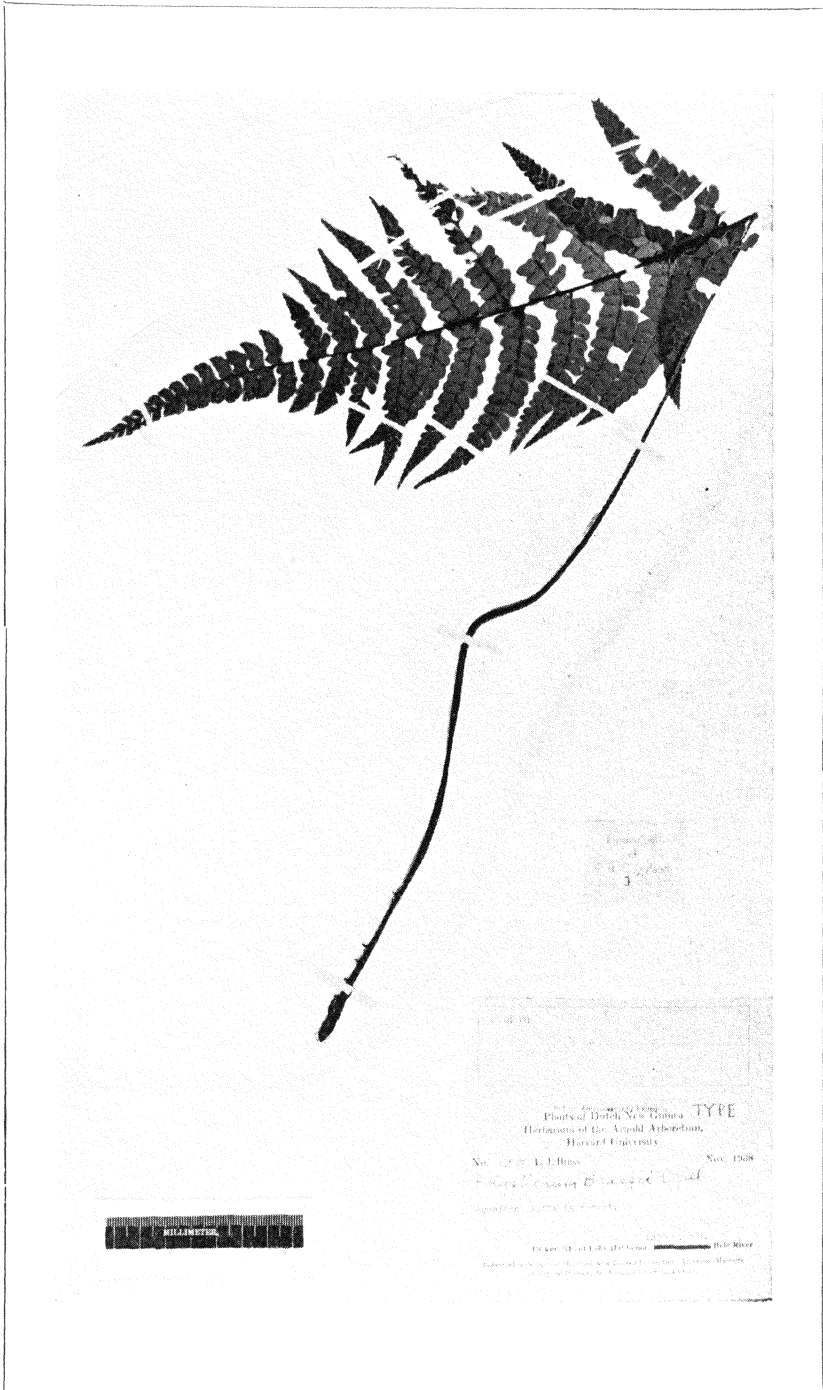
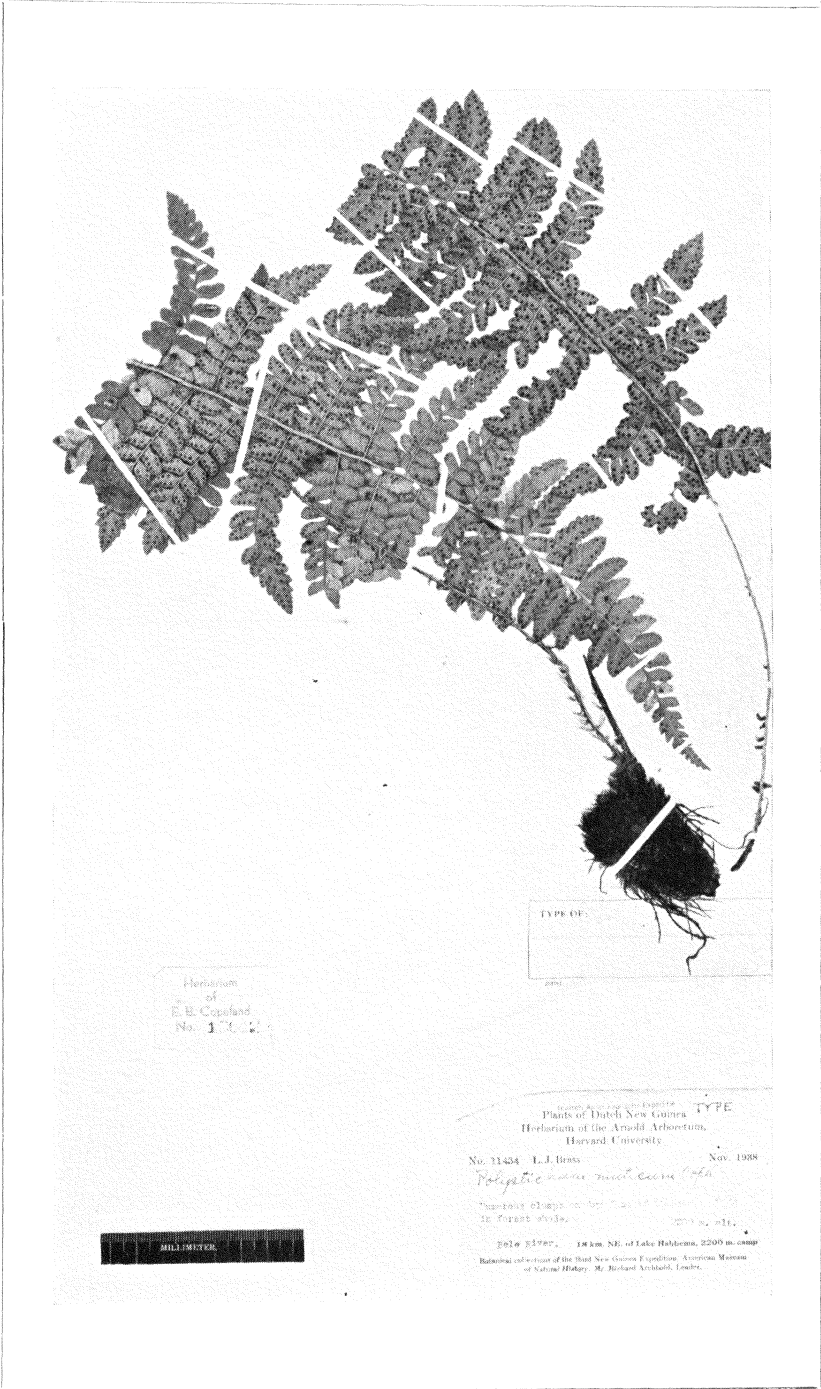


PLATE 2.



Herbarium
of
E. H. Copeland
No. 1734

TYPE OF

Plants of Dutch New Guinea
Herbarium of the Arnold Arboretum,
Harvard University

No. 11454 L. J. Brass Nov. 1938

Polypodium muticum Copl.

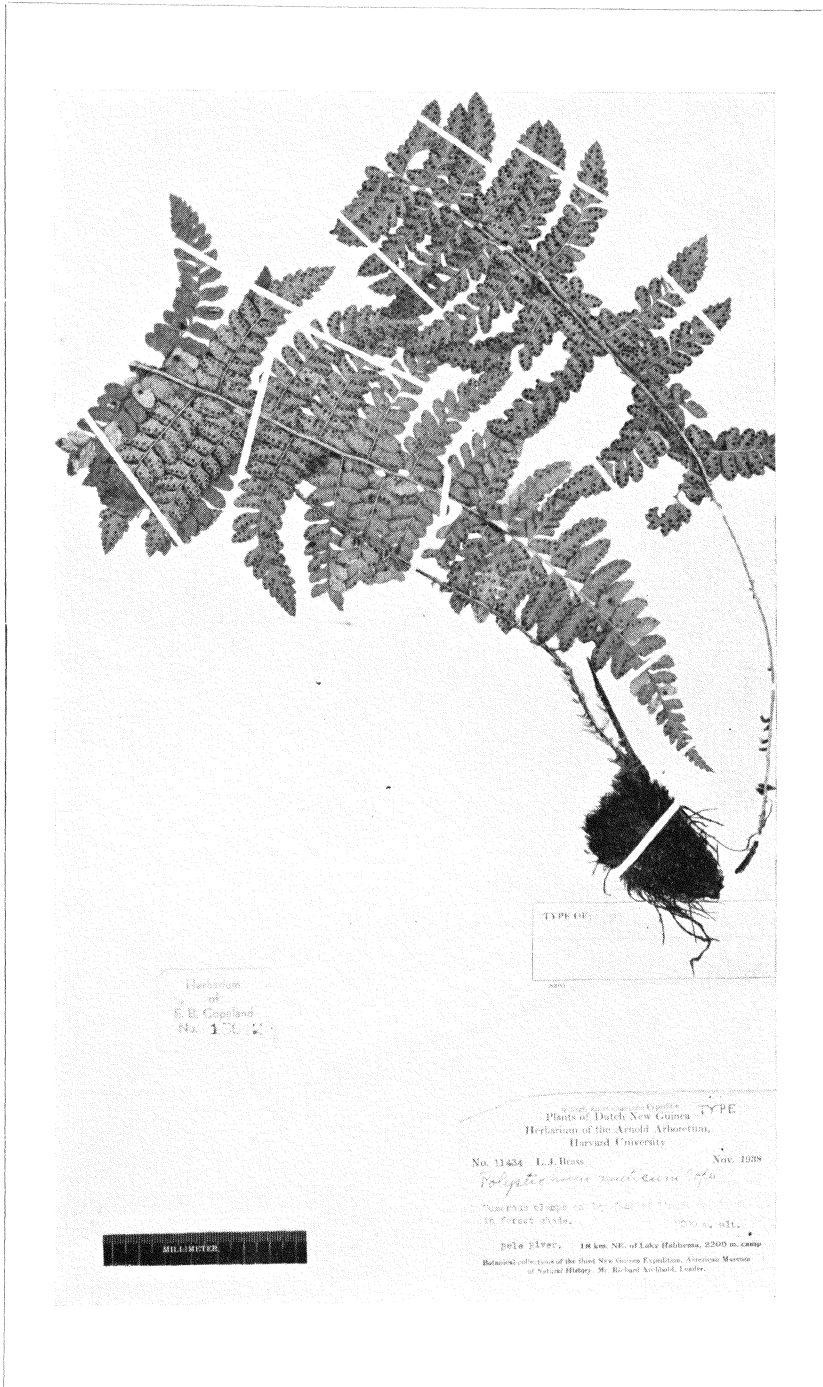
Terrestrial epiphyte on tree trunk in
in forest shade.

