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(QUARTERLY ISSUE, VOLUME V)

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The *Quarterly Issue* ends with the present number, Part 4, Vol. V. Articles will hereafter bear reference only to volumes of the regular series of SMITHSONIAN MISCELLANEOUS COLLECTIONS.

CHARLES D. WALCOTT,
Secretary of th. Smithsonian Institution.

ARTICLES

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VOL. 52 1908

SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOL. V QUARTERLY ISSUE PART 1

THE CRETACEOUS FISHES OF CEARÁ, BRAZIL

BY DAVID STARR JORDAN AND JOHN CASPER BRANNER

(WITH EIGHT PLATES)

The first part of this paper deals with the general geology and geography of the region from which the Cretaceous fishes of Ceará come, while the second part is a systematic description of the fishes themselves. The collection is especially important because it contains all of the species hitherto described from Ceará, besides three new genera and four new species. The large number of duplicates has made it possible to restore several of these fishes almost entirely.

The collection belongs to Senhor Francisco Dias da Rocha, proprietor of the Museo Rocha in Ceará, to whom it has been returned, but Sr. Rocha has generously presented several important counterparts and duplicates to the junior author. These counterparts and duplicates are deposited with the geological collections of Stanford University, in California, and of these several specimens have been given to the Smithsonian Institution, at Washington.

A. NOTES ON THE GEOLOGY OF THE CRETACEOUS FISH-BEARING BEDS OF CEARÁ, BRAZIL

The collection of fossil fishes described in this paper was made by Sr. Francisco Dias da Rocha, of the Rocha Museum, at Fortaleza, Ceará, Brazil. They come from several places about the base of the Serra do Araripe, in the extreme southern end of the State of Ceará, but the precise localities are not given. The region is one that has been so rarely visited by scientific men that but little is known of the details of its geology. By far the most extensive and most valuable notes on the geology of Ceará are those made by Barão de Capanema in 1859. Unfortunately the results obtained by that writer were never published in full, and the paper giving a general outline of his explorations is disconnected and contains much irrelevant matter. However, the general geology of the Serra do Araripe itself is quite simple and its relations to the surrounding regions seem to be clear.

The following facts are gleaned from the scanty notes of Gardner and Capanema, and from those of a few others who have crossed adjacent portions of Maranhão, Piauhy, Parahyba, and Pernambuco.

Spix and Martius refer to fossil fishes being found at Barra do Jar-

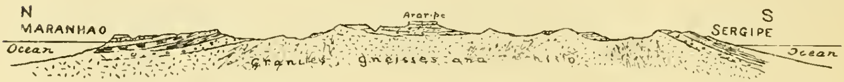

FIG. 1.—Hypothetical section across northeastern Brazil, showing the structural and geographical relations of the fish-bearing beds of the Serra do Araripe to the coast sediments of Maranhão and Sergipe.

dim, but it is not clear from their note (Reise in Brasilien, II, 799) that the place was visited by either of the authors. The lithographed figure of a fish, *Rhacolepis buccalis,* published in one of the plates of the atlas accompanying their work, is reproduced here. It is the first one of the fossil fishes ever figured from that region (pl. VI, fig. 2).

The water-sheds between the State of Ceará and the States that adjoin it on the south and west are mostly flat-topped table-lands or plateaus. These plateaus are composed for the most part of horizontal sedimentary beds. They rest unconformably upon schists, gneisses, and granites, and at some places upon what seem to be folded but unaltered Paleozoic sediments. The position, distribu-

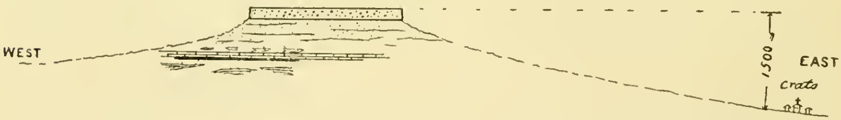

FIG. 2.—East-west section through the Serra do Araripe, constructed from the notes of Gardner and Capanema.

tion, and character of the beds show that the sediments forming the plateaus formerly had a wide distribution over northeastern Brazil, and that they have been gradually removed by the ordinary processes of denudation.

On the west these beds extend across Piauhy, probably with some interruptions, into the State of Goyaz; on the north they extend across Piauhy and into Maranhão; on the south they extend into Bahia and Pernambuco, approaching the Rio São Francisco; on the east they form, in part at least, the flat-topped mountains of the western and southern boundaries of the State of Ceará.

The section across the Serra do Araripe given herewith has been constructed from the notes of Gardner and Capanema:

Sandstone forming the top of the mountain, 140 feet (Capanema).

Sandstone series, yellow, white, and red, 600 feet (Gardner); (this includes the top bed of Capanema).

Thin-bedded limestone (thickness not stated).

Lignite, 2 feet (Gardner); bituminous shale (Capanema).

Blue clay and gray sandstone at base (Capanema).

The sequence, character, and relations of the rocks in the Serra do Araripe are sufficiently clear from this section to render further verbal description unnecessary.

The fishes have only been found in concretions, and are said to come from the sandstone bed above the limestone layer. They have never been found in place, but occur in the talus and soil on slopes at the base of the sandstone ridges. The matrix in which the fossils occur is mostly the buff or cream-colored limestone in which these fossils have hitherto been found.

The rock matrix suggests that while some of the specimens are from sandstone beds, most of them are from beds, or at least from lenses, of limestone.

Slides were made of the matrix of two of the concretions. Under the microscope it is seen that the bulk of the rock is composed of microscopic crystals of calcite somewhat stained with iron. The calcite crystals, however, are so small that they are scarcely distinguishable, even under an enlargement of 90 diameters. Between 5 and 10 per cent of the rock is made up of clear round calcite bodies evidently of organic origin.

Fragments were broken from specimens in the Rocha Collection and chemical analyses were made of them with the following results. Care was taken not to include parts of the fossil fishes in the pieces analyzed.

Analysis of pieces of a fossil-bearing concretion from Ceará, Brazil

L. R. Lenox, *Analyst*

(Record Book 779)

Silica (SiO_2)	3.64
Oxides of iron and alumina (Al_2O_3 Fe_2O_3)	1.46
Lime (CaO)	52.23
Magnesia (MgO)	0.56
Loss in ignition (CO_2, H_2O, etc.)	42.28
Total	100.17

Equivalent to—

Carbonate of lime ($CaCO_3$)	93.26
Carbonate of magnesia ($MgCO_3$)	1.16

Analysis of part of a concretion containing a somewhat telescoped fossil fish (Rhacolepis buccalis)

(Record Book 781)

Silica (SiO_2)	4.31
Iron and alumina (Fe_2O_3 and Al_2O_3)	3.05
Lime (CaO)	50.39
Magnesia (MgO)	0.66
Loss (CO_2 and water)	41.53
Total	99.94

Equivalent to—

Carbonate of lime ($CaCO_3$)	89.98
Carbonate of magnesia ($MgCO_3$)	1.38

Analysis of part of a concretion containing a fossil fish, Calamopleurus vestitus, Specimen No. 15

(Record Book 782)

Carbonate of lime ($CaCO_3$)	90.64
Carbonate of magnesia ($MgCO_3$)	1.27

Analysis of part of the concretion containing the large specimen of Calamopleurus cylindricus received from Dr. Paula Pessoa, of Rio de Janeiro

(Record Book 783)

Carbonate of lime ($CaCO_3$)	92.57
Carbonate of magnesia ($MgCO_3$)	1.25

Many of the specimens of fossil fishes have been crushed together lengthwise or telescoped, so that the scales are thrust farther over than they should be. This peculiarity of these fishes has been noted before by Dr. A. Smith Woodward in his paper published in the Proceedings of the Zoölogical Society of London, 1887. The chemical analyses suggest that this telescoping may be due to the partial dolomitization and consequent shrinking of the original limestone caused by the substitution of magnesium carbonate for the calcium carbonate.

The appearance of the rock and the analyses given above lead one to suppose that the composition of the concretions is fairly uniform. Some of them, however, are much more sandy than others, and the specimens in the sandy rocks are not so well perserved as those in the limestone concretions. Possibly the sandy concretions are not from the same localities as the more calcareous ones.

The fossil fishes from Ceará are generally spoken of as coming from Barra do Jardim, but they have been found at many other localities, though always about the base of the Serra do Araripe. Gardner's collections came from Barra do Jardim, from a sugar plantation called Massapé (or Maçapé, as he spells it), five leagues east of Barra do Jardim: from Mundo Novo, three leagues west of Barra do Jardim, and from Brejo Grande, a plantation west of the Serra do Araripe and about 35 miles west of Crato. Capanema found them also at Breijinho, a locality not mentioned by Gardner, but in the same neighborhood.

A few other fossils occur in the rocks containing the fossil fishes, but no effort seems to have been made to collect these other fossils on the ground. The only ones mentioned by the collectors are noted here. Gardner found a single valve of a *Venus* half an inch long, the cast of a cephalopod an inch and a half long and supposed by him to be a *Turrilites*. Both of these came from loose pieces of sandstone. He was told of a small snake having been found rolled up in one of the concretions, but he thinks it was probably a species of cephalopod.[1] Judging from the Rocha Collection, it seems more likely that it was a specimen of *Belonostomus comptoni,* which is occasionally found thus coiled up.

The specimens in the Rocha Collection contain a few entomostracan remains, but none of them have been specifically idenitfied. Dr. A. Smith Woodward notes that entomostracans found in the British Museum specimens were examined by Prof. T. Rupert Jones and Mr. C. D. Sherborn, who refer them with some doubt to *Cytheridea*.[2]

Barão de Capanema, who visited the Serra do Araripe in 1859, reports finding associated with the fossil fishes coprolites "the bones probably of saurians, the teeth of fishes, and an unknown plant with imbricated leaves. I heard of fossil shells and zoöphytes on the Piauhy frontier."[3] Gardner says that flints are common on the side of the mountain northwest of Crato, and he speaks of chalk being found in the mountains near Crato. Gardner found limestone and marl beneath the fossiliferous sandstone, and beneath the limestone a bed of lignite about two feet thick. Capanema thinks that the

[1] Geologia Elementar, por N. Boubeé, p. 55; Rio, 1846; Trans. Brit. Assoc., 1840, 120.

[2] Proc. Zoöl. Soc., London, 1887, 541.

[3] Trabalhos de Commissão Scientifica de Exploração, 1, Introducção, p. 130. Rio de Janeiro, 1862.

material reported to be chalk is only a white clay, but he confirms the existence of a thin-bedded limestone beneath the fossiliferous sandstone, and "beneath this limestone is a bed of very bituminous laminated shale. It is a kind of lignite changed to coal, only a few inches in thickness." He says that fossil wood was found by Dr. Gonçalves Dias near São Pedro, two leagues from the Villa de Milagres. The existence of the limestone and lignite induce one to hope that a careful search may yet lead to the discovery of considerable additional paleontologic material, though Gardner distinctly states that no fossils could be found in the limestones.[1]

In the Rocha Collection the rock inclosing the fossil fishes contains many fish scales and the remains of microscopic shells that have not been studied. One of the concretions is rather darker and more marly than the others, and in this are found many small rounded bodies evidently of organic origin. Some of these were submitted to Dr. E. O. Ulrich, paleontologist of the U. S. Geological Survey, who kindly reports as follows upon them:

> The ostracod seems to be one of the simple types of *Cytheridea,* apparently closely allied to the Miocene *C. subovata* U. & B. It resembles an Eocene species also very closely, and I know of a late Cretaceous form that is not far removed. However, with specimens in rock like yours it is difficult to satisfactorily determine even the genus of the host of smooth and subovate ostracods.

Referring to the broader features of the Cretaceous geology of northeastern Brazil, the area covered by the Cretaceous rocks is not known with any certainty. Even where they are best known they have been identified at only a few places on and near the coast. On the coast, however, they form only a narrow belt approximately parallel with the present shoreline, toward which they have a general and gentle dip, except on the immediate shores, where the dip is often landward. This coast belt of Cretaceous sediments is in places from twenty-five to fifty miles or more in width, while at other places the beds have been entirely removed and the old underlying rocks of the interior are exposed on the seashore. On the land side of the Cretaceous belt the surface rocks are usually granites, gneisses, schists, and other metamorphics of uncertain age or ages.

In the region drained by the Rio Paranahyba above Theresina, and lying mostly in the State of Piauhy, there is a series of horizontal sedimentary beds which appear to be the inland remnants of the series exposed along the coast. But little is known of the geology

[1] Trans. Brit. Assoc., 1840, 119.

of these inland sediments, however. What is here given has been collected from the notes of Spix and Martius and of Gardner.

While the structural relations of these highland beds is not certainly known at present, such information as we have suggests the relations indicated by the accompanying theoretic section across northeastern Brazil, say from about Maranhão on the north to Sergipe on the south, and passing through the Serra do Araripe. It should be added, however, that the slates reported near Lavras in Ceará are probably Paleozoic. No attempt is made to represent those slates in this section. There are probably local variations in the dips and relations of the Cretaceous beds which are not suggested in this hypothetical section.

Barão de Capanema says that the beds of the Serra da Ibiapaba along the northwestern boundary of Ceará dip toward the west, and he appears to think that the rocks of that range are the same as those of the Serra do Araripe. This attempted correlation is not based upon paleontologic evidence, and may be altogether erroneous.

The table-lands so characteristic of the Serra do Araripe follow the water-sheds toward the south and west. Mr. J. W. Wells describes what seems to be a similar topography and similar rocks about the southern ends of the states of Piauhy and Maranhão.[1] It is not to be inferred, however, that these sediments form the Serra Vermelha and Serra Dois Irmãos in the intermediate region, for the notes of Spix and Martius show that where they crossed the Serra Dois Irmãos the rocks are granites and schists,[2] a fact that lends support to the theory that this region was an archipelago during Cretaceous time.

The junior author's acquaintance with the geology of the surrounding region and the few published notes of travelers suggest that this northeast corner of Brazil was an archipelago at the time of the deposition of these Cretaceous sediments, and that the mechanical portions of these sediments were derived from islands of granites, gneisses, and schists.