2010 51907. 10 km. NE. of Lake Habbema, 2200 m. camp

Botanical collection of the Dutch New Guinea Expedition, American Museum
of Natural History, W. Richard Woodhead, London.



PLATE 3.



Herbarium
of
E. E. Copeland
No. 1001

TYPE OF:

Plants of Dutch New Guinea TYPE
Herbarium of the Arnold Arboretum,
Harvard University

No. 11454 L.J. Brass Nov. 1939

Polystichum melanocephalum

Number 63 kept in the Herbarium of the Arnold Arboretum, Harvard University.

MILLIMETER

Pele Iwac, 18 km. NE. of Lake Halhema, 2200 m. camp
Botanical collection of the Third New Guinea Expedition, American Museum
of Natural History, Dr. Richard A. Schud, London.

PLATE 3.



Herbarium
of
E. B. Copeland
No. 10022

TYPE OF:

Herbarium of the
Plants of Dutch New Guinea TYPE
Herbarium of the Arnold Arboretum,
Harvard University
No. 10022 E. J. Brass & F. Meyer-Dress Sept. 1908

Asplenium Taylorii Copl.
7 km. northwest of Hidenon-tan, 2500 m. alt.,
clumped under rocks in subalpine forest.
Mt. Wilhelm
Botanical collection of the Dutch New Guinea Expedition, American Museum
of Natural History, St. Richard, Archde. London.



PLATE 4.

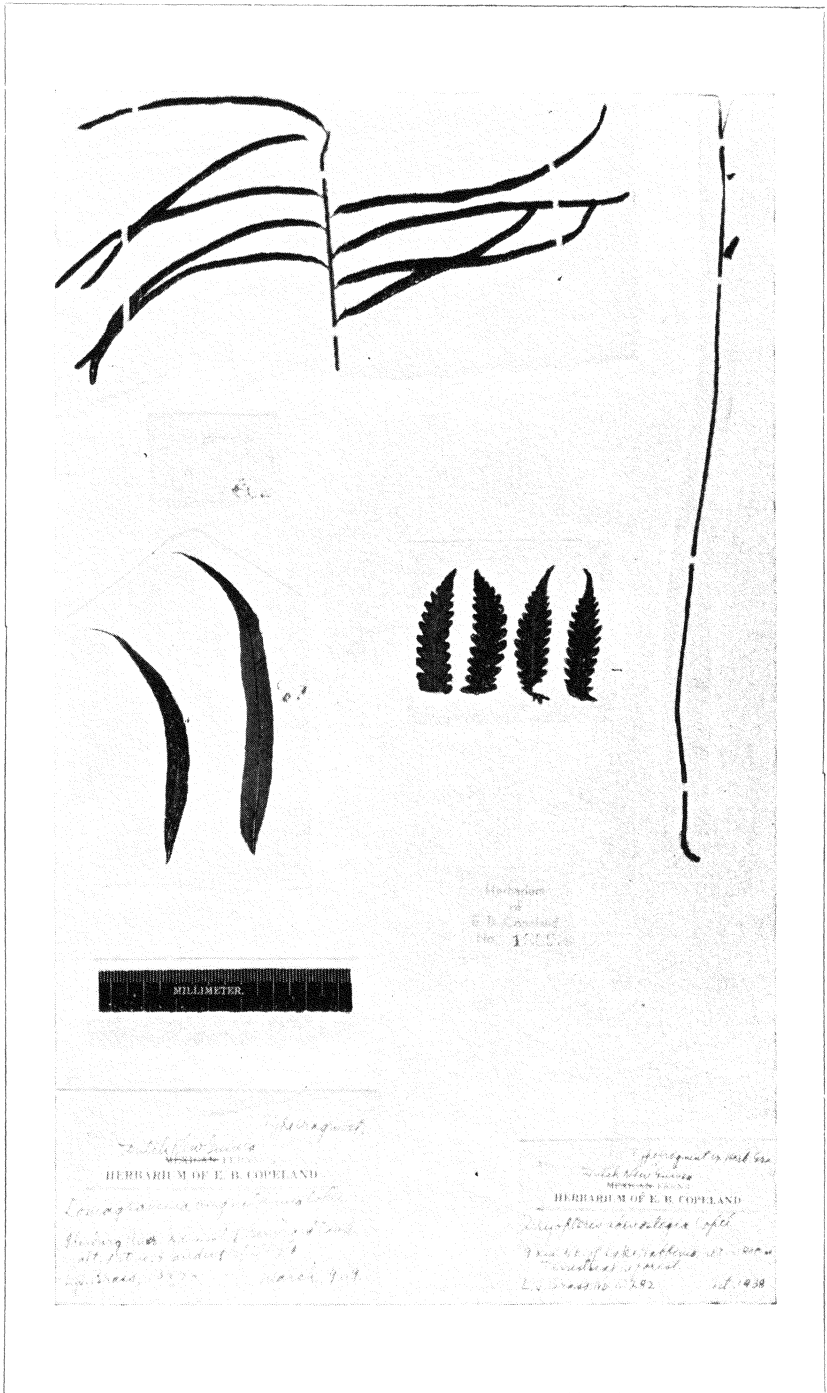


PLATE 6 A & B.

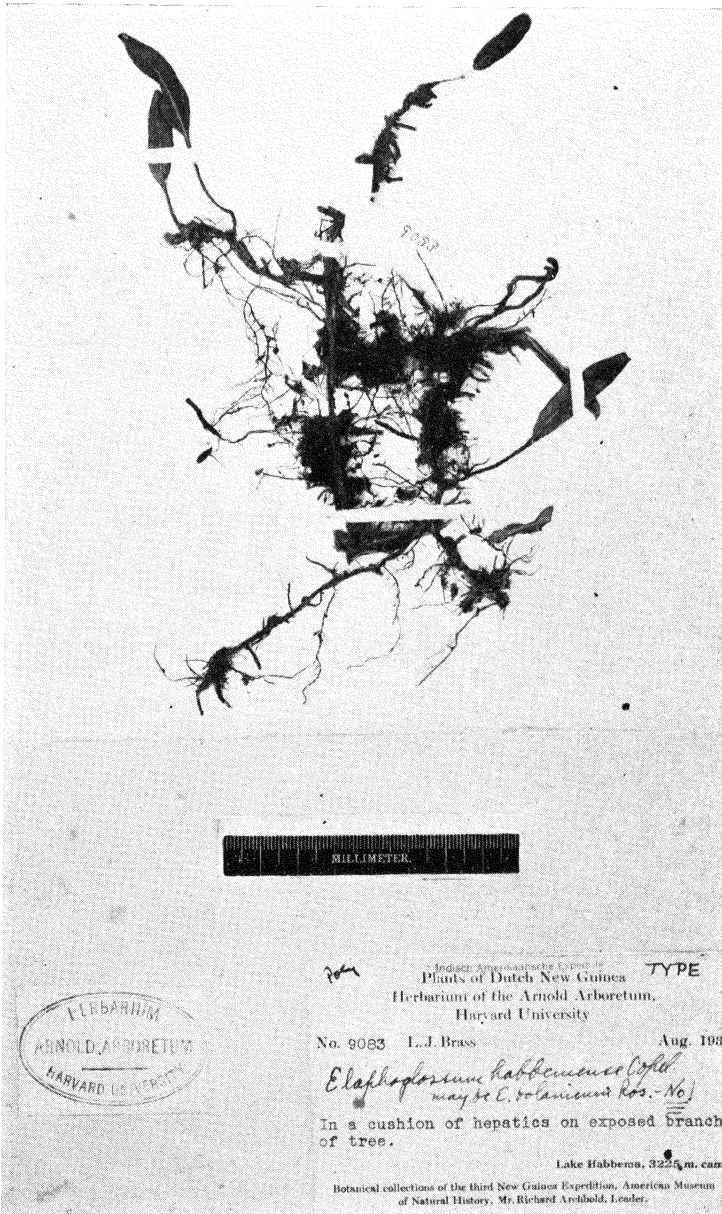


PLATE 7.

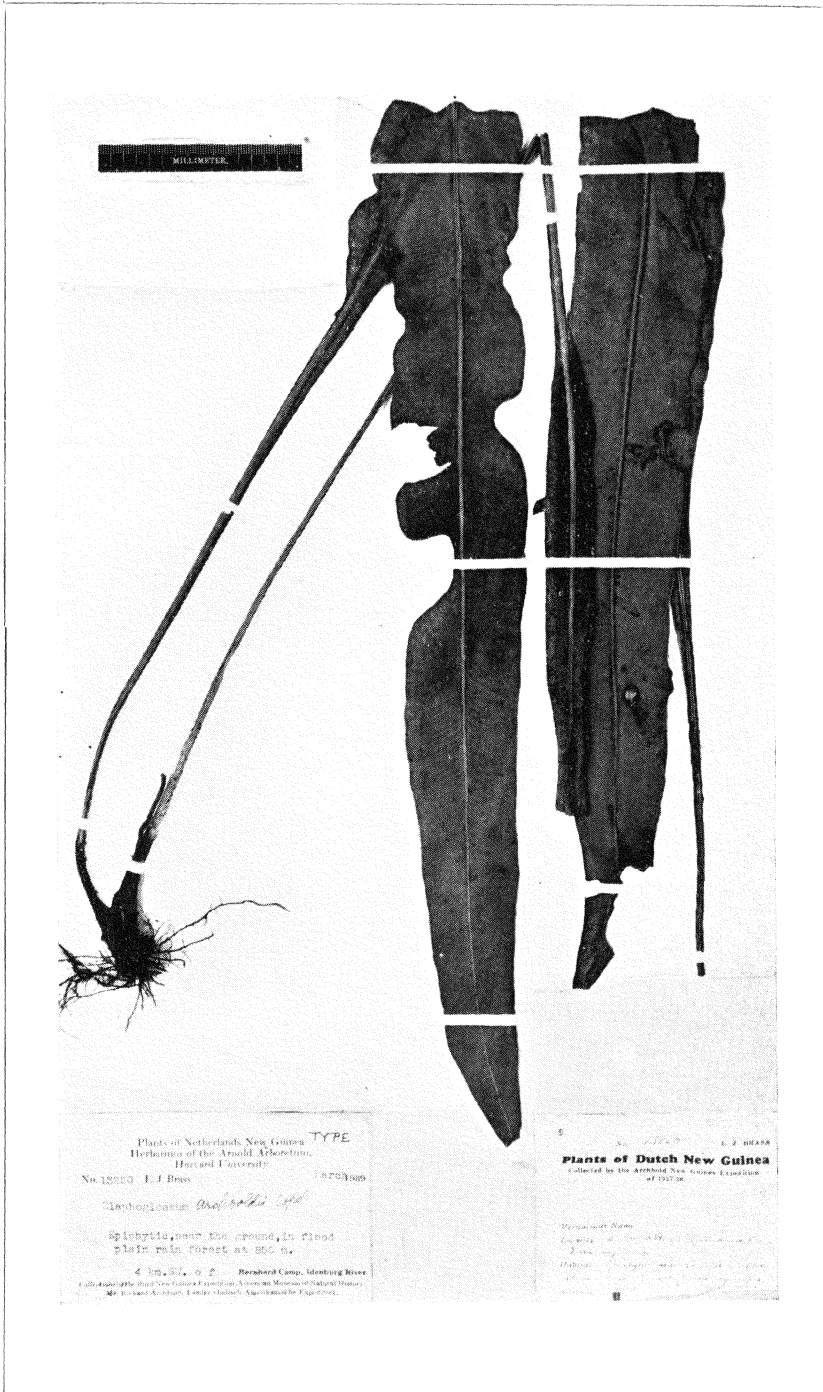


PLATE 8.



Indisch-Amerikaansche Expedities
 Plants of Dutch New Guinea TYPE
 Herbarium of the Arnold Arboretum,
 Harvard University

No. 10032 L. J. Brass & E. Myer-Drees Sept. 1938

Elaphoglossum latiusculatum Copel.

7 km. northeast of Ilberina-tou, 2860 m. alt.
 one plant in moss of forested cliff.

1
 Mt. Wilhelmiana

Botanical collections of the third New Guinea Expedition, American Museum
 of Natural History, Mr. Richard Archbold, London.

PLATE 9.



PLATE 10.

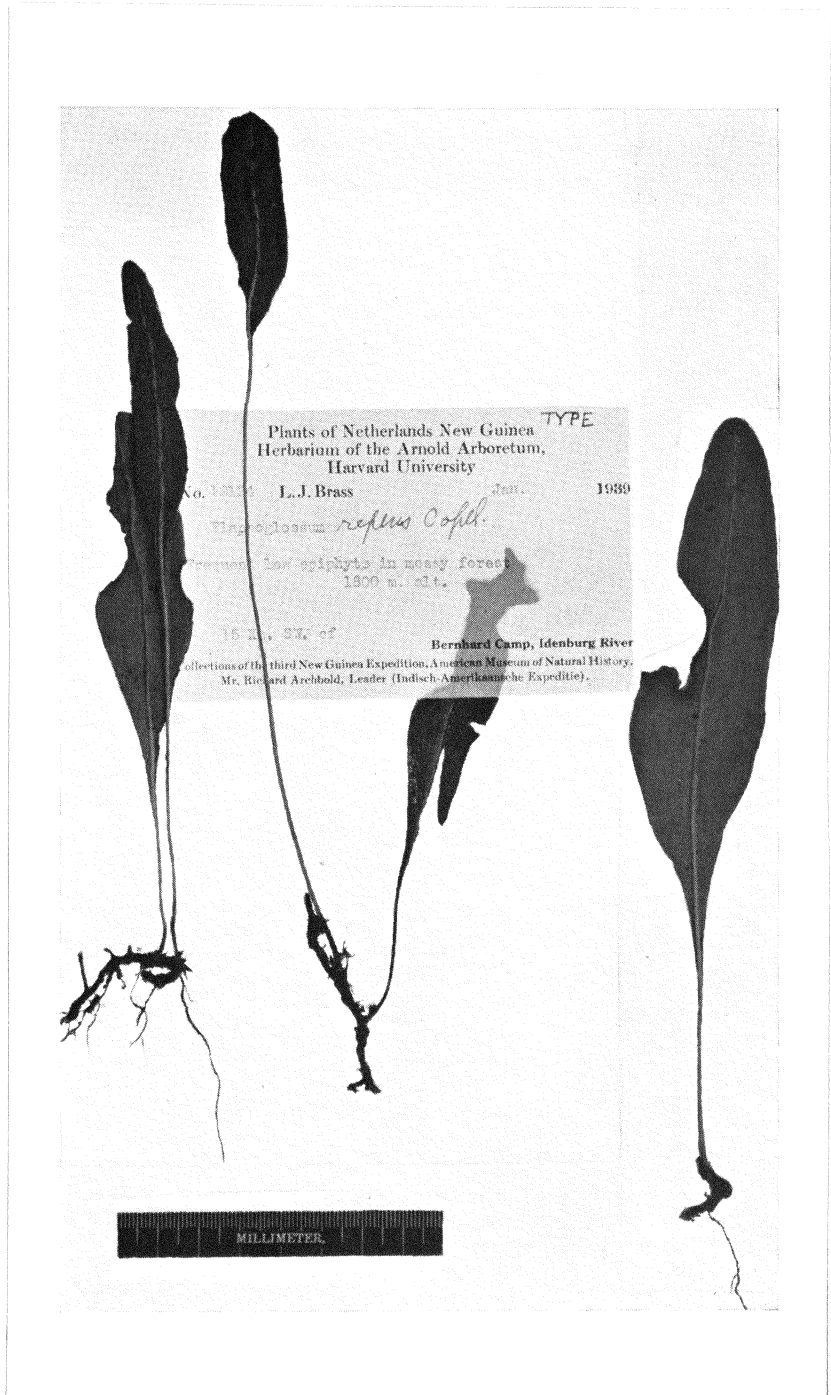


PLATE 11.

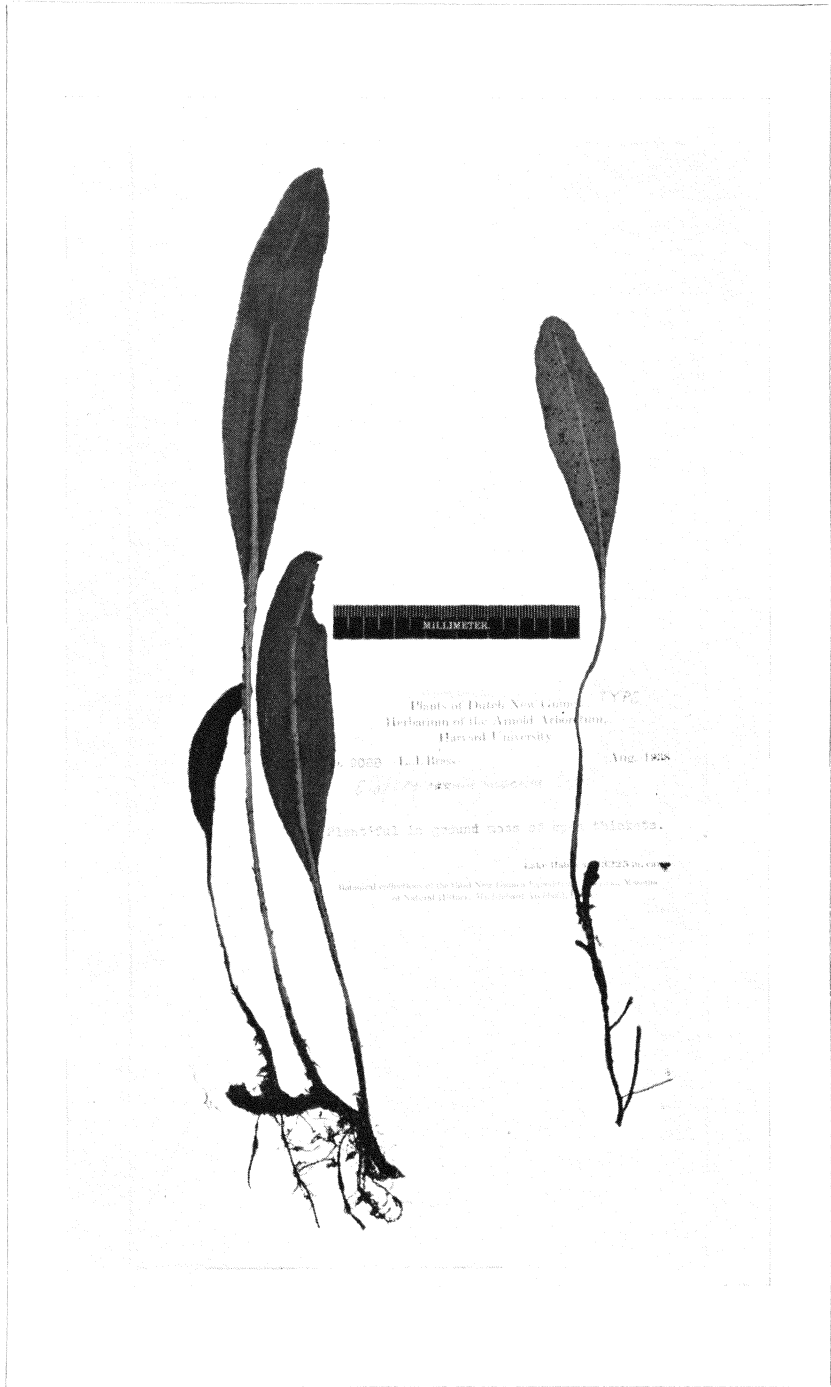


PLATE 12.



PLATE 14.



Aspidium
No. 2094
1934




Plate of *Aspidium* No. 2094
Herbarium of the Department of Agriculture
No. 2094 1-1-1934
1934

PLATE 15.



PLATE 16.