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[1] James W. Wells: Exploring and traveling three thousand miles through Brazil. London, 1886, II, 144.

[2] Reise in Brasilien, II. 768.

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L. AGASSIZ: Sur quelques poissons fossiles du Brésil. Comptes Rendus, XVIII, 1007–1015. Paris, 1844.

F. CHABRILLAC: Sur quelques poissons fossiles de la province de Ceará au Brésil. Comptes Rendus, XVIII, 1007. Paris, 1844.

GUILHERME S. DE CAPANEMA: Trabalhos da Commissão Scientifica de Exploração. Introducção. Rio de Janeiro, 1862. Secçãa Geologica, pp. 120–143.

E. D. COPE: On two extinct forms of Physostomi of the neotropical region. Proc. Am. Phil. Soc., XII, 53–55. Philadelphia, 1871.

A. SMITH WOODWARD: On the fossil Teleostean genus, Rhacolepis Agass. Proc. Zoöl. Soc. London for 1887, 535–542.

J. C. BRANNER: Geologia Elementar preparada com referencia especial aos estudantes Brazileiros. Rio de Janeiro, 1906, pp. 273–274.

B. NOTES ON THE FOSSIL FISHES OF CEARÁ

ANALYTICAL KEY TO THE CRETACEOUS FISHES KNOWN FROM CEARÁ

a.—GANOIDEI: Scales large, diamond-shaped or plate-like; tail strongly heterocercal; dorsal inserted behind the ventrals.

b.—(ASPIDORHYNCHIDÆ): Scales plate-like, those on the sides of the body much deeper than the others; both jaws much elongate, pointed .... *Belonostomus comptoni*, 1

bb.—(SEMIONOTIDÆ): Scales large, firm, diamond-shaped; a series of spine-like scales along middle of back; jaws not greatly elongate. *Lepidotes temnurus*, 2

aa.—ISOSPONDYLI: Scales thin, cycloid or rhombic; no spines in fins; tail homocercal or slightly heterocercal; snout (in Brazilian Cretaceous species) not produced.

d.—(LEPTOLEPIDÆ): Scales small, thin, more or less diamond-shaped, at least along back; tail somewhat heterocercal, the last vertebra reduced in size and turned upward; ventral fins inserted under front of dorsal; subopercle small, its suture horizontal; cheek and postorbital region with three large plates (gular plate unknown); distance from gill opening to dorsal not greater than depth of body. *Tharrhias araripis*, 3 *dd.*—(ELOPIDÆ): Gular plate present ventrals (in Cretaceous species from Brazil) inserted under last rays of dorsal; temporal region with a bony plate or sheath; two parallel bony plates behind eye, with a third, usually larger, one sheathing the cheek.

f.—Teeth subequal, without large canines.

g.—Lateral line well developed; teeth small (less than one-tenth diameter of eye).

h.—Scales small, 30 to 33 in a cross-series from dorsal to ventral; suborbital broad, its suture oblique. *Calamopleurus cylindricus*, 4

hh.—Scales large, about 20 in a cross-series from dorsal to ventral; suborbital very narrow; its suture nearly horizontal *Calamopleurus vestitus*, 5

gg.—Lateral line obsolete or nearly so; teeth rather large.

i.—Scales cycloid, entire; teeth strong, more than one-tenth diameter of eye. *Notelops brama*, 6

ii.—Scales crenate; teeth probably small.

j.—Body subcylindical, the depth not much greater than length of head. *Rhacolepis buccalis*, 7

jj.—Body compressed, the depth much greater than length of head. *Rhacolepis latus*, 8

ff.—Teeth very strong, unequal, many of those in each jaw canine-like (scales unknown). . *Enneles audax*, 9

e.—CHIROCENTRIDÆ(?): Gular plate wanting; scales large, the surface pustulose (no lateral line). *Cladocyclus gardneri*, 10

cc.—OSTEOGLOSSIDÆ(?): Opercle large, without suture, the subopercle wanting; scales firm, with concentric striæ; dorsal inserted over ventral, at a distance behind head greater than depth of body. *Cearana rochæ*, 11

FAMILY ASPIDORHYNCHIDÆ

Genus BELONOSTOMUS Agassiz

Belonostomus AGASSIZ, Neues Jahrbuch, 1834, p. 388; type, *Aspidorhynchus tenuirostris* AGASSIZ.

Ophirhachis COSTA, Ittiol, Fossil, Ital., 1856, p. 13; type, *Ophirhachis deperditus* COSTA.

? *Platycerhynchus* COSTA, Atti Acad. Pontan, VIII, 1864, p. 98; type, *Platycerhynchus rhombeus*.

This genus contains numerous species of large, gar-like fishes, having rhombic scales, those of the lateral line deeper than the others, and having both jaws produced, subequal in length. According to Woodward, the suborbitals lie in contact with the cheek-bone, without separate cheek-plate, such as exists in *Aspidorhynchus*. In both these genera the vertebræ are double-concave, not concave-convex, as in the true gar-fishes or Lepisosteidæ. According to Woodward, the vertebræ in *Belonostomus* are "well ossified, smooth and constricted, about as long as deep, and pierced by a small thread of persistent notochord."

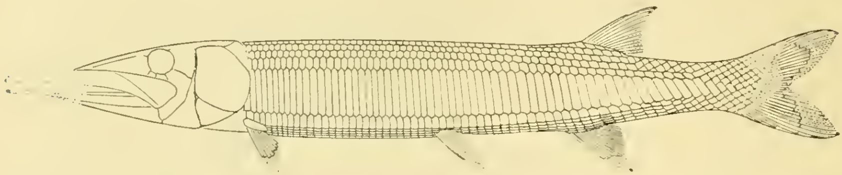

FIG. 3.—*Belonostomus comptoni* (Agassiz). Barra do Jardim, Brazil. (Restoration.)

The Brazilian species of *Belonostomus* differs from the type of the genus in the very much greater depth of the scales composing the lateral line. These are anteriorly about five times as deep as long. The jaws are also more robust than in the typical species.

1. BELONOSTOMUS COMPTONI (Agassiz)

Aspidorhynchus comptoni AGASSIZ, Edinburgh Phil. Journal, XXX, p. 83. 1841; Ceará.

Agassiz, Comptes Rendus, XVIII, p. 1009, 1844; Ceará.

Belonostomus comptoni WOODWARD, Proc. Zoöl. Soc. London, p. 629, pl. LIV, LV, figs. 1–10; Ceará.

Woodward, Cat. Fossil Fishes, III, p. 435, 1895; Ceará.

Of this species we have fragments of different sizes from 5 or 6 different fishes (Nos. 6, 7, 10, 23, 24, 27, 28, 29, and 31, Rocha Col-

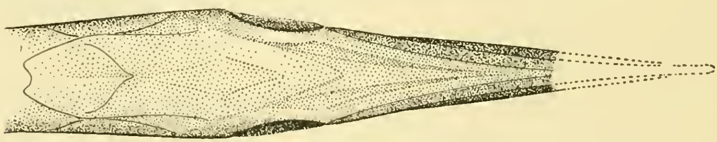

FIG. 4.—*Belonostomus comptoni* Agassiz. Top of head.

lection, the largest fish (No. 7) being about 20 inches long if restored and nearly 2½ to 3 inches in depth, the depth about 7 in length.

Length of head about twice greatest depth, about 4 in length. Jaws apparently equal, both pointed, the tips of both broken in all our specimens. Snout half head, or perhaps less, the tip being lost. Eye about 2 in snout, nearly 5 in head; maxillary broad behind, almost fan-shaped, extending to a little behind middle of eye; opercle large, with concentric striæ, provided with small pustulations along the ridges; top of head flat, narrow, the interorbital space about width of eye; lower jaw with what seem to be traces of long, slender, unequal teeth, but this is not certain.

Scales ganoid, those of the median series very much enlarged, with parallel edges, the depth of each scale anteriorily 4 to nearly 5 times its length, each scale with vertical striæ; about 4 rows of small scales above these, the small scales about as long as deep, impricated. Below the large scales are about three rows of smaller ones, those of the upper low largest. Posteriorly the large scales are progressively less deep, and at base of caudal they are scarcely deeper than those of the lowest of the upper rows or the highest of the lower row; 18 scales in a lengthwise series backward from the front of dorsal, about 33 anteriorly from the front of ventral; the scales in all probably about 60. Bands of scales anteriorly nearly vertical, those posteriorly extending downward and backward. Scales all enameled, their surface rugose.

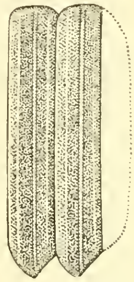

FIG. 5.—Scales of *Belonostomus comptoni.*

Pectorals placed low, the upper ray broad (the fin broken); ventrals inserted at a distance behind head equal to 1¼ length of head. Body tapering backward, subterete, but distinctly compressed, much deeper than broad; depth at dorsal fin 2¼ in distance from front of dorsal to base of caudal; dorsal and anal opposite each other, each of about 10 rays; both fins higher and long, the posterior rays rapidly shortened, caudal broken, evidently strongly heterocercal, with rudimentary rays at base of each lobe.

Vertebræ distinctly biconcave, apparently well ossified. Two of the specimens are partly coiled within nodules of stone, their position and armature suggesting millipedes, or even snakes. From our excellent material we have ventured on a restoration of this species (fig. 3). Of these specimens numbers 7, 10, and 27 are in the United States National Museum.

Family SEMIONOTIDÆ

Genus LEPIDOTES Agassiz

Lepidotes Agassiz, Neues Jahrbuch, 1832, p. 145; type, *Lepidotes gigas* Agassiz.

Lepidotus Agassiz, Poissons Fossiles, II, pt. 1, 1833, pp. 8, 233 (altered spelling).

Lepidosaurus von Meyer, Palæologica, 1832, p. 208; type, *Lepidotus unguiculatus* Agassiz.

Scrobodus von Münster, Neues Jahrb., 1842, p. 38; type, *Scrobodus subovatus.*

Plesiodus Wagner, Abh. Bay. Akad. Wiss., IX, 1863, p. 632; type, *Plesiodus pustulosus* Wagner.

Prolepidotus Michael, Zeitschr. Deutsch. Geol. Ges. XIV, 1893, p. 729; type, *Prolepidotus gallineki* Michael.

This large genus is distinguished among the Semionotidæ by the deeply fusiform body, the presence of grinding teeth on the inner part of the jaws, and by the relatively low dorsal and anal fins. The teeth have not been preserved in any specimen of the Brazilian species.

2. LEPIDOTES TEMNURUS Agassiz

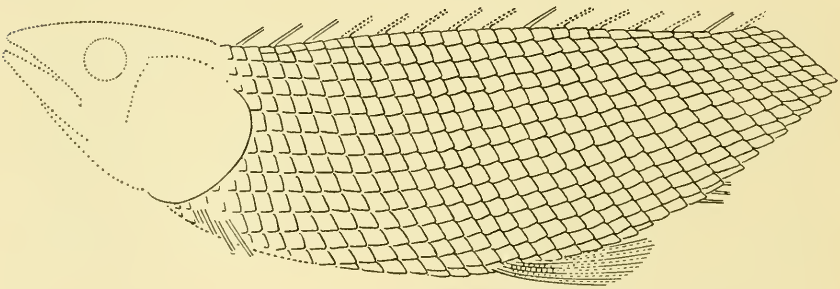

Fig. 6.—*Lepidotes temnurus* Agassiz.
Barra do Jardim, Serra do Araripe, Brazil.

Lepidotus temnurus Agassiz, Edinburgh Phil. Journ., XXX, 1841, p. 83; Serra do Araripe, Ceará.

Agassiz, Comptes Rendus, XVIII, 1844, p. 1010; Ceará (misprinted lemnurus).

Woodward, Cat. Fossil Fishes, III, p. 123, 1895; Ceará.

? *Lepidotus mawsoni* Woodward, Ann. Mag. Nat. Hist., VI, p. 135, 1888; Cretaceous at Bahia, Brazil.

Woodward, Cat. Fossil Fishes, III, p. 120, 1859; Bahia, Plataforma, Itacaranha, Pedra Furada, Brazil.

Of this species we have one specimen within a concretion (No. 2, Rocha Collection), preserved also in counterpart. It includes the greater part of the body of the fish; is somewhat distorted by being bent downward in the middle, the head is entirely crushed, and the dorsal, anal, and tail are absent and the pectoral fin broken (fig. 6).

The head was about 3½ times in length to base of caudal, the greatest depth over the ventral fins about 3⅔. The scales are rhombic, entire, deeply overlapping, most of them deeper than long. The surface of the scale is not smooth, but marked with about three coarse ridges, parallel with the anterior margins. The distance of the ventral from the head is apparently a little more than length of head. The ridge scales on the back are very distinct, spine-like, more elevated than usual in *Lepidotes*. Three are distinct behind the nuchal region, and there are traces of others farther back.

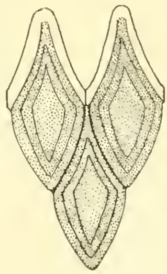

FIG. 7.—Scale of *Lepidotes temnurus*.

In the description of *Lepidotus mawsoni* it is stated that the principal flank scales are "with frequently discontinuous enamel marked with a few broad ridges and furrows radiating from the center to the hinder border, where they form feeble indentations." The markings on *L. temnurus* do not answer to this description.

FAMILY LEPTOLEPIDÆ

This family stands almost intermediate between the Ganoids and the Isospondyli. It has the general fin arrangement of the latter, but the scales are more or less diamond-shaped and ganoid on their exposed parts, and the last vertebræ are more or less turned upward, although the tail is usually or always forked. The orbital plates cover the cheek as in the Elopidæ, but there is no gular plate, so far as known.