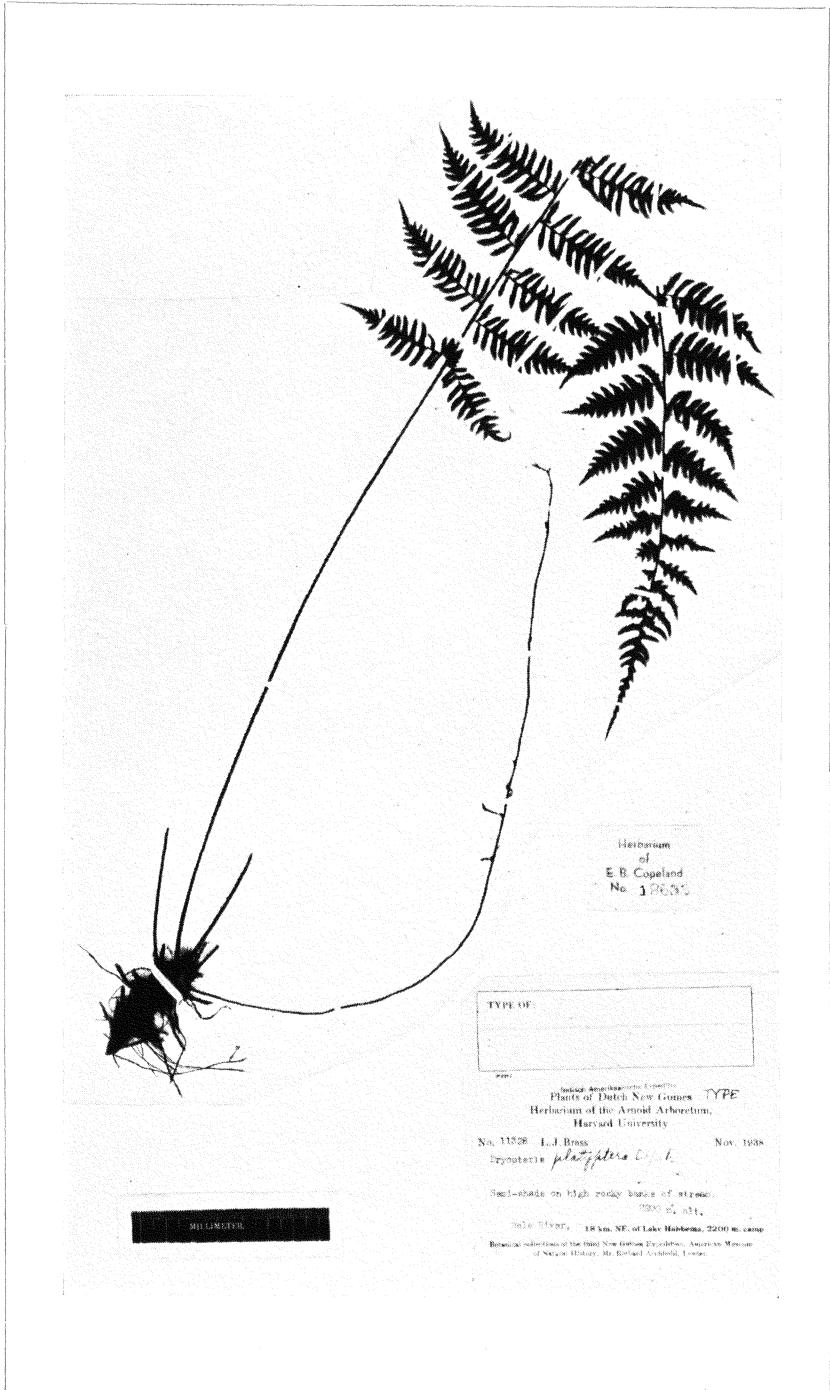


PLATE 17.

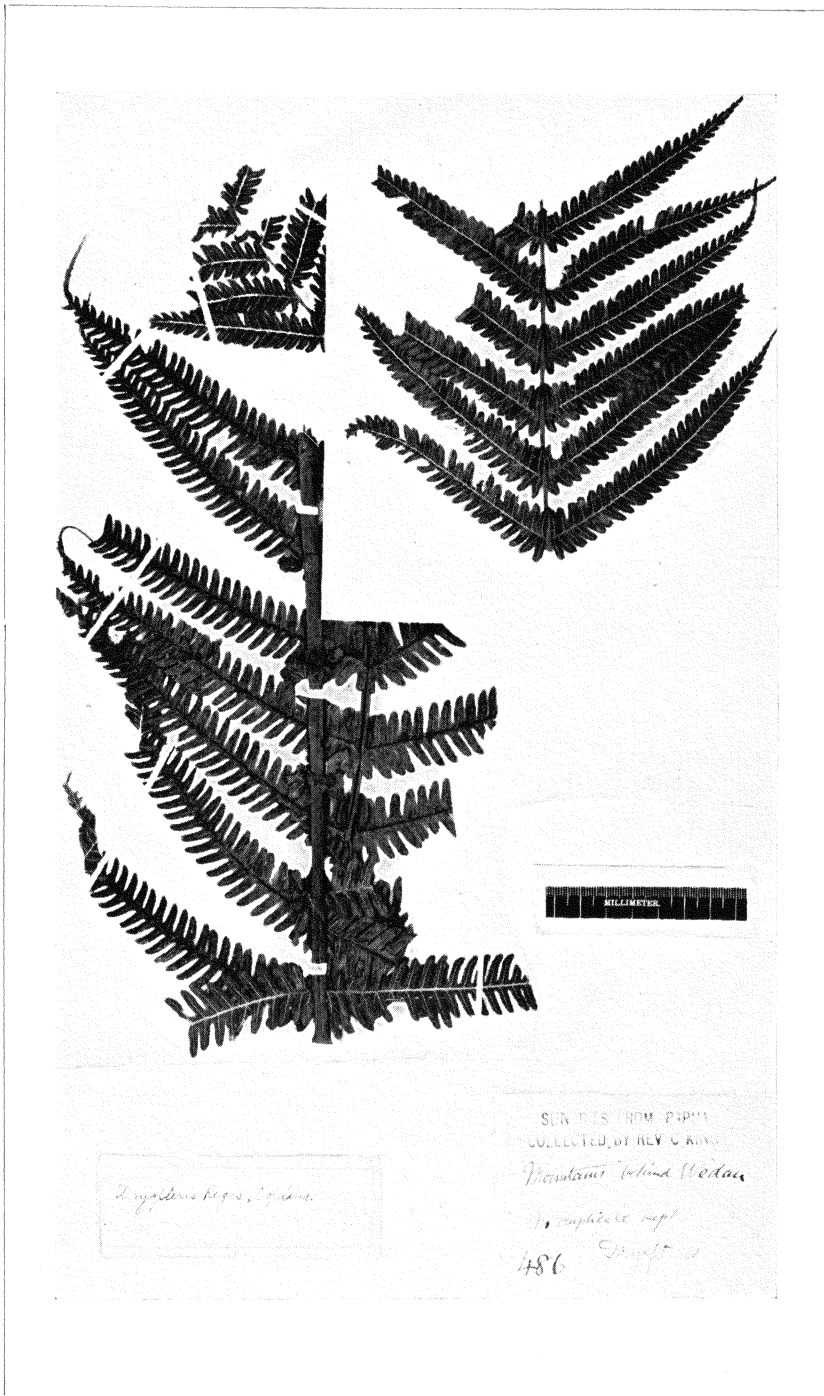
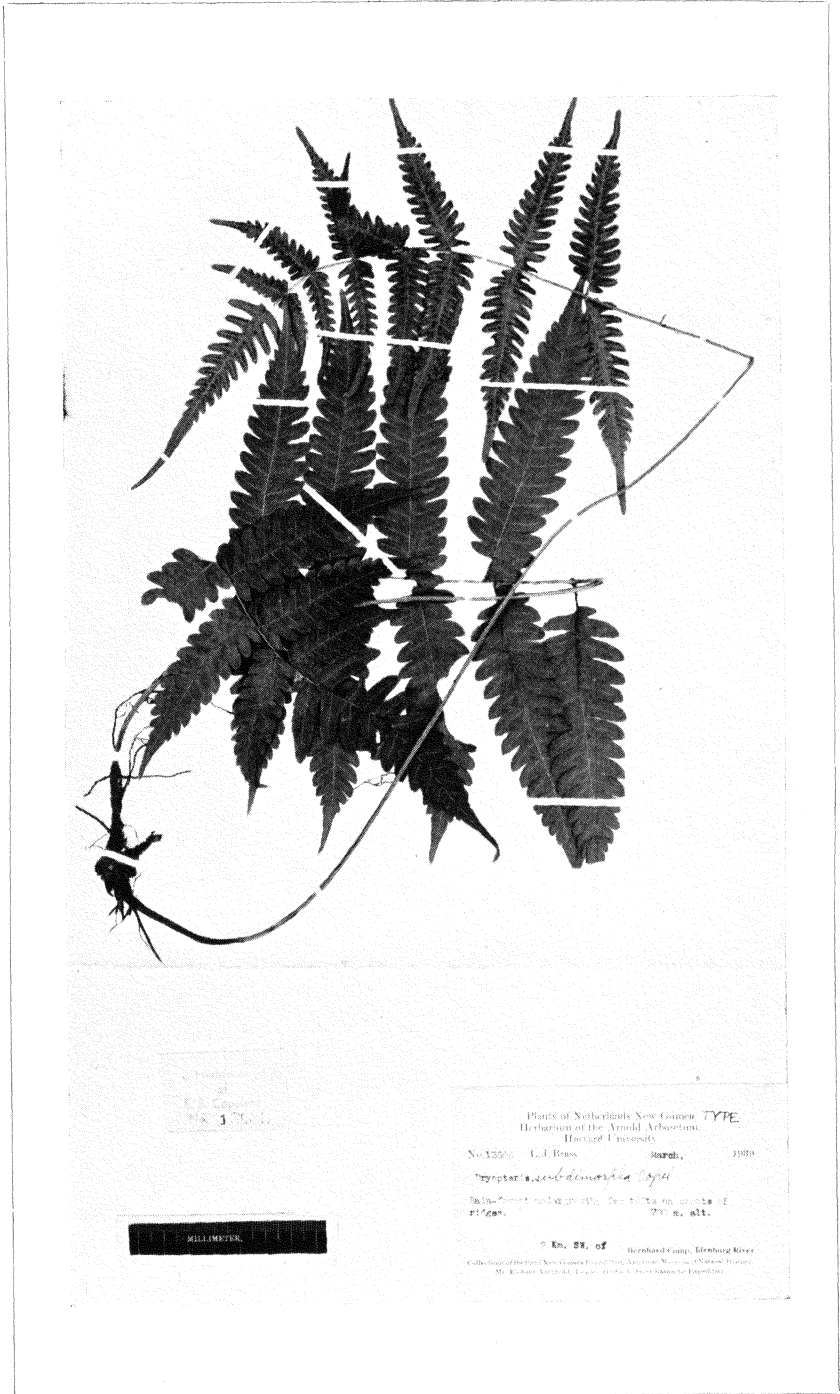


PLATE 19.



No. 3
 C. J. Copeland
 No. 3

MILLIMETER

Plants of Netherlands New Guinea TYPE
 Herbarium of the Arnold Arboretum,
 Harvard University
 No. 12550 L. J. Brass March, 1928
Cephaelis subdimeria Copel.
 Palau Forest and Agricultural Station on slopes of
 ridge. 700 m. alt.
 P. No. 28. of Herford Camp, Eideburg River
 Collection of the New Guinea Expedition, American Museum of Natural History,
 Dr. Robert Knuth, Leader, 1927-28.

PLATE 20.



PLATE 21.