Genus THARRHIAS Jordan and Branner, new genus

A species from Ceará is referred by us to the family of Leptolepidæ, and it is very closely allied to the typical genus, *Leptolepis,* of the Triassic and Cretaceous of Europe. It is, however, distinguishable by the much larger opercle, which is more than four times as deep as the subopercle and separated from it by a horizontal suture. The vertebræ are 50 to 55 in number, while the type of *Leptolepis*[1]

[1] *Leptolepis* AGASSIZ, Neues Jahrbuch 1832, p. 146; type, *Leptolepis bronni* AGASSIZ (1832), *Cyprinus coryphænoides* BRONN (1830).

Ascalabos VON MÜNSTER, Beitr. Petrsfakt, I, 1839, p. 112; type, *Ascalabos voithii* VON MÜNSTER.

Tharsis GIEBEL, Fauna der Vorwelt, Fische, 1848, p. 145; type, *Tharsis radiatus* GIEBEL.

Sarginites COSTA, Alte. Accad. Pontan, V, 1850, p. 285; type, *Sarginites pygmæus* COSTA.

Megastoma COSTA, l. c., 1850, p. 287; type, *Megastoma apenninum* COSTA.

(*Leptolepis coryphænoides* Bronn, *L. bronni* Agassiz) has but 40. In *Leptolepis dubius* (subgenus *Tharsis*) the number is 50.

The name Tharrhias, equivalent to Tharsis (θάρσος, θάῤῥος, courage, boldness), is suggested for the Brazilian fish.

In *Tharrhias,* as in *Leptolepis,* the dorsal is inserted slightly before the ventrals.

3. THARRHIAS ARARIPIS Jordan and Branner, new species

Type No. 4, Rocha Collection, in Counterpart. PLATE II

Head about $3\frac{2}{3}$ in length to base of caudal; opercle large, with radiating striæ; nearly $\frac{1}{3}$ deeper than long; subopercle small, its depth not more than one-fourth that of the opercle, the suture horizontal; depth of opercle $1\frac{2}{3}$ in distance from gill opening to dorsal;

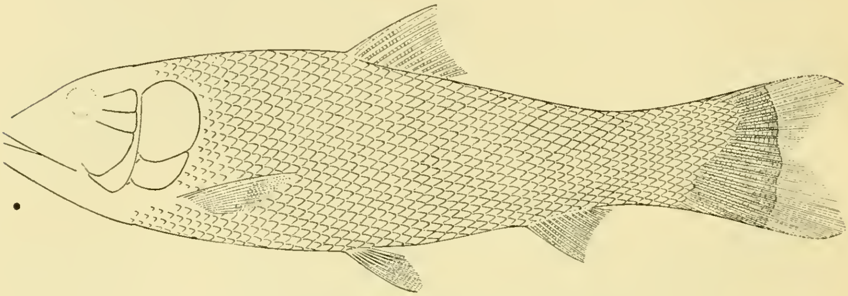

FIG. 8.—*Tharrhias araripis* Jordan & Branner. Barra do Jardim, Brazil. Restored.

preopercle with its upright limb nearly vertical; two bones behind eye and bone on cheek traceable, but the form not clearly made out (jaws and front of head destroyed).

Dorsal fin with strong interneural bones, its insertion behind gill opening nearly equal to length of head and greater than depth of body, which is about $4\frac{1}{5}$ times in length to base of caudal; dorsal short, higher than long, about 12 rays traceable; ventrals about under middle of dorsal; anal inserted behind dorsal at a distance greater than depth of body and about equal to length of head; the fin smaller than the dorsal, of about 9 rays, the first longest, as in the dorsal. Vertebræ about 55, the last five small and turned upward; caudal apparently forked, the upper lobe perhaps the longer.

Scales rather small, very thin, even, diamond-shaped along back, those below obscurely shown, but apparently rounded; no enamel on scales or ganoin; no trace of lateral line or of scaly sheaths. Scales about 56-19, 18 in a longitudinal row before dorsal; those at base of upper lobe of caudal smaller and more distinctly rhombic.

The type (No. 4, Rocha Collection) is 8½ inches long, fairly well preserved from the preopercle backward, and represented in counterpart in a nodule of coarse sandstone.

The species may be known from the Elopidæ found at Ceará, by the narrow scales, by the subheterocercal tail, and by the large opercle, which is many times larger than the horizontal subopercle. This small subopercle separates this from other species of Leptolepidæ. From the Cretaceous species of Elopidæ it is distinguished by the insertion of the ventrals under or slightly before the front of the dorsal. This is seen also in the genus *Cearana*, but in that genus both dorsal and ventrals are inserted farther back.

A second specimen (No. 3, Rocha Collection), also in counterpart, 9½ inches long, shows the thin rhomboid scales and the fins fairly well, but the head is entirely crushed.

Another nodule (No. 1, Rocha Collection) is referred provisionally to *Tharrhias araripis*, with which it agrees in general form, in the insertion of the ventrals directly below the dorsal, and in having the distance from dorsal to gill opening about equal to depth of body. The bones of the head are all crushed, and the thin scales, about equal in number to those of *Tharrhias araripis*, are not any of them enameled nor rhombic in form; but, on the other hand, none of them are well preserved. The vertebræ are well preserved and compactly inserted. There is no trace of lateral line. We do not much doubt the identity of this specimen with the type of *Tharrhias araripis*, but the difference in the scales suggests that possibly the rhombic form in the latter case may be due in part to shrivelling of the specimen before it was encased in clay. Of these specimens, No. 3 is in the U. S. National Museum and the counterpart of No. 1 in the geological collection of Stanford University.

Family ELOPIDÆ

The family of Elopidæ is characterized among the soft-rayed fishes by the presence of a triangular bone, or gular plate, between the rami of the lower jaw. This plate is present in the Amiatidæ and in some other ganoids, and it furnishes strong evidence that the Elopidæ are descended from extinct forms resembling *Amiatus*. In any event, the Elopidæ are among the oldest and most generalized of all the bony fishes. Their occurrence at Ceará in company with extinct ganoids like *Belonostomus* and *Lepidolepis* is significant. Another character of the Elopidæ is the enlargement of three bones of the suborbital ring below and behind the eye, a character which appears in others of the lower Isospondyli and points to their ganoid origin.

Genus CALAMOPLEURUS Agassiz

Calamopleurus Agassiz, Edinburgh Journ. xxx, 1841, p. 84; type, *Calamopleurus cylindricus* Agassiz.

Agassiz characterizes the fragments on which this genus is based by the following characters:

"Le long tube étroit des écailles de la ligne latérale, et par l'uniformité de ses écailles arrondies." To this Woodward (499) adds the following, based on a specimen in the British Museum: "The scales are cycloidal, very much imbricated, and apparently longer than deep; the fin-rays are widely spaced and much divided distally."

A fine, large specimen in counterpart, from Ceará, shows the lateral line with well-developed tubes, and the scales equal, cycloid, and closely imbricated. As the species is one not specifically recognized by Woodward and as it is from Agassiz's original locality, we venture to identify it with Agassiz's unrecognized *Calamopleurus cylindricus.*

The genus *Calamopleurus*, as understood by us, belongs to the Elopidæ, differing from *Notelops* in the well-developed lateral line and in the small teeth, and from *Elops* in the more posterior insertion of the ventrals and in the less elongate form. Mouth large, the jaws subequal, the gape oblique, extending beyond the eye; teeth even, pointed, small, less than one-fifteenth the diameter of the eye; two large, oblong, parallel postorbital bones; below these a large trapezoidal cheek-plate, broadest posteriorly; two parallel postorbital bones above this; subopercle very broad, its depth rather more than half that of the opercle. Scales cycloid, closely imbricated, the individual scales a little longer than deep; a sheath of scales at base of dorsal, as in *Elops;* a sheathing projection on occiput and one above opercle; lateral line well developed, nearly straight and median, its tubes simple and straight; dorsal short, median, inserted at a distance behind gill opening about equal to depth of body ventrals; inserted under or perhaps behind last ray of dorsal; moderate; caudal well forked, its base closely scaly nearly to the tips of the median rays.

4. CALAMOPLEURUS CYLINDRICUS Agassiz

Plates III, IV

Calamopleurus cylindricus Agassiz, Edinburgh Journ. xxx, 1841; Ceará.
Agassiz, Comptes Rendus, xviii, 1844, p. 1012; Ceará.
Woodward, Cat. Fossil Fishes, iii, p. 499, 1894.
Jordan, Bull. Cal. Univ., 1907, p. 139, pl. 12; Ceará.

We refer to this species the large specimen above mentioned. It is about 15 inches long. It was presented by Dr. Paula Pessoa, of

Rio de Janeiro, to Dr. Branner. It was found in the Barra do Jardim, Serra do Araripe, State of Ceará. This specimen in a concretion, represented in counterpart, is one of the most perfect of fossil fishes, showing most distinctly the eye-ball and the dark pigment which lies in streaks along the rows of scales. It was at first identified by us with *Notelops brama*, but the distinctness of the lateral line and the small size of the teeth render this identification untenable. The genus *Calamopleurus* is very close to *Elops*, having the same general structure of the head and the same extension of the scales on the tail.

The firmer character of the suborbital bones and the insertion of the ventrals furnish the only tangible difference, unless we consider the greater elongation of the body in *Elops*.

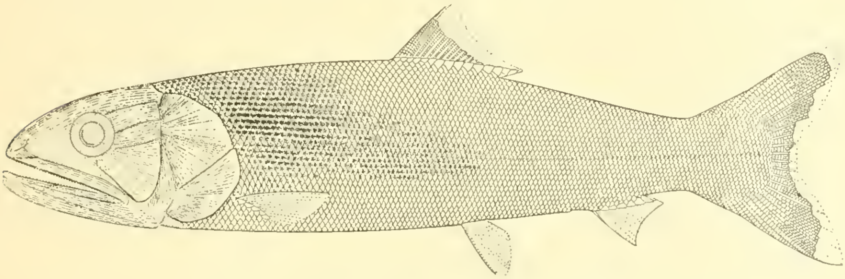

FIG. 9.—*Calamopleurus cylindricus* Agassiz.
Cretaceous of Ceará, Brazil. Partial restoration of type.

Head $3\frac{1}{5}$ in length to base of caudal; depth about 4 in body, $1\frac{1}{6}$ in head. Eye 5 in head, $1\frac{1}{2}$ in snout, snout $3\frac{2}{3}$ in head, head as long as from gill opening to last ray of dorsal (bones of head all more or less crushed). Scales about 13-120-18. Mouth large, oblique, the maxillary extending well beyond eye, $1\frac{1}{2}$ in head; teeth small, sharp, even, not one-fifteenth diameter of eye; opercle broadly triangular, with the broad base anterior, the lower suture separating it from the subopercle, distinct and very oblique; upper part of opercle covering more than one-third of the bone separated from the rest by a horizontal mark indicating a ridge or suture, this perhaps due to crushing; subopercle nearly twice as long as deep, nearly half as large as opercle; preopercle broadly rounded, the upright limb directed somewhat forward; a large trapezoidal plate on cheek extending from level of lower part of eye to angle of mouth; this is a little longer than high and deepest posteriorly; two parallel horizontally elongate suborbital bones behind eye; these about equal in size and each about twice as long as high; rest of orbital chain obscurely shown. The

2

cheek-plate evidently belongs to this suborbital series. A trace of an occipital sheathing bone, as seen in *Elops*.

Scales on body small, cycloid, those along base of dorsal enlarged, forming a distinct sheath; lateral line well defined, slightly curved downward, anteriorly about 15 rows of scales between dorsal and lateral line; the tubes straight and simple, scales extending over middle part of caudal fin nearly to its posterior edge. Dorsal rays about 12 (all the fins more or less broken); ventrals inserted under last rays of dorsal (or a little farther backward); caudal deeply forked, the vertebræ of the caudal peduncle strong.

Each scale of upper anterior and middle part of body with a distinct black spot of pigment, these spots forming distinct lines along

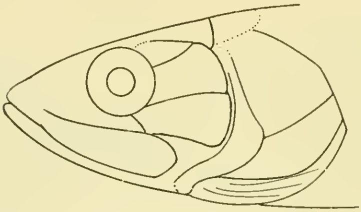

FIG. 10.—Head of *Elops saurus* Linnæus. Honolulu.

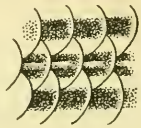

FIG. 11.—Scales of the lateral line of *Calamopleurus cylindricus*. Showing pigment.

the rows of scales. No fossil fish known to the writers shows its original coloration so clearly as this. Of this specimen we have attempted to give a restoration. The pigment stripes doubtless extended the whole length of the body.

Besides this specimen, we have another smaller one with its counterpart (No. 14, Rocha Collection). This shows the lateral scales very perfectly, but the lateral line is obliterated, being crushed against the vertebral column. Specimen No. 14 also shows black pigment underneath some of the scales. Specimen No. 23, Rocha Collection, is a crushed head, showing the opercular bones.

Another nodule (No. 20, Rocha Collection) shows the side of the head and the anterior part of the body; the lateral line is traceable, though obscured by the telescoping of the scales, which are abnormally crowded together.

Another fine specimen (No. 21, Rocha Collection) has the anterior part of the head crushed, but the anterior part of the body is very well shown. The bones of the head are as in the larger specimen. The distance from gill opening to dorsal is a little less than greatest depth of body and considerably less than length of head. There are 25 scales along the lateral line before dorsal and about 30

(14 + 1 + 15) between dorsal and ventrals. The lateral line is very distinct. The well-preserved ventral is under the very last rays of the dorsal, a character which at once distinguishes *Calamopleurus* from the living genus *Elops,* in which the dorsal is inserted directly over the ventrals.

Another specimen (No. 12, Rocha Collection) shows much the same parts, but not nearly so well preserved. The head is somewhat crushed and telescoped; the teeth are obliterated. The gular plate is apparently present. The lateral line is evident, but its position is distorted. There are 25 scales before the dorsal along the course of the lateral line. The ventrals are under the last rays of the dorsal, at a distance from base of caudal but little more than the length of the head. Vertebræ about 50.

Another nodule (No. 13, Rocha Collection) is a badly telescoped individual of *Calamopleurus cylindricus* showing the scales of the sides.

5. CALAMOPLEURUS VESTITUS Jordan and Branner, new species

Plate V

A nodule contains the outline of the body and of part of the side of the head of a fish with cycloid scales, similar to those of *Calamopleurus cylindricus,* but very much larger. The specimen when complete would be about a foot in length.

We here describe this specimen (No. 11, Rocha Collection) as a new species of *Calamopleurus.* It differs from the type species, however, in the very much smaller size of the subopercle, a character which may distinguish it generally. We call the species *Calamopleurus vestitus,* as the body is well clothed with scales.

Head about 3½ in length to base of caudal. Greatest depth about equal to length of head. Distance from gill opening to dorsal a little more than greatest depth. Anterior part of head destroyed; traces of three plates behind and below eye, as in other Elopidæ. Upright limb of preopercle directed forward above. Opercle large, convex, with some black pigment within the bone as long as deep. Subopercle with concentric striæ, its depth about 3½ times in depth of opercle. Suture between opercle and subopercle very oblique and somewhat curved.

Scales cycloid, deeper than long, much larger than in any other of the Cretaceous Elopidæ from Brazil, about 28 along lateral line to front of dorsal; 8 in a vertical series from front of dorsal to lateral line, 10 to 12 between lateral line and ventrals. In *Calamopleurus cylindricus* there are about 32 scales before dorsal on lateral line, about 15 above it and 18 to 20 below.

Lateral line very distinct, nearly median, slightly decurved anteriorly. Dorsal mostly obliterated, and pectorals also. Ventrals and anal wholly wanting, as is the whole caudal peduncle. Gular plate obliterated.

This fish is undoubtedly one of the Elopidæ. It is near *Calamopleurus;* distinguished from *C. cylindricus* by the large scales and (perhaps generically) by the narrow subopercle.

A second nodule (No. 15, Rocha Collection) shows a portion of the posterior part of the body of a large example. The ventral fins, as in *Calamopleurus cylindricus,* are inserted under the last rays of the dorsal, both fins being apparently rather small. Between the dorsal and ventrals there are apparently only about 20 scales. The lateral line, although abraded, is readily traceable. Opercle and subopercle separate, separated by a distinct suture.

The relatively large size of the scales leads us to refer this example to *Calamopleurus vestitus.*

The counterpart of No. 11 is in the geological collections at Stanford University.

Genus NOTELOPS Woodward

Notelops WOODWARD, Cat. Fossil Fishes, IV, p. 27, 1901; type, *Rhacolepis brama* AGASSIZ.

This genus is close to *Calamopleurus,* from which it differs in the much stronger teeth and in the absence of a distinct lateral line. From *Rhacolepis* it differs in the entire scales, and, according to Woodward, in having the parietal bones not separated by a supraoccipital. This character we have been unable to verify.

6. NOTELOPS BRAMA (Agassiz)

PLATE VI, FIG. 1

? *Amblypterus olfersi* AGASSIZ, Poissons Fossiles, II, pt. 1, p. 40, 1833; Ceará, Brazil (fragment; said to be unidentifiable).

Agassiz, Poissons Fossiles, IV, p. 293, 1844; Ceará.

(Not *Rhacolepis olfersi* AGASSIZ, Comptes Rendus, XVIII, p. 1012, 1844, which is based expressly on a figure of *Rh. buccalis.*[1])

Phacolepis brama AGASSIZ, Edinburgh Phil. Journ., XXX, p. 83, 1841. Barra do Jardim, based on a better specimen (misprint for *Rhacolepis*).

Rhacolepis brama WOODWARD, Proc. Zoöl. Soc. London, p. 539, pl. XLVI, fig. 1; pl. XLVII, fig. 4; Ceará.

Notelops brama WOODWARD, Cat. Fossil Fishes, IV, p. 27, 1901; Ceará.

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[1] In the Comptes Rendus, Agassiz thus refers to *"Rhacolepis olfersi:"*

"C'est au genre *Rhacolepis* qu' appartient l'espèce figurée par Spix; elle est plus large que la vôtre (*R. buccalis*), ses écailles sont plus grandes, et le second sous-orbitaire est plus étroit que les autres. Je l'ai appellée *R. olfersi.*"

Of this species, well described and figured by Woodward, we have one head (No. 25, Rocha Collection), more or less crushed and split through the middle, but showing the long jaws armed with long, sharp, slender, even teeth, each ¼ to ⅙ the diameter of the eye. Maxillary more than half head, extending far behind eye; subopercle about half size of opercle and nearly ⅔ its depth; the suture horizontal, the lower bone with radiating ridges; orbital bones obscurely shown.

This head corresponds fairly well to Woodward's figure of the head of *Notelops brama,* but the postorbital bones are wanting and no scales are preserved. Whether this is the same as the *Rhacolepis brama* of Agassiz we are not certain.

The name *brama* should apparently stand for this species, the name *olfersi* being rather a synonym of *buccalis.*

Genus RHACOLEPIS Agassiz

Phacolepis AGASSIZ, Edinburgh Phil. Journ., XXX, p. 83, 1841; type, *Phacolepis buccalis;* misprint for *Rhacolepis.*
Rhacolepis AGASSIZ, Comptes Rendus, XVIII, 1844, p. 1011 (*buccalis*).

This genus is very close to *Notelops,* the only difference evident in our specimens being the subcylindrical form of the body, the more pointed head, and the crenate edges of the scales. According to Woodward, the genus differs in having the parietals separated by the intervention of the supraoccipital. The lateral line is obsolete, though a few traces of tubes can be seen on the anterior region.

7. RHACOLEPIS BUCCALIS (Agassiz)

PLATE VI, FIG. 2

Spix and Martius, Reise Brasilien, pl. XXII, fig. 5; Ceará.
Rhacolepis buccalis AGASSIZ, Edinburgh Phil. Journ., XXX, p. 83; Cretaceous of Ceará.
Rhacolepis buccalis AGASSIZ, Comptes Rendus, XVIII, p. 1011, 1844; Agassiz, Poiss. Fossiles, IV, p. 293, 1844; Ceará.
Woodward, Proc. Zoöl. Soc. London, 1887, p. 539, pl. XLVI, figs. 2–7; pl. XLVII, figs. 1 to 3; Ceará.
Woodward, Cat. Fossil Fishes, IV, 1901, p. 30; Ceará.
? *Amblypterus olfersi* AGASSIZ, Poissons Fossiles, II, pt. 1, p. 40, 1833; Ceará; a fragment said to be unidentifiable.
Rhacolepis olfersi AGASSIZ, Comptes Rendus, XVIII, p. 1012, 1844; based expressly on the figure of Spix and Martius.

Body subcylindrical, a little compressed, more slender than in *Calamopleurus.* Scales small, with crenate edges, about 12 above and 12 below lateral line. Lateral line inconspicuous or obsolete, traceable anteriorly as a narrow streak or faint ridge on nearly all our specimens. Size small, the length about 6 inches. Of this species we have fragments of five individuals (Nos. 8, 9, 16, 17, Rocha Collection), besides a geodized trunk (Pessoa Collection)

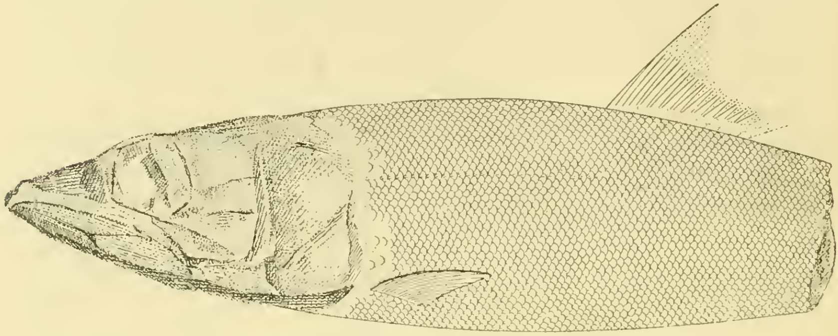


FIG. 12.—*Rhacolepis buccalis* Agassiz.
Barra do Jardim. The head restored after Woodward.

filled with quartz crystal, more or less telescoped, showing the scales well, but without head or fins. This specimen shows no trace of ventral fins, although the belly is completely preserved. In most of

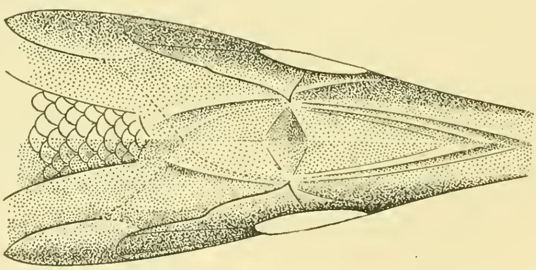


FIG. 13.—*Rhacolepis buccalis* Agassiz. Ceará. Top of head.

these specimens the substance under the scales is jet black. This is apparently due to the presence of the original pigment, in which case we may assume that the fish itself was black in life.

The plate or sheath-like projection above the opercle, more or less developed in all the Elopidæ, is very distinct in this species.

8. RHACOLEPIS LATUS Agassiz

PLATE VI, FIG. 3

Rhacolepis latus AGASSIZ, Edinburgh Phil. Journ. XXX, p. 83, 1841; Cretaceous of Ceará.

Rhacolepis latus AGASSIZ, Comptes Rendus, XVIII, p. 1012, 1844; Ceará.

Agassiz, Poiss. Fossiles, IV, p. 293, 1844; Ceará.

Woodward, Proc. Zoöl. Soc., London, 1887, p. 539, pl. XLVII, fig. 5; Ceará.

Woodward, Cat. Fossil Fishes, IV, 1901, p. 322; Ceará.

Of this small species we have two fragments (18, 19, Rocha Collection) fram Ceará. The best of these (No. 18) shows a crushed head and part of the side of the body. Scales in about 15 rows above lateral line and 15 below. It seems to differ from *Rhacolepis buccalis* in the greater depth and compression of the body, the head being rather abruptly reduced in depth. Three orbital plates subequal, parallel; distance from gill opening to ventrals less than length of head. Opercle more than twice as large as subopercle, the suture very oblique; nuchal plate distinct. A trace of lateral line. The other specimen shows mainly the scales on the side anteriorly. Our specimens, however, add nothing to the account given by Woodward, and it may be possible that these specimens are simply *Rhacolepis buccalis* crushed flat.

Genus ENNELES Jordan and Branner, new genus

Allied to *Elopopsis* (Heckel, Denkschr. Akad. Wiss. Wien., XI, 1856, p. 251; type, *Elopopsis fenzli* Heckel). Among the *Elopidæ* this genus is distinguished by the very wide-set teeth, and by the wide gape which extends beyond the eye. From the type of the genus *Elopopsis* our Brazilian species differs in having a series of short, compressed teeth in the posterior part of the mandible, and the teeth on maxillary sharp and equal in length.

Pachyrhizodus, Agassiz, another Cretaceous genus with similarly large teeth, is closely related, but in that genus the teeth are closer set and more uniform.

9. ENNELES AUDAX Jordan and Branner, new species

PLATE VII

Type a skull six inches in length, from Ceará (No. 22, Rocha Collection). With this is a partial counterpart showing the anterior part of the head without the lower jaw, the teeth of the maxillary being well preserved.

Depth of head $1\frac{2}{3}$ in its length. Snout rather pointed, longer than eye, $3\frac{1}{2}$ in head; eye about $5\frac{1}{2}$. Gape of mouth extending far beyond eye, its length about $1\frac{3}{4}$ in head; supraoccipital crest somewhat elevated; branchiostegals numerous, 10 behind the end of the gular plate. Gular plate well preserved, very large, narrowly fan-shaped, its length nearly half that of head, its breadth at posterior end nearly half its length; mandible very strong, about $1\frac{2}{3}$ in length of head; jaws even in front.

Teeth large, robust, wide-set, broadened at base and bluntly and rather abruptly narrowed at tip, the free portion of the longest about

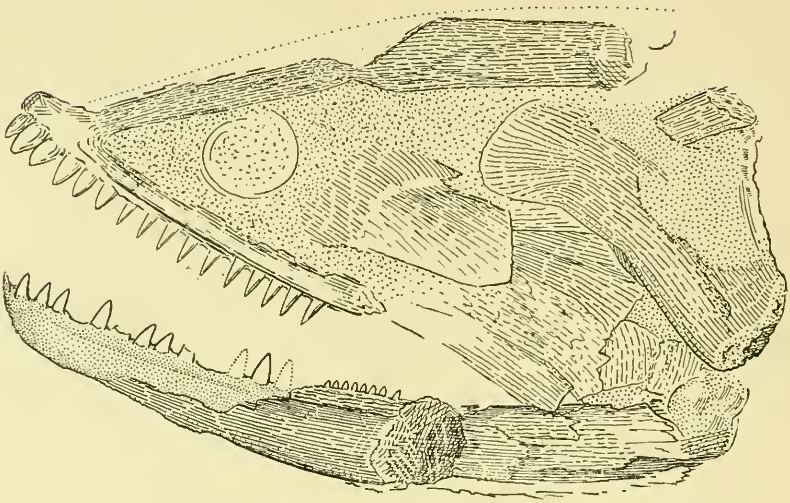


Fig. 14.—Skull of *Enneles audax* Jordan and Branner. Barra do Jardim. Type.

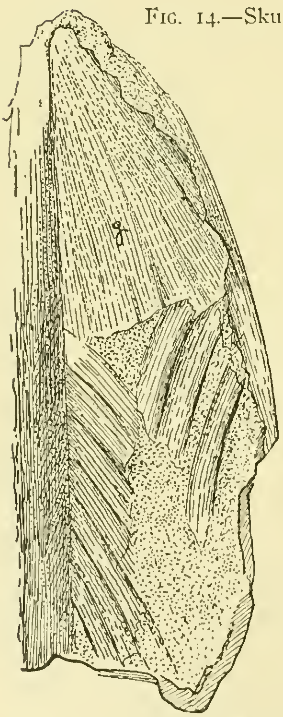


Fig. 15.—Skull of *Enneles audax* from below, showing gular plate and branchiostegals.

one-third diameter of eye. Premaxillary with four very large teeth at its tip, these thicker and rather longer than any other teeth in the mouth. Similar teeth at tip of lower jaw, these followed by slenderer teeth; those in the middle of the jaw also very robust and nearly as large as the front teeth; posterior part of lower jaw with a row of small compressed teeth, not very dissimilar and not one-third the length of the middle teeth; about eight of these teeth are evident. Teeth all one-rowed, none of them close-set; maxillary with a row of 8 or 10 stout, large, equal, sharp-pointed teeth, the anterior teeth most robust, similar to those of the middle of lower jaw; suborbital region narrow, the space between the eye and the roots of the maxillary teeth about half diameter of eye. Edge of maxillary straight. The maxillary teeth seem to be equal, not increasing in size backward, as in *Elopopsis fenzli.* The lower teeth do not increase in size backward, the large fangs being followed by a series of short, compressed teeth.