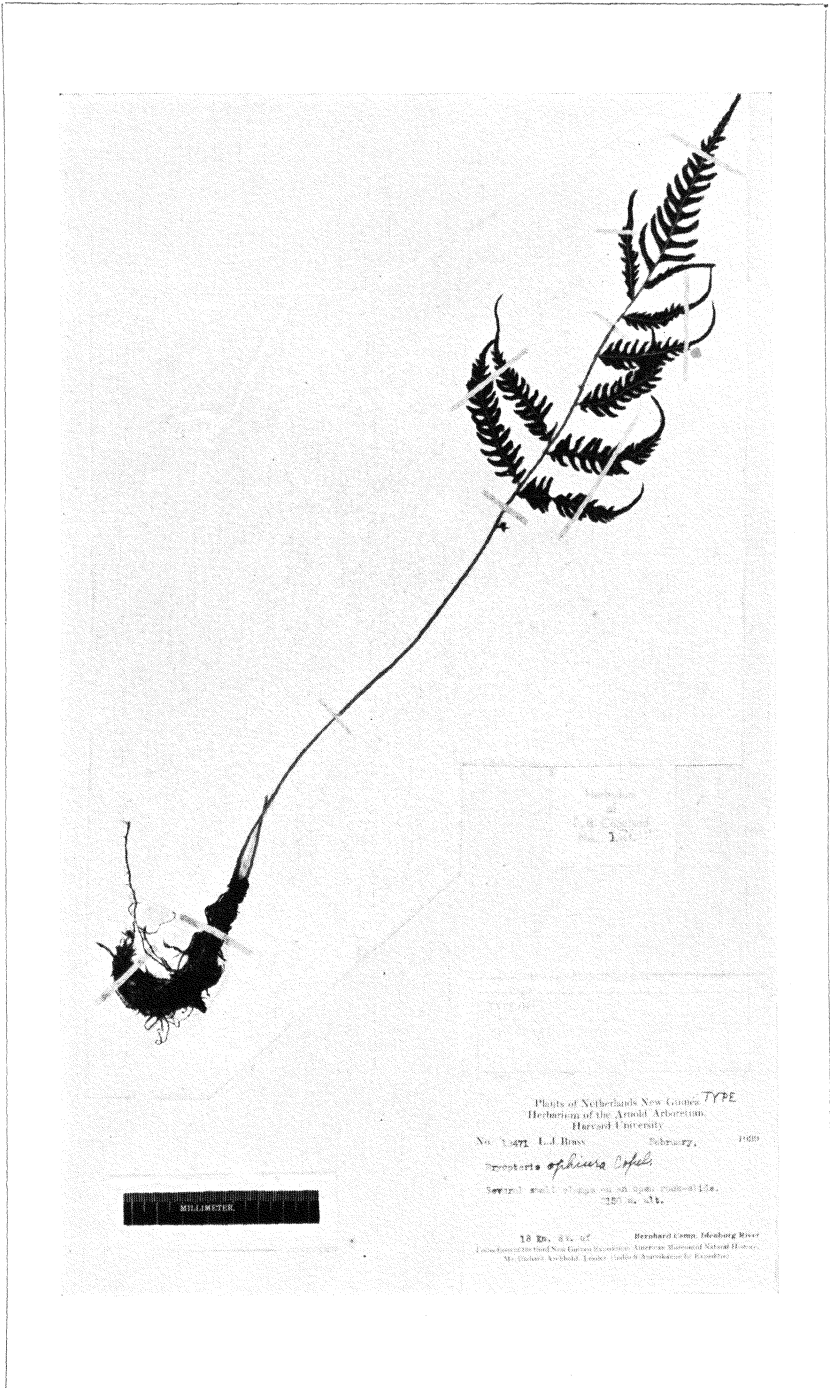


PLATE 22.

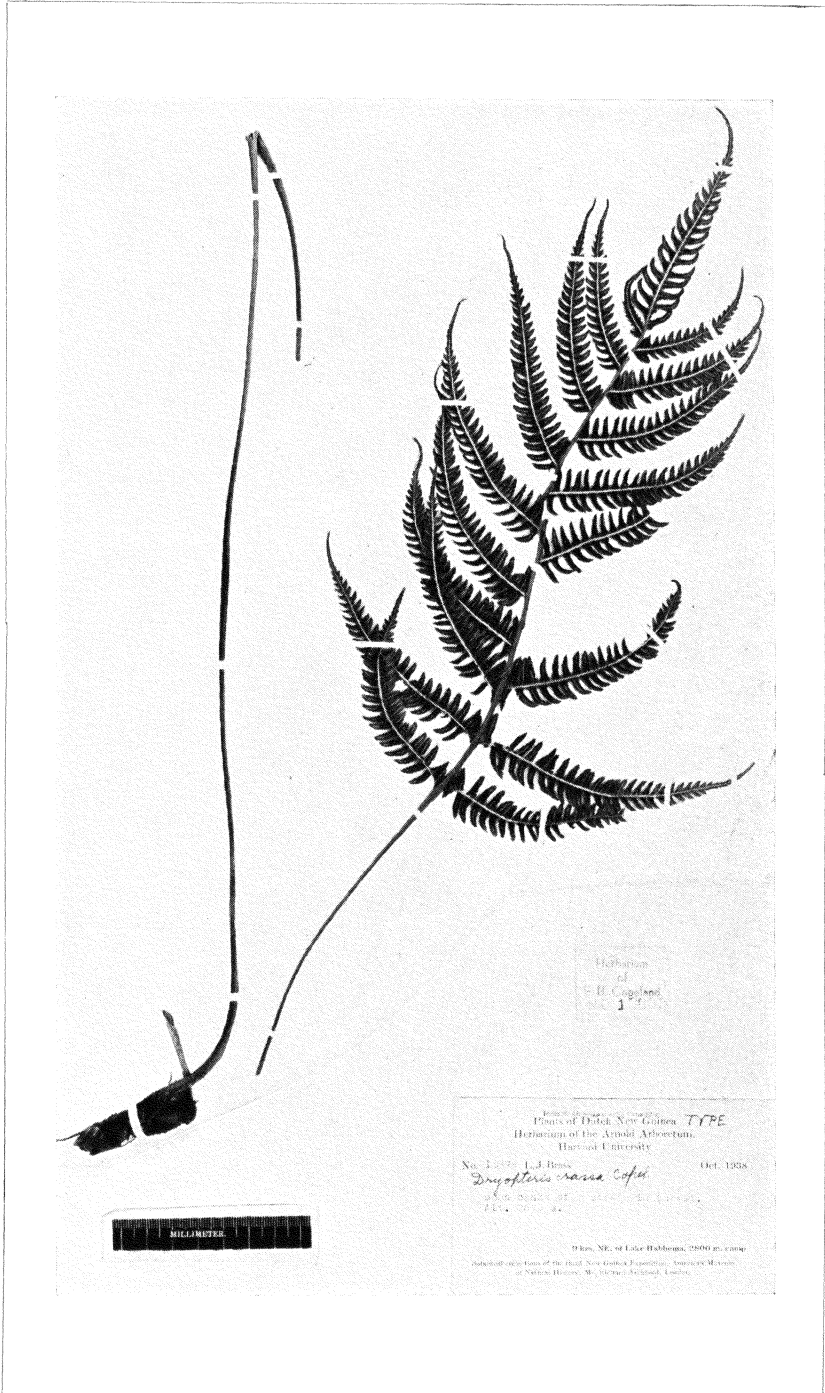


PLATE 23.

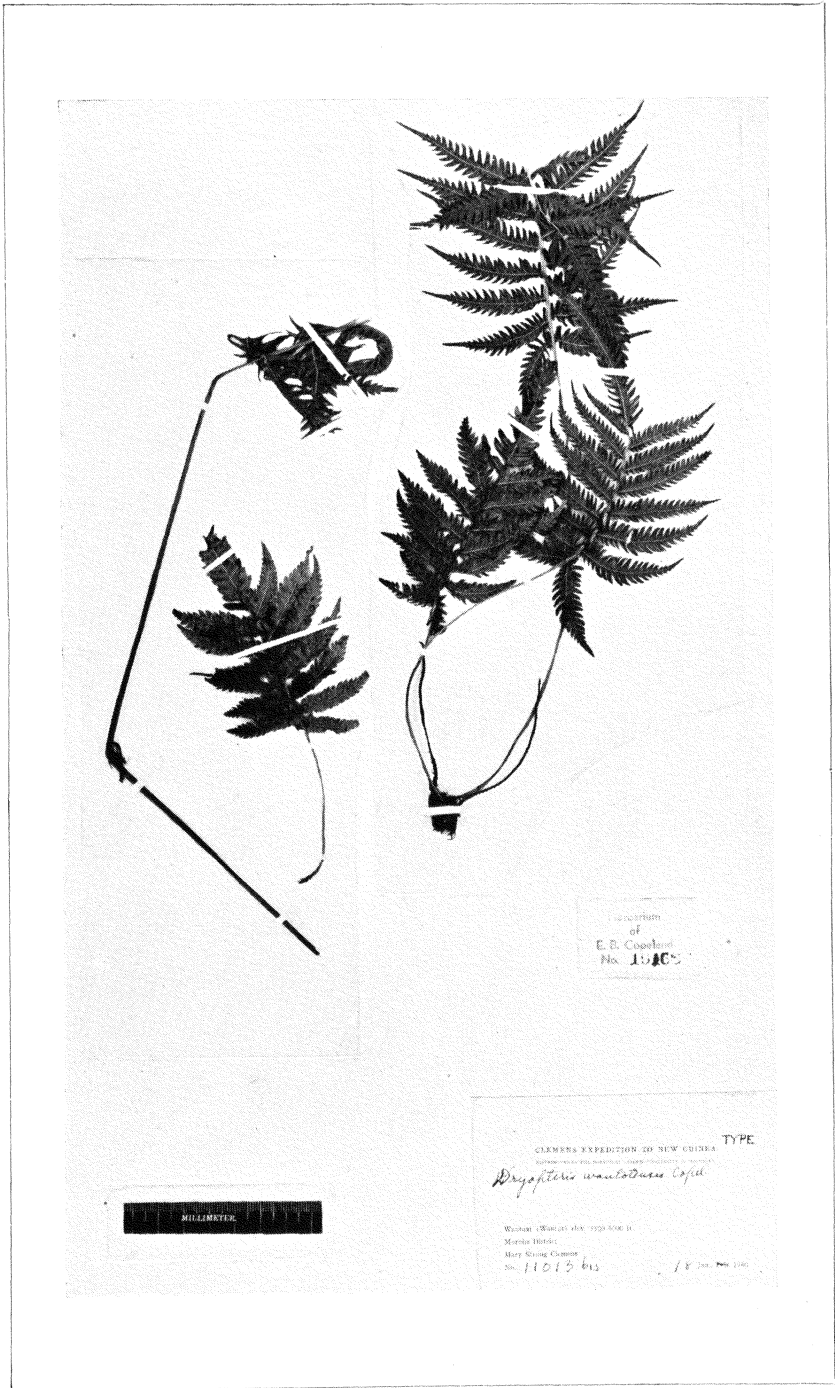


PLATE 24.