The species is apparently new. On the characters at hand it is separable from *Elopopsis* by the form of the small teeth on the posterior part of the mandible, the presence of sharp subequal teeth on the maxillary, and by the relative size of other teeth. This may be held to indicate generic difference. In *Pachyrhizodus* the teeth of the mandible are subequal and close-set. The type of this species is in the possession of Senhor da Rocha at Ceará; the broken counterpart is in the geological collections at Stanford University.

The genera of Brazilian Cretaceous Elopidæ may be thus compared with the living genera:

a.—ELOPINÆ: Pseudobranchiæ large (in living species); scales relatively small; last ray of dorsal not prolonged; anal smaller than dorsal; base of caudal more or less scaly.
- *b.*—Dentition even, the teeth slender and close-set; dorsal with a sheath of scales.
  - *c.*—Ventrals inserted behind middle of dorsal.
    - *d.*—Lateral line well developed; teeth small....... *Calamopleurus*
    - *dd.*—Lateral line obsolete or developed on the anterior scales only.
      - *e.*—"Parietals not separated by the supraoccipital"; scales entire or nearly so.......................... *Notelops*
      - *ee.*—Parietals separated by the supraoccipital; scales crenate. *Rhacolepis*
  - *cc.*—Ventrals inserted under first ray of dorsal; lateral line well developed; body elongate; teeth small, even............... *Elops*
- *bb.*—Dentition uneven, some of the teeth large, robust canines..... *Enneles*

aa.—MEGALOPINÆ: Pseudobranchiæ none; scales large, firm; anal fin larger than dorsal; last ray of dorsal produced in a long filament; postorbital bones very thin, membranaceous.
- *e.*—Dorsal fin inserted above ventrals (*cyprinoides*). *Megalops*
- *ee.*—Dorsal fin inserted behind ventrals (*atlanticus*)... *Tarpon*

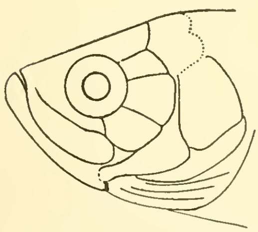


FIG. 16.—Head of *Megalops cyprinoides* Broussonet. Riu Kiu Islands.

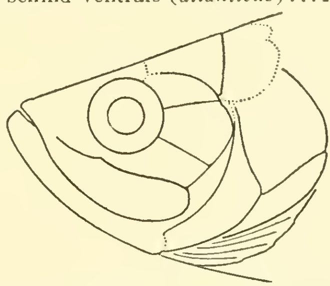


FIG. 17.—Head of *Tarpon atlanticus* C. & V. Porto Rico

Family CHIROCENTRIDÆ (?)

Genus CLADOCYCLUS Agassiz

Cladocyclus Agassiz, Edinburgh Phil. Journ., xxx, 1841, p. 83; type. *Cladocyclus gardneri* Agassiz.

Anædopogon Cope, Proc. Am. Phil. Soc., xii, 1871, p. 53; type, *Anædopogon tenuidens* Cope.

This genus is notable for its large scales. The teeth are said to be small and nearly uniform.

10. CLADOCYCLUS GARDNERI Agassiz

Plate VIII, Fig. 1

Cladocyclus gardneri Agassiz, Edinburgh Phil. Journ., xxx, p. 83, 1841; Cretaceous of Ceará.
Agassiz, Poiss. Fossiles, v, pl. 1, pp. 8, 103, 1844; Ceará.
Agassiz, Comptes Rendus, xviii, p. 103, 1844.
Woodward, Cat. Fossil Fishes, iv, 1901, p. 108, pl. 9, fig. 1; Ceará.
Anædopogon tenuidens Cope, Proc. Am. Phil. Soc., xii, 1871, p. 53; Ceará.

We refer to this species a piece of a broken nodule (No. 26, Rocha Collection), showing a cast of part of the side of a very large fish. It shows little except that the scales are very large, about half an inch in diameter, with uneven or pustulose surface and edges. No trace of lateral line. We follow Woodward in referring the genus *Cladocyclus* to the Chirocentridæ.

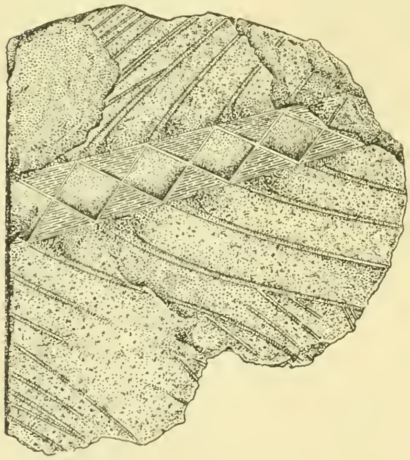


Fig. 18.—Species unknown. Barra do Jardim. Perhaps *Cladocyclus gardneri.*

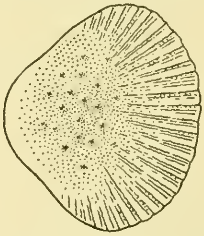


Fig. 19.—Scale of *Cladocyclus gardneri.* Ceará, Brazil.

Besides this specimen we have also a fragment of the caudal portion of the backbone of some unknown species (No. 30, Rocha Collection), possibly *Cladocyclus gardneri.* The fragment is remarkable for the regular rhombic form of the interspaces between the vertebræ and for the extreme narrowness of the centrum of each vertebra as seen in section.

Family OSTEOGLOSSIDÆ (?)

Genus CEARANA Jordan and Branner, new genus; type, Cearana rochæ

A specimen, badly preserved in a sand nodule, of different and harder texture than most of the others from Ceará, seems to represent a new genus, which we refer very doubtfully to the Osteoglossidæ, because, as in *Osteoglossum*, there is no division between the opercle and subopercle. The elongate body distinguishes this genus from *Pharcodus* (*Dapedoglossus*) and *Brychætus;* fossil genera of the Eocene, referred to the Osteoglossidæ.

In *Cearana* the head is oblong, forming about two-sevenths of the length to base of caudal. The greatest depth of the body is a little less; the body is oblong; the distance from the gill opening to the dorsal is considerably more than the greatest depth, a character apparently important in this group. About two-fifths of the length of the head is formed by the very large convex opercle, which is a single undivided bone marked by radiating striæ; preopercle with the upper limb erect and forming nearly a right angle. Jaws and teeth not preserved, and mouth apparently large and oblique, extending past the eye. Two postorbital bones behind eye and one on cheek approximately subequal in size; vertebræ 50. Distance of ventrals from gill opening about equal to length of head. Dorsal short, rather high, inserted over ventrals, its basal bones strong; ventrals midway between gill opening and anal. Caudal rays fine, the fin well forked, the tail a little heterocercal. Scales not well preserved, apparently small, firm and somewhat bony, with marked striæ.

11. CEARANA ROCHÆ Jordan and Branner, new species

Plate VIII, Fig. 2

Of this species we have two specimens (No. 5 and No. 32, Rocha Collection), one in a nodule and represented in counterpart and one small one not in a nodule. In one specimen (No. 5) part of the body and the posterior portion of the head are very badly preserved. The head must have been a little less in length than the distance from the gill opening to the ventral fin. The preopercle is rounded, its upright portion nearly vertical. The opercle is very large, very convex, and in one piece, without separation of the subopercle. Its length is about equal to its depth and about three-fifths the greatest depth of the body, which is two-thirds the distance from gill opening to central. Surface of opercle nearly smooth. Pectoral fin placed low, a little longer than the opercle. Dorsal few-rayed (8 to 10) and rather high, the first rays longest, the first interneural large and wedge-shaped, broadest below. Ventrals rather large, inserted opposite front of dorsal; vertebræ spool-shaped, about 22 before dorsal. Scales mostly lost, apparently firm and cycloid, with marked concentric striæ, about 14 in a cross-series below dorsal, these much larger than in *Calamopleurus*.

This specimen is about 5 inches long, represented in counterpart, the portion in front of the preopercle and that behind the vent being lost. A small example (No. 32, Rocha Collection) of the same species and showing nearly the same parts is not quite 3 inches long.

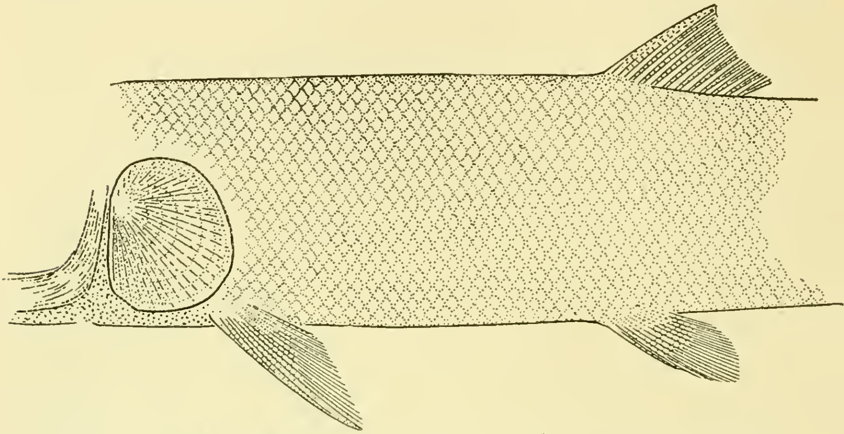


FIG. 20.—*Cearana rochæ* Jordan and Branner. From type. Ceará, Brazil.

This shows the large, undivided opercle. The eye is shown also, its diameter about two-thirds that of the opercle, and the space between eye and opercle about two-thirds eye.

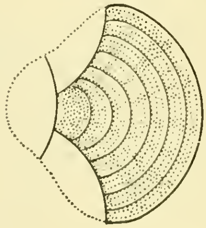


FIG. 21.—Scale of *Cearana rochæ*.

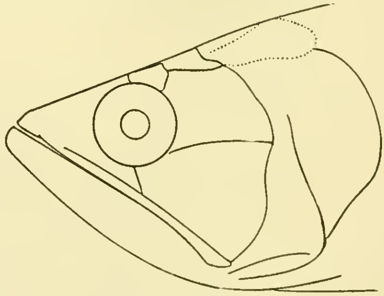


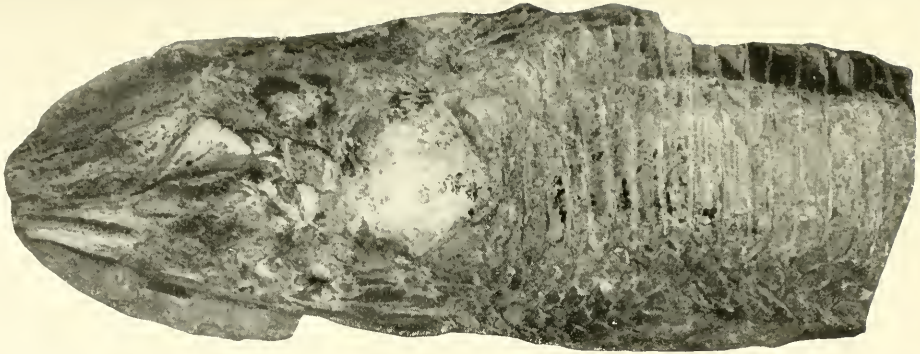
FIG. 22.—*Osteoglossum bicirrhosum* (a living form). Itaituba, Brazil.

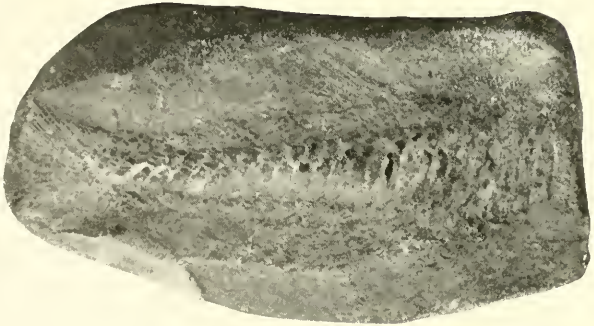
What seems to be the maxillary is also evident, rather broad, and extending behind the eye. About 18 vertebræ before dorsal, which is rather higher than long. On the same stone is a faint impression of another specimen still smaller.

The species cannot be fully described without better material, but in any event it may be known at once among Brazilian Cretaceous fishes by the character of the large convex undivided opercle, very conspicuous in all these specimens. It is also distinguishable at once from *Calamopleurus*, *Notelops*, and *Tharrhias* by the much greater distance from the gill opening to the dorsal fin. This is greater than length of head or than depth of body. At the request of Senhor Dias da Rocha, its discoverer, this genus is named for his native province of Ceará, where the type was obtained; the species is named for Senhor Rocha himself, who brought together this remarkable collection.

The counterpart of No. 5 is in the department of geology at Stanford University; the type is with Senhor Francisco Dias da Rocha at Ceará.

It may be noted that a peculiar interest attaches to this, as to any other accessible portion of the Cretaceous fish fauna. This period represents the decline and partial disappearance of the ganoid types, with rhombic enameled scales, represented by *Belonostomus* and *Lepidotes*. This is contemporaneous with the first appearance of the lowest of the bony fishes, of which the Leptolepidæ and the Elopidæ are both among the most primitive, followed later by Chirocentridæ, Osteoglossidæ, and other forms allied to the herring.