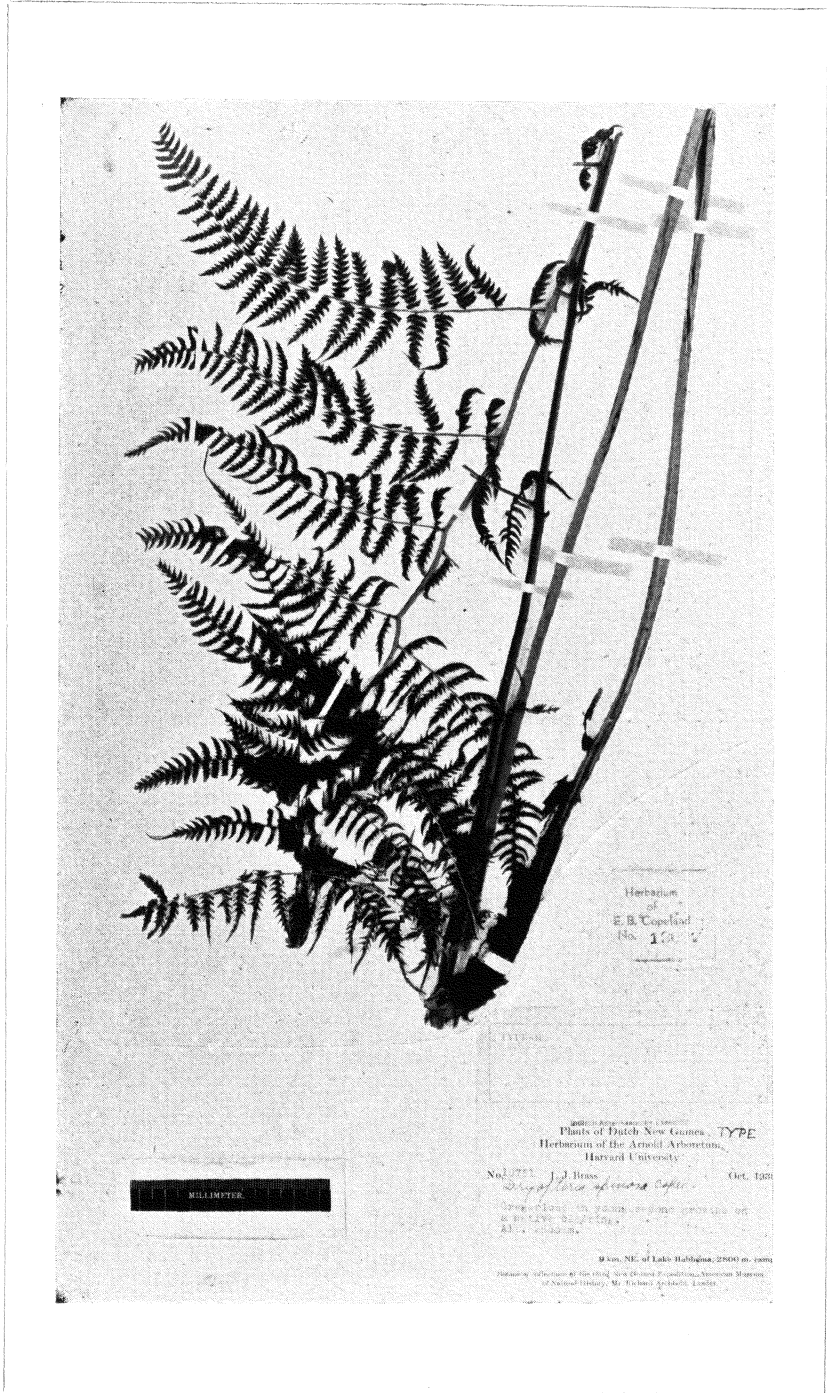


PLATE 25



PLATE 26.

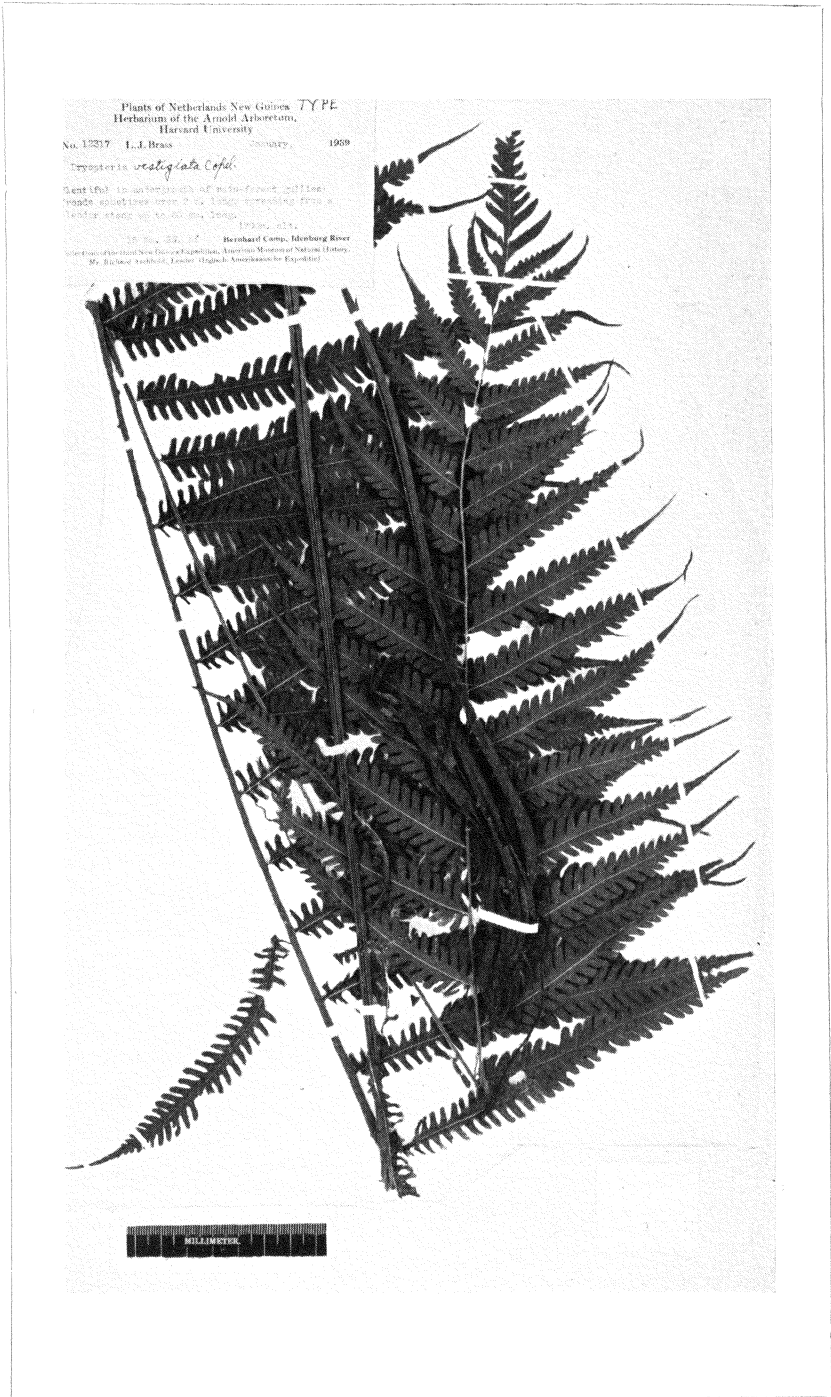


PLATE 27.



PLATE 28.