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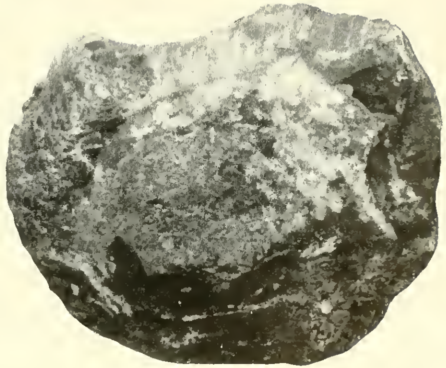
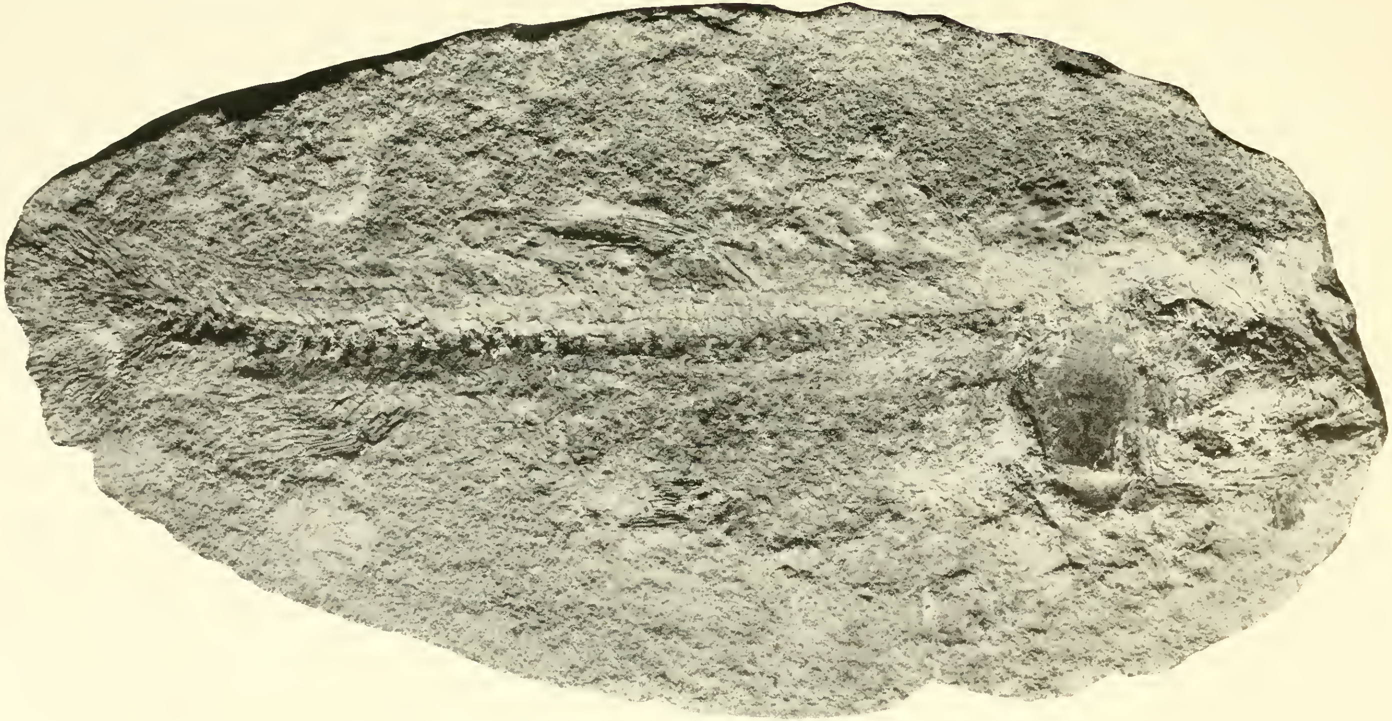


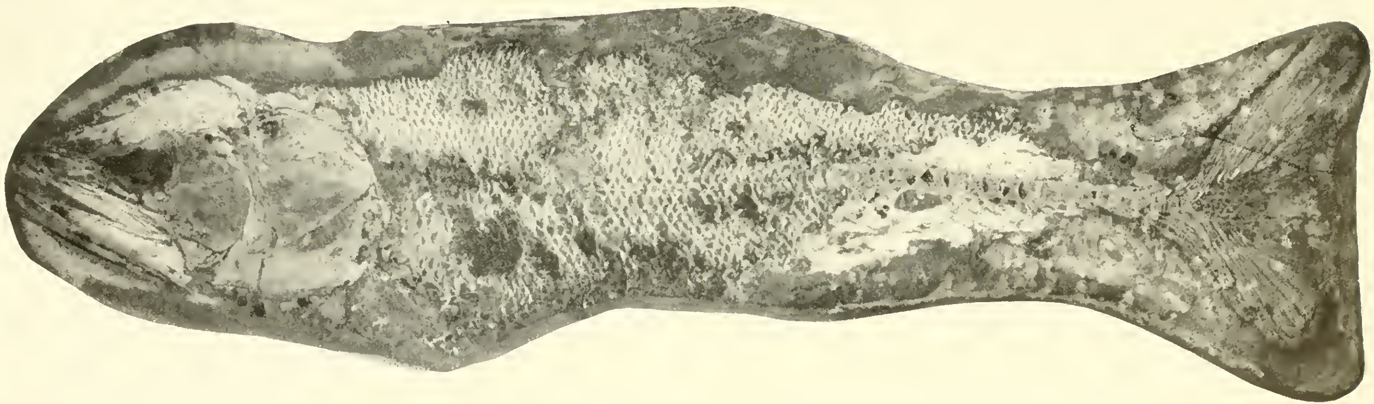
3

BELONOSTOMUS COMPTONI Agassiz

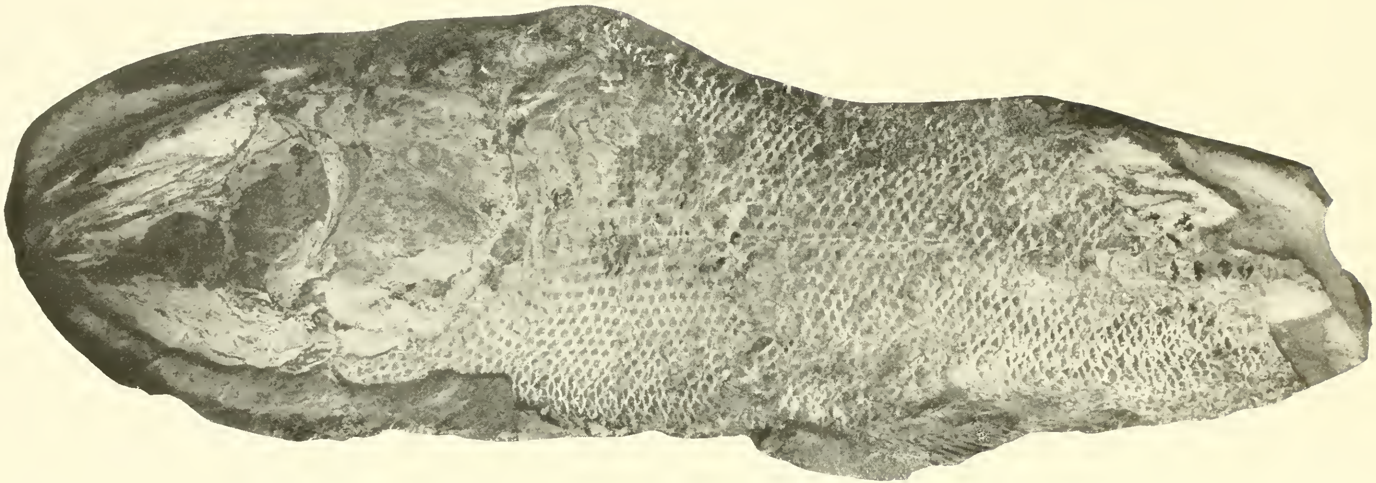
1.—Head and anterior parts. 2.—Caudal region. 3.—Example coiled in a nodule



THARRHIAS ARARIPIS Jordan and Branner. Type, Serra do Araripe, Ceará, Brazil

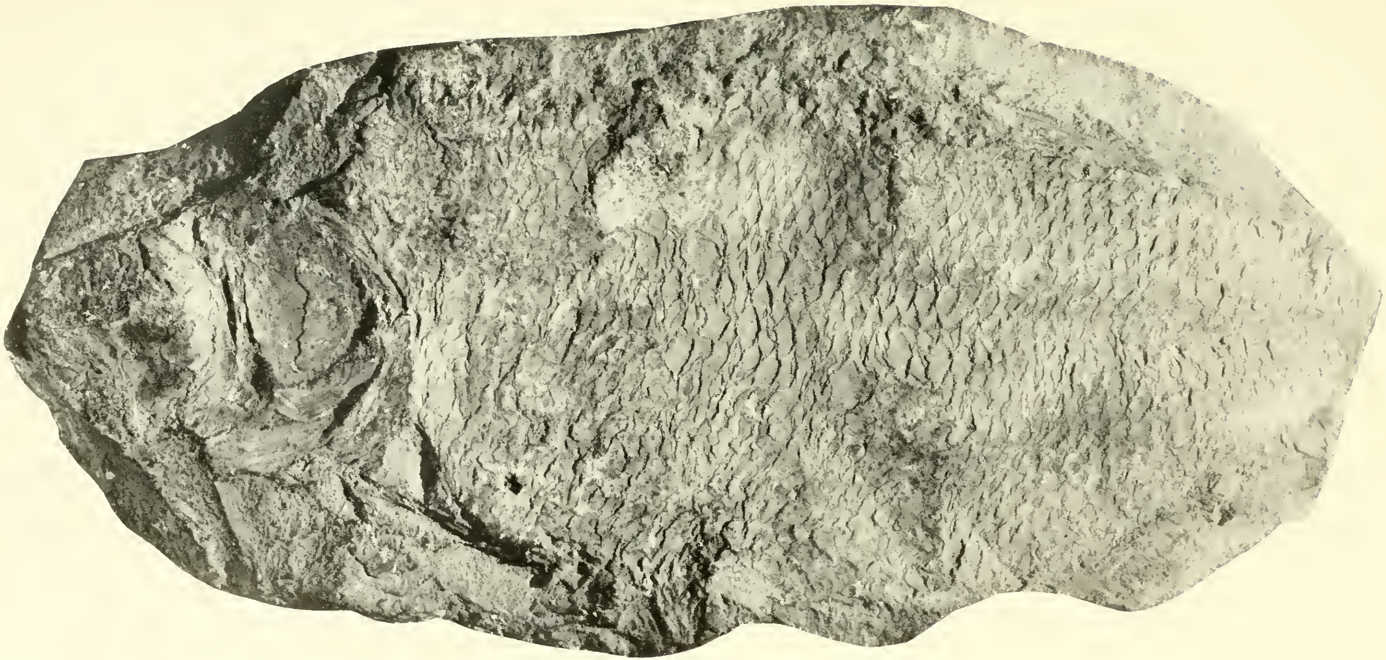


CALAMOPLEURUS CYLINDRICUS Agassiz. Ceará

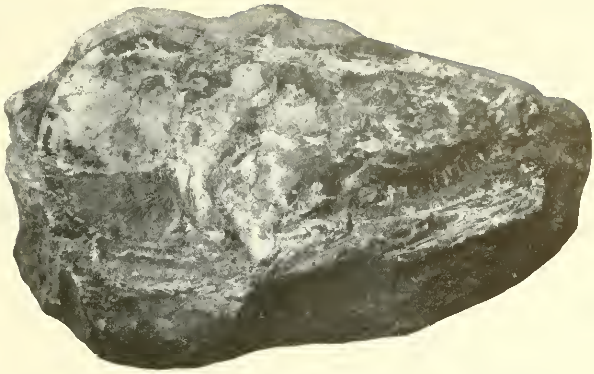


CALAMOPLEURUS CYLINDRICUS Agassiz

Counterpart of Plate III



CALAMOPLEURUS VESTITUS Jordan and Branner. Type, Ceará

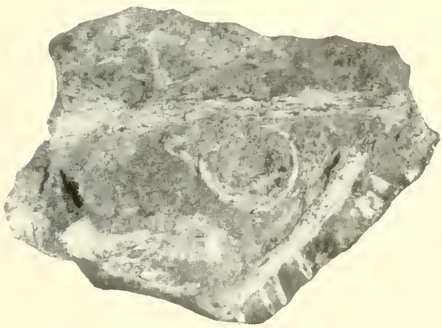


1. HEAD OF NOTELOPS BRAMA (Agassiz). Ceará, Brazil

2. RHACOLEPIS BUCCALIS Agassiz
(From figure of Spix & Martius, type of *Rhacolepis olfersi*)

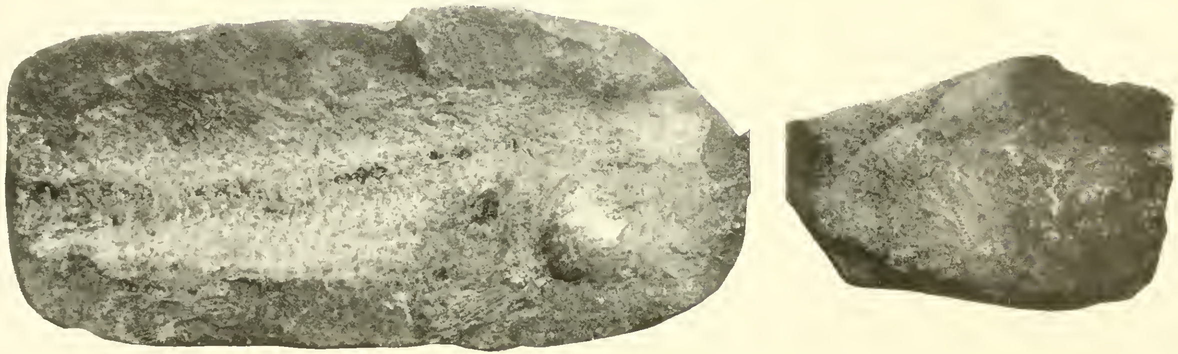
3. RHACOLEPIS LATUS Agassiz. Ceará

1. ENNELES AUDAX Jordan and Branner
Head. Cretaceous of Ceará



2. ENNELES AUDAX Jordan and Branner
Counterpart of part of head. Cretaceous of Ceará

1. CLADOCYCLUS GARDNERI Agassiz. Ceará



2. CEARANA ROCHAE Jordan and Branner. Ceará

OBSERVATION OF THE TOTAL SOLAR ECLIPSE OF JANUARY 3, 1908: A BOLOMETRIC STUDY OF THE SOLAR CORONA

By C. G. ABBOT

Director of the Astrophysical Observatory of the Smithsonian Institution

By invitation of Director Campbell, of the Lick Observatory, an expedition in charge of the writer was sent by the Smithsonian Institution to join with the Crocker Eclipse Expedition to Flint Island. In all matters of transportation, subsistence, and companionship the writer and his assistant, Mr. A. F. Moore, were cared for by Director Campbell as if members of his own staff; but the expenses of the Smithsonian party were paid in full by the Smithsonian Institution.

Narrative

The writer left Washington on November 7, 1907, necessary equipment, comprising 14 boxes of apparatus, having preceded him on the way to San Francisco. A stop was made at Pasadena, California, in order to ascend Mount Wilson and make there certain comparisons of readings between a pyrheliometer which was carried as hand baggage and instruments of the Smithsonian Astrophysical Observatory stored on Mount Wilson. Additional small pieces of apparatus were taken from Mount Wilson and a few supplies were procured in San Francisco. According to previous arrangement, the provisions and camping outfit for the stay on Flint Island were procured by Director Campbell. At San Francisco the Flint Island eclipse party, comprising Director and Mrs. Campbell, Professors Perrine and Aitkin, and Doctor Albrecht, of the Lick Observatory; Professor Lewis, of the University of California; Mr. Moore (a student at the University of California), and the writer, besides some friends of members of the expedition who were to accompany us as far as Tahiti, embarked on the steamship *Mariposa* November 22, 1907. We had a calm and pleasant voyage of 12 days to Tahiti, where it was expected that the gunboat *Annapolis*, under command of Governor Moore, of Tutuila, would be in waiting to convey the expedition to Flint Island. Owing to a broken steam pipe, the *Annapolis* was delayed in reaching Tahiti until two days after our arrival, and owing to the making of necessary repairs, the start for Flint Island was deferred until the evening of December 7. About noon of December 9 the island was sighted, and soon a boat was seen to leave its shore to meet us. On near approach it proved to contain the English manager, Mr. Hawk, and a half dozen native boatmen. Our landing was immediately begun, as the circumstances were unusually favorable, owing to the complete absence of surf—a condition which Mr. Hawk said was not apt to be met with three days in a year.

Flint Island, a low coral island lying in latitude 11°½ S., longitude 152° W., is about two and a half miles long by half a mile wide, and only 24 feet above sea-level at the highest point. It is surrounded by a fringing reef, upon which the surf beats so strongly on the eastern, or windward, side that landing is there impracticable. An opening has been blasted out of the reef on the western, or leeward, side to facilitate the shipping of copra, or dried cocoanut pulp, which is the only export. The water becomes deeper so rapidly beyond the reef that there is no anchorage for ships, although it is safe to cruise back and forth within a quarter of a mile of the shore. Favored by a bright moonlight, the equipment of the expedition, comprising over 300 separate packages and weighing more than 25 tons, was all taken ashore by the natives of the island and the Samoans of the *Annapolis* by 9 o'clock p. m. of December 9.

Our first night was spent on the veranda of the manager's house, where we slept most comfortably, lulled by the swaying branches of the cocoanut palms and the incessant murmur and croaking of birds. Toward morning the sudden coming of a smart shower made us glad that we had worked late, tired though we were, and had thoroughly secured our equipment. Two days later we learned how fortunate we had been in getting ashore so easily, for without much wind or roughness at sea the surf rose rapidly on the western side of the island and finally reached almost to the highest land of all. At this time our surf-boat was floated away and narrowly escaped loss at sea.

The Lick Observatory camp was located in an open space of the cocoanut grove near the manager's house, but as the writer desired to make measurements of the brightness of the sky, he preferred to locate the Smithsonian apparatus on the beach. After partly deciding upon a place nearly a quarter of a mile south of the main camp, he at length chose a point about 1,000 feet north of the camp and near the landing. As the event proved, the whole fortune of the

Smithsonian expedition hung upon this choice, for on January 3, the day of the eclipse, a rain-cloud almost hid the total phase from view, and rain would probably have fallen throughout totality at the station first proposed.

In the three and a half weeks spent on Flint Island the apparatus was put in the most perfect condition, many practice rehearsals were carried through, measurements were made of the brightness of the sky, the sun, and the moon, and a meteorological record was kept by Mr. Moore. At the suggestion of Mr. Rathbun, Assistant Secretary in charge of the U. S. National Museum, the writer collected a number of kinds of shells and corals for the use of that Museum.

Among the interesting social events were the coming of the English eclipse party of Mr. F. K. McLean and the celebration of Christmas, New Year's, and a marriage anniversary. On Christmas day Rev. Mr. Walker, of the McLean party, read a service at 9 a. m., and in the evening a company of seventeen English-speaking people from England, Australia, New Zealand, Tahiti, and the United States had a turkey dinner together on this coral island of the South Pacific. On New Year's evening a prize poetic contest was enjoyed.

After the eclipse the expedition left Flint Island on January 5, reached Tahiti on January 7, and embarked for San Francisco January 13. During the stay at Tahiti on the outward trip the presence of so many Americans had been taken advantage of by Consul Dreher as a fitting time to celebrate the completion of the new consulate at Papeite. Our stay on the return was also made pleasant by the attentions of the consul, and by trips to the interior and along the coast to the home of Chief Tati Salmon. The scenery of Tahiti is exceptionally beautiful and fine, for high mountains are broken at many points by nearly vertical precipices thousands of feet high, yet clothed from top to bottom by luxuriant tropical verdure. Clear streams run down the steep-sided valleys and water-falls of more than 600 feet sheer fall are found upon them. Our visit to Chief Tati Salmon was made most interesting by his recounting of ancient stories of the islands and by the serving of native dishes cooked on hot stones by the seashore.

Our voyage to San Francisco, while unpleasantly rough, was made without mishap to the expedition, and the writer reached Washington on February 1, 1908.

Objects and Methods

We proposed to measure with the bolometer the intensity of the radiation of the solar corona and to determine the quality of coronal radiation as compared with that of the sun.

In the year 1900 the first bolometric observations of the corona were made by Smithsonian observers,[1] and from these observations certain inferences were drawn by different authors as to the quality of the radiation of the inner corona.

All bodies, by virtue of their temperatures, emit radiation; but it is only when the temperature is fairly high that any considerable part of the radiation is visible. The higher the temperature the larger becomes the proportion of the radiation caused thereby which is visible.

All bodies exposed to radiation reflect some fraction of it diffusely, but thereby generally alter the quality of complex radiation. When the reflecting bodies are particles whose diameters are small compared with the wave-length of light, they reflect the shorter wave-lengths better than the longer ones, and thus tend to render a larger proportion of the radiation visible. Larger particles and gross bodies, like the moon, by reflecting, generally alter the quality of radiation in a way to diminish the proportion visible.

Visible rays are sometimes emitted by bodies which are apparently far below the temperature of incandescence, as in the cases of electrical discharges and of luminous insects. Such radiation may perhaps be almost wholly visible, without much intensity in the infra-red spectrum.

In view of these considerations and others, the inferences drawn by the writer from the bolometric study of the corona made in 1900 were contrary to the view that the radiation of the inner corona is produced mainly by the incandescence of matter heated to high temperatures by reason of its proximity to the sun, and more favorable to supposing the coronal radiation due largely to luminescence, or perhaps to the reflection of solar radiation by small particles. Arrhenius came to a different conclusion; but, as pointed out in the reference last cited, he misinterpreted the position of the bolometer in the coronal image.

The bolometric observations at Flint Island were designed to test the inferences above referred to and to measure more definitely the quantity and quality of the coronal radiation.

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[1] See Astrophysical Journal, vol. 12, pp. 71–75; also pp. 366–375, 1900. "The 1900 Solar Eclipse Expedition of the Astrophysical Observatory of the Smithsonian Institution," pp. 22–26. Washington, Government Printing Office, 1904. Lick Observatory Bulletin No. 58. Astrophysical Journal, vol. 20, pp. 224–231, 1904; Astrophysical Journal, vol. 21, pp. 194–195, 1905.

Apparatus

A concave mirror of 50 centimeters diameter and only 100 centimeters focus, mounted equatorially and driven by a clock, served to produce a very intense image of the corona.[1] A small guiding telescope was attached to the mirror frame, so that the observer might point the mirror toward any desired object. In the focus of the mirror was placed the bolometer. A glass plate three millimeters thick was fixed close to the bolometer, between it and the mirror, so that the radiation examined was thereby limited to wave-lengths less than about 3μ. This device prevented any exchange of rays of long wave-lengths between the bolometer and the sky, such as produced negative deflections when the bolometer was exposed toward the corona in 1900.[2] The bolometer had blackened platinum strips 8 millimeters long and 0.7 millimeter wide and of 0.5 ohm resistance. A metal diaphragm with circular aperture of 1 millimeter diameter was fixed between the glass plate and the central bolometer strip, so as to limit the region of the corona examined at each observation to an angular area of about 3′ of arc in diameter.

About 10 centimeters in front of the bolometer was a self-closing blackened metal shutter which cut off the beam excepting when designedly opened. The opening of this shutter therefore exposed the central part of the bolometer to such rays as are transmissible by glass. Between the shutter and the glass plate, and close to the latter, was a special screen composed of a thin stratum of asphaltum varnish laid on one side[3] of a plane parallel glass plate 3 millimeters thick. This screen was held out of the beam by a spring, except when designedly interposed. Its property, when used, was to cut off nearly all the visible part of the radiation, while transmitting nearly all of the infra-red rays transmissible by glass. The transmissibility of this screen for rays of different wave-lengths follows:

	μ	μ	μ	μ	μ	μ	μ	μ	μ	μ
Wave-length......	0.50	0.55	0.60	0.65	0.70	0.80	1.00	1.20	1.60	2.00
Transmissibility. .	0.00	0.01	0.04	0.10	0.20	0.41	0.66	0.80	0.90	0.92

[1] The mirror was freshly silvered and polished on the day before the total eclipse.

[2] Negative deflections in those experiments were due to the fact that the card screen used was warmer than the effective temperature of the sky, not, as Deslandres intimated, because any kind of rays cools rather than warms when absorbed.

[3] The side nearest the bolometer.

By interposing this absorbing screen the proportion of the observed radiation which lay in the infra-red spectrum could be roughly determined. Various trials made on Flint Island showed that ordinary sun-rays comprised from 29 to 37 per cent of rays transmissible by this screen, depending on the humidity of the air and the altitude of the sun; whereas sky-rays were only about 20 to 25 per cent transmissible. Moon-brightness (and by this is meant reflected sun-rays, not rays proper to the moon itself, for such were eliminated by the glass plate) was examined on one occasion and showed a transmissibility of about 50 per cent.

Several diaphragms were provided for graduating the aperture of the concave mirror. The apertures of these diaphragms were knife-edged, and those of less than 1 centimeter diameter were adjusted to lie within 3 millimeters of the silvered surface of the mirror. Allowing for the portions of the mirror shaded by the bolometer and its adjuncts, the apertures available were as follows:

Area (sq. cm.).........	1,618.0	283.0	62.0	0.316	0.077
Factor..................	1.0000	0.1750	0.0383	0.000195	0.000048

The equatorial was set up at Flint Island, on the beach, at about 12 meters' distance from the galvanometers used for observing the indications of the bolometer. Two galvanometers were provided, exactly alike in resistance and general construction, and arranged so that if at the last moment any accident should happen to one, the observer might pass at once to the other.[1] A thatched hut shaded by palm trees sheltered the galvanometers and their appliances and was found to give most satisfactory protection both from heat and rain. The galvanometers were each of 1.5 ohms total resistance, composed of 12 coils all connected in series. The needle systems, of 30 needles each, had mirrors 1 mm. by 1.2 mm. and weighed complete 0.011 gram each. Acetylene lamps were employed as light sources, and the images of the narrow flames were read on ground-glass scales 90 centimeters in front of the galvanometers. Resistances of 3, 8, 17, 45, 200, and 1,000 ohms, respectively, could be put in series with either galvanometer to reduce its deflections if required. The corresponding factors of reduction are 2.0, 4.0, 6.0, 13.1, 60.0, and 300. These numbers were obtained by actual trial.

The Wheatstone's bridge of the bolometer comprised the two platinum strips of 0.5 ohm each and two coils of 5.0 ohms each.

[1] This prudent measure was suggested by Mrs. Abbot.

These were inclosed in a wooden cylinder 7 centimeters in diameter and 18 centimeters long, itself shaded by a ventilated double-walled brass shield. A battery of 4 Gladstone-Lalande cells was used, furnishing a current of 0.4 ampere. This battery was located in the hut, and means for exactly balancing and trying the sensitiveness of the bolometric circuit were provided by joining to one galvanometer terminal and one battery terminal an adjustable resistance of about 500 ohms, acting as a shunt around one of the 5-ohm coils. It proved necessary to shade the copper cables connecting the bolometer and the apparatus in the hut, but after this was done the whole apparatus worked very satisfactorily, without prejudicial drift or wiggle of the galvanometer spot. When considerable changes of the pointing of the equatorial were made, it was generally necessary to alter the balancing resistance slightly, as would be expected in consideration of the changed inclination of the bolometer strips. During the eclipse the time of single swing of the galvanometer was 1.9 seconds, and a change of 1 ohm in the balancing resistance produced 250 millimeters deflection. This indicates that a rise of temperature of one bolometer strip of about 0.00001° C. would have produced 1 millimeter deflection at that time. These, of course, are far from the most sensitive conditions possible,[1] but were regarded as good for a temporary installation.