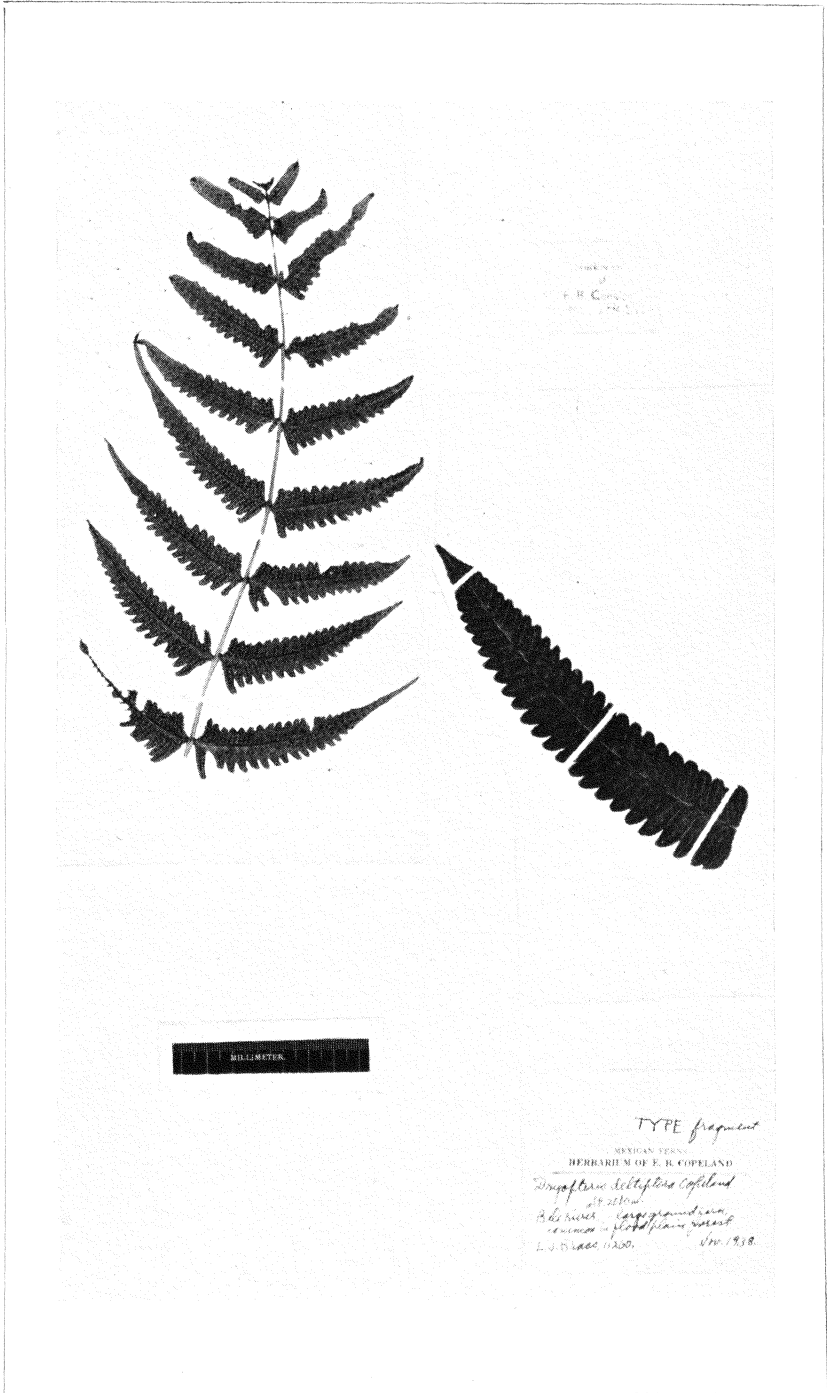
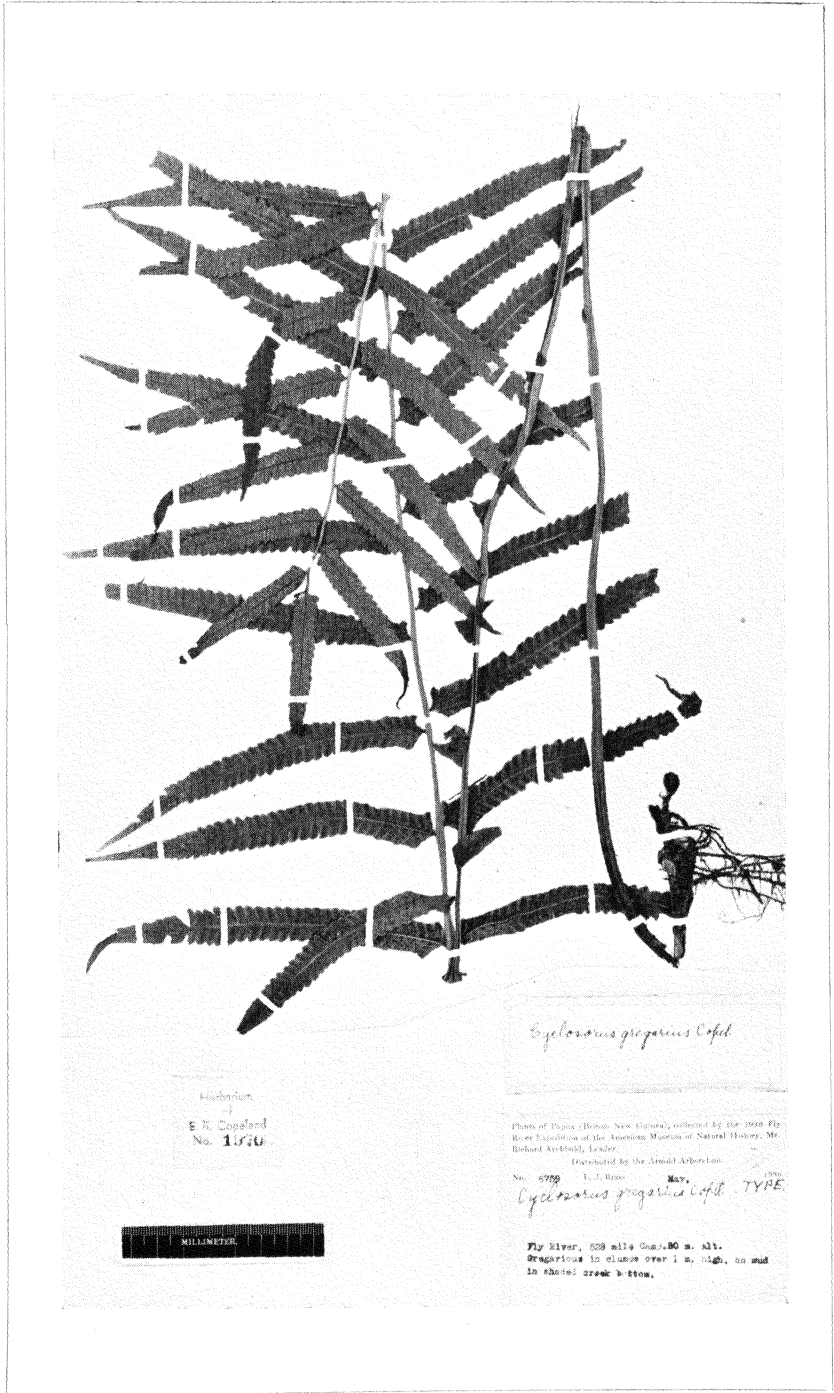


PLATE 29.



PLATE 30.



Herbarium
 E. N. Copeland
 No. 1570

MILLIMETER

Cyclosorus progerius Copel.

Plants of Papua (British New Guinea), collected by the 1928 Fly River Expedition of the American Museum of Natural History, Mr. Richard Seward, Leader.

Distributed by the Arnold Arboretum.

No. 6799 1-3, 1930 May, 1930
Cyclosorus progerius Copel. TYPE

Fly River, 509 miles from S.W. A.S.
 Progerious in clump over 1 m. high, on mud
 in shaded creek bottom.

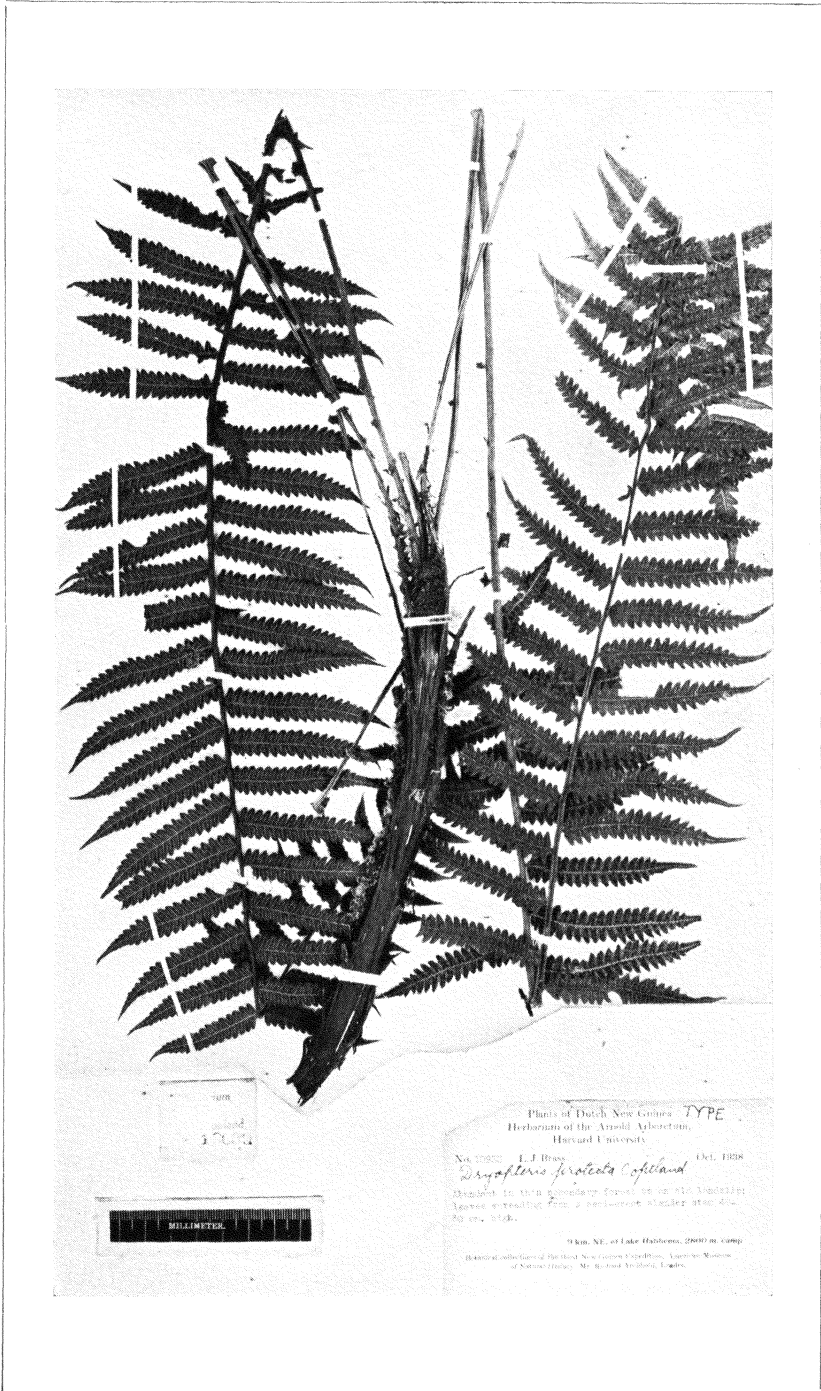
PLATE 31.



Dryopteris multinaviculata Copel.

Common ground fern in rain-forest
shrub; fronds almost sessile, spread-
the frond an erect stem up to 40 cm
in length, 6 km. S. of Bernhard
Camp, Idenburg River, 1150 m alt.

L.W. Brass (12890)



Plants of Dutch New Guinea. TYPE
 Herbarium of the Arnold Arboretum,
 Harvard University

No. 1700 L.J. Brass Oct. 1898
Dryopteris furcata Copeland
 Observed in three specimens from 40 to 600 meters;
 leaves exceeding 100 cm. slender stem 40
 cm. high.

Wain. N.E., at Lake Habema, 2600 m. camp
 (Herbarium collection of the Dutch New Guinea Expedition, Leiden; Museum
 of Natural History, Mr. Richard Schimper, Leiden.)

PLATE 33.



PLATE 34.

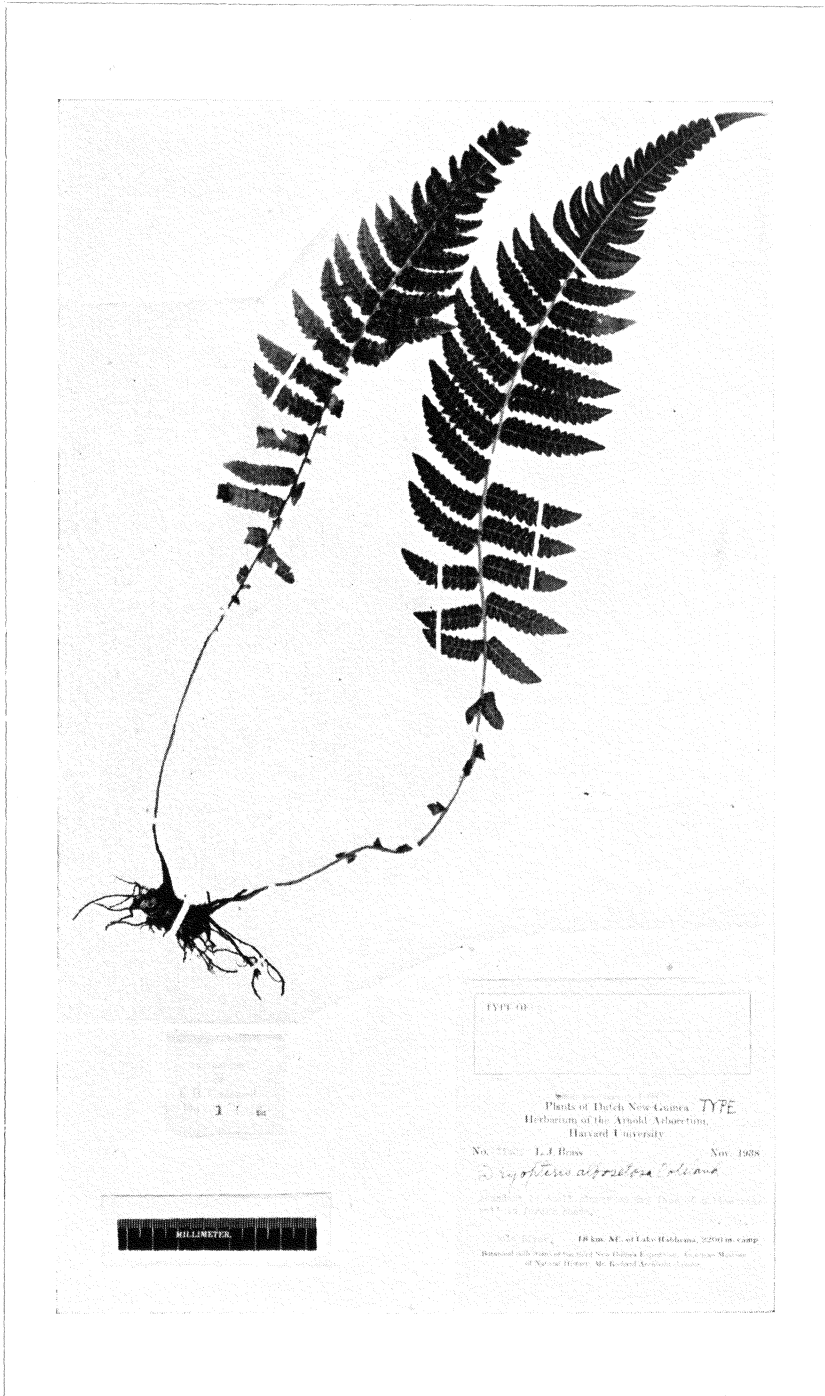


PLATE 35.



Herbarium
of
E. S. Copeland
No. 10012

MILNESTER

PLANTS OF DUTCH NEW GUINEA TYPE
Herbarium of the Arnold Arboretum,
Harvard University
No. 11436 L. J. Brass Nov. 1938
Dryopteris atropurpurea Copeland
A few plants tufted on dry face of a limestone
cliff in forest shade. 2290 s. 655.
Sela River, 18 km. NE. of Lake Haldemes, 2200 m. camp
Botanical collection of the field New Guinea Expedition, American Museum
of Natural History, Dr. Richard Archibald, Director

PLATE 36.

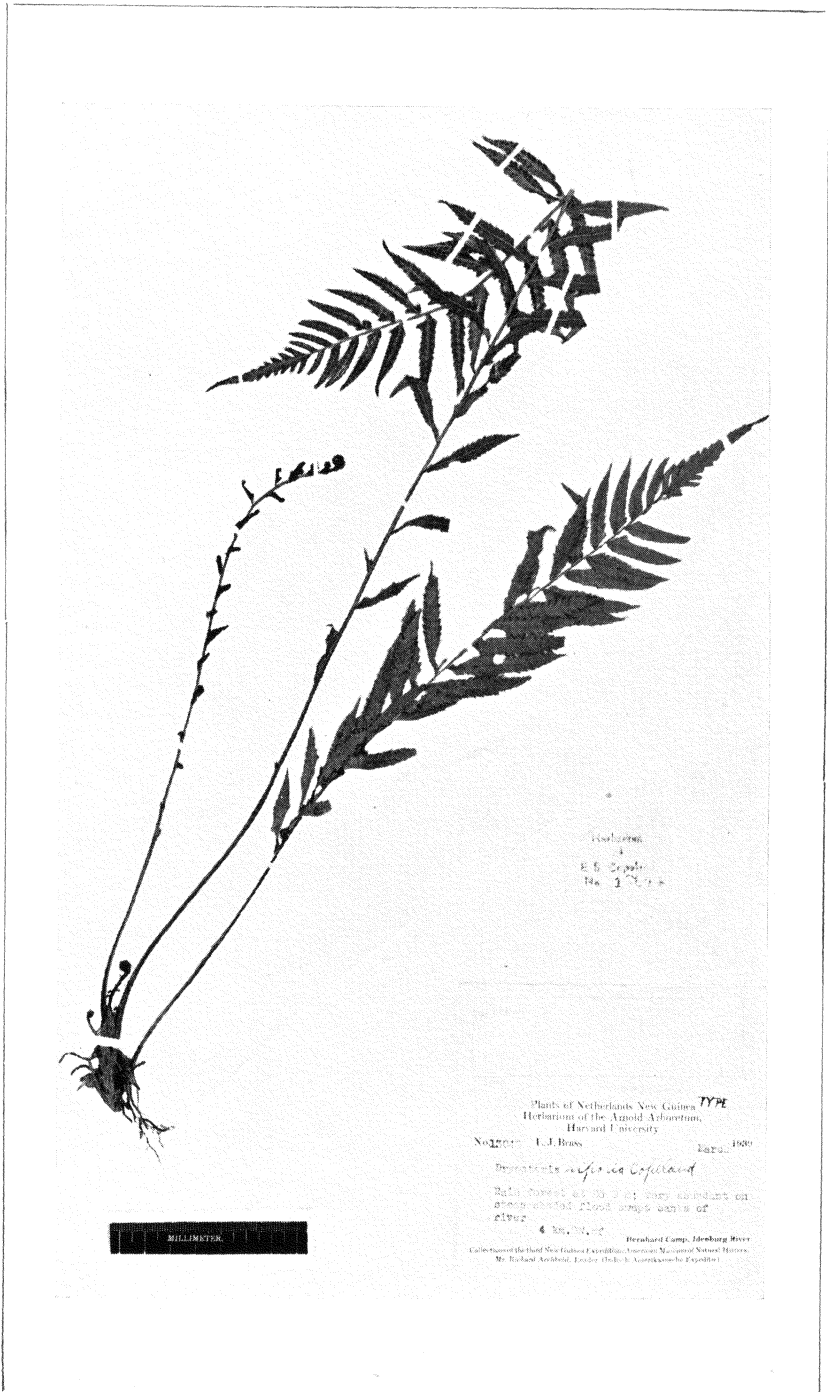
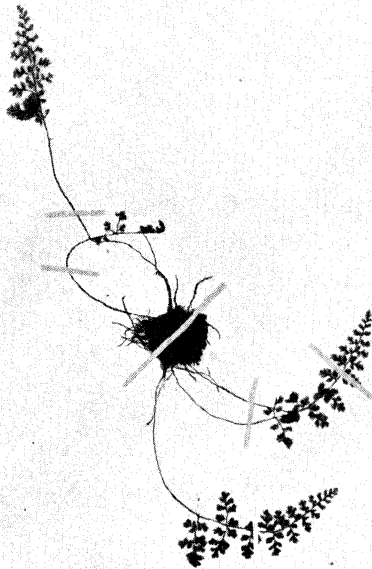


PLATE 37.



PLATE 38.

TYPE OF
Athyrium minutum Copel.



Herbarium
of
E. B. Copeland
No. 1803.

Deutsches Amerikanische Expedition
Plants of Dutch New Guinea TYPE
Herbarium of the Arnold Arboretum,
Harvard University

No. 10197 L. J. Brass & E. Myer-Drees Sept. 1938

Asplenium minutum Copel.

In a rock-hole on grassland.

3950m. alt.

Northern slopes of Mt. Wuhethina

Botanical collections of the third New Guinea Expedition, American Museum
of Natural History, Mr. Richard Archibald, Leader.





PLATE 40.



PLATE 41.



PLATE 43.



PLATE 44.

ERRATA

VOLUME 78

Page 97, line 6 for Zonker, should read Zenker.

Page 97, lines 6 and 11, for Beuin, should read Bouin.

Page 151, line 20, for E., should read F.

Page 151, line 23, for EE., should read FF.

Page 208, line 31, for *A. gracile* Fée, should read 19. *A. Clemensiae*.

Page 209, line 3 from bottom, H. Nepah., should read Fl. Nepal

Page 211, line 14, for dent., should read deut.

Page 213, after line 19 and before 13a. *A. Regis*, insert the entire first paragraph from p. 214.

Page 217, line 7 from bottom, for *toyayanum*, should read *tavoyanum*.

Page 217, bottom line, for *Goadyi*, should read *Goadbyi*.

Page 218, lines 9 and 10, for insiticum, should read insiticium.

Page 219, line 27, should read 9,000 feet *Clemens 12384* and *bis*. The type is *Keysser II*.

Page 220, reverse lines 9 and 10 from bottom, and line 10, for Schroder's, should read Schrader's.

Page 223, line 9, for *Novoy*, should read *Novog*.

Pages 223 to 227, in the running head, for Asplemaceae, should read Aspleniaceae.

Page 224, line 15, should read Fronds bipinnatifid or bipinnate.

Page 225, in the running head, for Aspeneacea, should read Aspleniaceae.

Page 228, line 6, from bottom, for *Bamber*, should read *Bamler* (twice).

Pages 233 to 274 were missed in pagination.

Page 291, line 10, for (Hooker) ⁷ should read (Hooker) ⁸.

Page 292, line 1, for 8 to μ to 19 μ , should read 8 to 10 μ .

Page 292, line 5, for Bismarch, should read Bismarck.

Page 292, line 25, for dactic, should read lactic.

Page 293, line 7, for Pl. 1, fig. 2, should read Pl. 1, fig. 1.

Page 294, line 1, for fig. 2, should read figs. 1 and 2.

Page 294, line 3, for Pl. 1, fig. 5, should read Pl. 2, fig. 5.

Page 296, line 37, for 4 Helt, should read 4 Heft.

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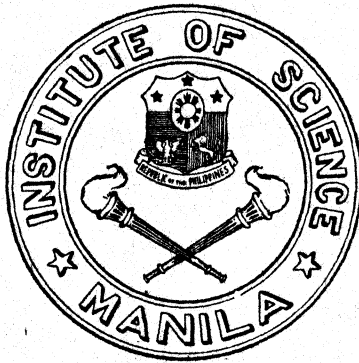
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