The attention of the reader is invited to the following improvements in the apparatus of 1908 as compared with that of 1900:

1. One mirror replaces seven.

2. The uncertain exchange of radiations of long wave-length between the bolometer and sky is eliminated by interposing glass.

3. Each observation is limited to a comparatively small angular area, well defined in position.

4. An absorbing screen for indicating the quality of the rays is introduced.

5. Means are employed for comparing in intensity the rays of the sun, the sky, and the corona.

During the eclipse the writer was charged with pointing and manipulating the equatorial, Mr. Moore with reading the galvanometer, and Chief Yeoman Edward M. Chase, of the *Annapolis,* with giving time signals and exposing two small cameras.

[1] In Washington, with a scale distance of 4 meters and a time of single swing in a vacuum galvanometer case of 7 seconds, a deflection of 0.1 millimeter has been measurable. This corresponded to a rise of temperature of 0.00000001.

Preliminary Observations

Meteorological

The sky conditions were seldom constant for any great length of time on Flint Island, so that pyrheliometer readings were not often attempted. On December 29, at noon, the intensity of solar radiation at the camp was 1.423 calories per square centimeter per minute, with fine blue sky.

Mr. Moore observed on Flint Island the temperatures of wet and dry bulb thermometers, barometric pressure, direction, and approximate velocity of the wind in miles per hour, and cloudiness, at the hours 7 a. m., $11^h\ 18^m$ a. m., 5 p. m., and 9 p. m., each day from December 10, 1907, to January 4, 1908. Without giving individual values, excepting for January 3, a summary of the mean results of his observations follows. The column marked P indicates the pressure of aqueous vapor at the earth's surface in centimeters of mercury, and that marked Q the corresponding total precipitable water in a vertical column of the atmosphere 1 sq. cm. in cross-section, according to Hann's formulæ.

Time.		Temperature. Dry bulb	Temperature. Wet bulb.	P.	Q.	Barometric pressure.	Direction of wind.	Velocity of wind.	Cloudiness.
		°C.	°C.	*cm.*	*cm.*	*In.*			
7 a. m.	Jan. 3..	27.0	24.7	2.53	5.82	30.11	....	0.	0.8
	Mean ..	26.75	24.23	2.48	5.70	30 078	E	7.8	0.78
$11^h\ 18^m$	Jan. 3..	....	....	....	....	....	....	....	....
	Mean ..	28.83	24.69	2.74	6.30	30.049	E.	11.7	0.63
5 p. m.	Jan. 3..	28.2	25.0	2.68	6.16	30.05	......	0.	0.9
	Mean ..	27.09	24.22	2.52	5.80	30.012	E.	5.6	0.62
9 p. m.	Jan. 3..	26 5	24.5	2.47	5.68	30.14	N. E.	5.	0.0
	Mean ..	26.11	23.90	2.40	5.52	30.068	E.	8.4	0.53

Bolometric

The eclipse observations are of much more interest when considered along with other observations which have been made of the relative brightness and quality of sun, sky, and moon rays.

Sun-brightness, Sky-brightness, and Moon-brightness[1]

On December 29, 1907, one of the very few days during our stay on Flint Island when the sky was mostly free from clouds and of a

[1] I propose to employ these terms for brevity, to mean the intensity of the radiation of the sun, sky, or moon transmissible by glass, and therefore of less wave-length than 3 μ.

good blue color for a considerable time, numerous measurements were made with pointings on the center of the sun's disk and on many parts of the sky. In these measurements the full aperture of the concave mirror was employed for the sky, and the "0.316" aperture for the sun. Sun-brightness was further reduced by interposing in the beam a rotating disk from which a sector of .045 of the whole circle had been cut. Eight ohms' resistance was placed in series with the galvanometer, under which circumstances 1 ohm change in the balancing resistance produced 55 mm. deflection. The measurements were begun about 9^h 40^m a. m. and continued till 10^h 40^m a. m., local time, so that the sun was 20° to 40° from the zenith.

Reserving for another publication a detailed study of these and other comparisons of sun and sky brightness, it will be sufficient here to state that the relative brightness of sky and sun, equal areas being measured, varied from 0.0000031 at distant parts of the sky to 0.0000140 at 20° from the sun. The average value was 0.0000062. It was impossible to secure accurate observations nearer the sun than 20°, because the mirror could not be properly shaded from the sun in such cases, and the diffused reflection of sun-brightness would have masked the true sky-brightness.

Measurements made on Mount Wilson, in California,[1] in 1905–6 showed that the average ratio at that altitude was about 0.0000015, so that the sky at sea-level appears to be, roughly, four times as bright as on Mount Wilson.

From measurements made on December 27 at 3^h 30^m a. m., the moon-brightness was about 0.0000012 of sun-brightness; but this ratio can only be regarded as roughly approximate,[2] and likely to be altered with the haziness or humidity of the air as well as with the altitudes of the sun and moon.

Quality of Sun-brightness, Sky-brightness, and Moon-brightness

On December 26, with the sun about 40° from the zenith, the ratio of the sun-brightness transmissible by the asphaltum screen to the total sun-brightness was found to be 0.366, while for zenith sky-brightness the result came out 0.248. Owing to the change of humidity from time to time, with consequent large alterations of the

[1] Altitude, 1,800 meters.

[2] This ratio is not directly comparable with the determinations which different observers have made of the relative photometric measures of the light of the sun and moon, nor, on the other hand, with determinations of the relative amounts of the total radiation of the sun and moon.

intensity of the infra-red spectrum, ratios like these just given are not to be regarded as constants. In order to avoid errors from this cause, care was taken on eclipse day to determine the transmissibility of sun-brightness immediately before and after totality, as will appear in its place.

On other days before the eclipse, values of the transmissibility ratio for sun-brightness were obtained, ranging from 0.29 to 0.37.

On the morning of December 27, at 3^h 30^m a. m., the transmissibility of the moon-brightness was found to be 0.50.[1] It is very significant to note that the day sky and the moon, both reflecting sun rays, alter the quality of sun rays in opposite directions and in such marked degrees. The blue quality of the sky-brightness, as Lord Rayleigh has shown, is probably due to the fact that the reflection takes place from particles small compared with the wave-length of light, and principally perhaps from the molecules of air themselves.

In view of the data just given, we should suppose that the brightness of the solar corona, if we imagine it to be caused merely by the reflection of ordinary sun rays, would be more transmissible to the asphaltum screen than sun-brightness, if the reflecting particles are of gross magnitude, like those composing the surface of the moon; but less transmissible than sun-brightness, on the other hand, if the reflecting particles are minute like the molecules of gases.

Observations on Eclipse Day

The approach of totality was uncommonly exciting on this occasion. Early in the morning the sky was overcast with high clouds, but these gradually grew thinner, so that after 9 a. m. the prospects indicated a streaky sky containing something almost too thick for haze, but almost too thin for cirrus clouds. These prospects were fulfilled exactly during totality, but in the quarter of an hour next preceding a thick cloud came up, rain fell fast from 11^h 08^m to 11^h 14^m, and the view of the sun became clear of the rain-cloud only 15 seconds before totality, at the Smithsonian station. The rapid change from fair prospects to completely discouraging ones and the return of good conditions just at the critical time will long be remembered. Our entire immunity from rain during totality was due to the fact that our station was about 1,000 feet north of the one occupied by the Lick Observatory. Second contact was observed by the writer, and recorded by Yeoman Chase at 11^h 15^m $7.^s5$, local civil time.

[1] See also Langley's comparison of the visible spectra of the sun and moon. Memoirs National Academy of Sciences, vol. III, 1884, p. 21.

At about 10^h 55^m and 11^h 45^m the following two series of observations were recorded on the brightness of the center of the sun's crescents visible respectively before and after the eclipse. In each series there was employed the "0.077" aperture, and also a series resistance of 200 ohms in the galvanometer circuit. The table includes actual readings on the galvanometer scale before and after opening the shutter of the bolometer, sometimes with, sometimes without, the asphaltum screen. In reading the galvanometer, the position of steady condition is first noted; then the furthest excursion of the spot of light after opening the shutter, which corresponds to the first swing of the galvanometer. In computing actual deflections, no account has been made of drift of zero between the steady position and the end of the first swing, because this interval is only 2 seconds, and the drift was at no time rapid enough to be of import in this brief interval. During all these measurements of sun-brightness the time of swing of the galvanometer was the same as employed during the total eclipse. The places on the sun may be regarded as having been 0.7 radius distant from the center of the solar disk.

Measurements at 10^h 55^m

Closed.	Open.		Deflection.	
	No screen.	Screen.	No screen.	Screen.
cm.	*cm.*	*cm.*	*cm.*	*cm.*
16.0	22.5	....	6.5	....
16.0	....	18.2	....	2.2
16.3	22.8	....	6.5	....
16.3	....	18.5	....	2.2
16.5	23.1	....	6.6	....
16.5	....	18.8	....	2.3
16.6	23.3	....	6.7	....
16.6	....	18.7	....	2.1
	Means...........		6.60	2.20

Ratio, 0.333

Measurements at $11^h\ 45^m$

Closed.	Open.		Deflection.	
	No screen.	Screen.	No screen.	Screen.
cm.	*cm.*	*cm.*	*cm.*	*cm.*
8.4	15.3	....	6.9	....
8.6	....	10.9	....	2.3
8.4	15.3	....	6.9	....
8.5	....	10.7	....	2.2
8.4	14.6	....	6.2	....
8.4	....	10.7	....	2.3
8.4	15.4	....	7.0	....
8.5	....	10.7	....	2.2
8.5	15.5	....	7.0	....
	Means...........		6.80	2.25

Ratio, 0.331
Mean transmissibility of sun-brightness, 0.332

Measurements on the Corona

In the field of the finder telescope were cross-threads, two of which intersected in the center, making an angle of 75°. One of these threads was adjusted along the line of diurnal drift of the sun, as found by stopping the clock of the equatorial. When the moon's image was adjusted tangent to the threads, there were four positions available, according as the moon occupied one of the obtuse angles or one of the acute angles between the intersecting threads. During the eclipse, measurements were made of the corona-brightness at the two positions of tangency in the obtuse angles, and one measurement was made in one of the acute angles. Besides these three positions, two others were employed, situated 1.5′ of arc beyond the extremities of the moon's east and west diameter, and one position in the center of the dark moon, making six in all. In view of the symmetrical character of the results to be given, and of the uncertainty of precise setting on so small an image with the bolometer, it seems unnecessary to specify the first three positions more definitely than to add, that in the two positions of obtuse angle tangency the bolometer was central on points 4′ of the arc beyond the extremities of a lunar diameter inclined 52.5° to the east and west diameter, and in the position of acute angle tangency the distance from the moon's limb was about 12′ of arc.

Let the six positions be designated in the order described above as Positions I, II, III, IV, V, and VI.

The measurements are as follows:

Position I

Closed.	Open.		Deflection.	
	No screen.	Screen.	No screen.	Screen.
cm.	*cm.*	*cm.*	*cm.*	*cm.*
11.3	14.2	....	2.9	....
11.2	14.5	....	3.3	....
11.2	....	12.4	....	1.2
11.4	....	12.0	....	1.2
	Mean....	....	3.1	1.2

Ratio, 0.387.

Position VI

No deflection whatever.

Position II

Closed.	Open.		Deflection.	
	No screen.	Screen.	No screen.	Screen.
cm.	*cm.*	*cm.*	*cm.*	*cm.*
7.1	10.2	....	3.1	....
6.9	....	7.9	....	1.0

Ratio, 0.323

Position III

No deflection whatever.

Position IV

Closed.	Open.		Deflection.	
	No screen.	Screen.	No screen.	Screen.
cm.	*cm.*	*cm.*	*cm.*	*cm.*
13.1	23.9	....	10.8	....
13.6	....	17.3	....	3.7

Ratio, 0.343

POSITION V

Closed.	Open.		Deflection.	
	No screen.	Screen.	No screen.	Screen.
cm.	*cm.*	*cm.*	*cm.*	*cm.*
17.8	27.7	....	9.9	....
19.0	....	22.8	....	3.8
		Ratio, 0.384		

On account of the number of observations, the result in Position I is entitled to twice as much weight as that in Position II; and on account of the larger deflections observed, the results in Positions IV and V are regarded as each of twice the weight of those in Position II. It is not thought that the variations of the ratio of transmissibility between the several observations just noted are beyond the probable errors of the single determinations, so that without distinguishing separate positions, the weighted mean result for the transmissibility of the inner corona-brightness may be regarded as 0.364. For positions I, II and IV, V, taken in pairs, the means are 0.366 and 0.362 respectively.

In order to determine the intrinsic corona-brightness as compared with sun-brightness, we must first multiply the average solar deflections observed before and after the eclipse by the two factors appropriate to allow for the ratio of size of mirror apertures employed and for the introduction of series resistance in the galvanometer circuit respectively. Performing this reduction and introducing also the data of sky-brightness already given, we obtain the following values based on a sun-brightness of 10,000,000:

Sun near zenith (Flint Island)	10,000,000
Sky 20° from sun (Flint Island)	140
Sky distant from sun (Flint Island)	31
Sky average (Flint Island)	62
Sky average (Mt. Wilson)	15
Corona Positions IV and V	13
Corona Positions I and II	4
Moon about 50° zenith distance (Flint Island)	12 (?)

DISCUSSION OF THE RESULTS

When we recall the extreme brightness of the sky within a single degree of the sun as compared with that 20° away, and consider also the figures just given, the proposal to observe the carona without an eclipse seems an unpromising one.

From the figures just given it appears that the corona of 1908 equaled the moon in radiation transmissible by glass only at the brightest observed part of the inner corona. Referring to the conclusions made by the writer from the bolometric observation of the eclipse of 1900, it will be recalled that it was assumed by him that the region of the corona then observed was equally as bright as the moon visually. It now seems probable that this was not so, and accordingly the argument he made for an exceptional richness of visible light in coronal radiation, which depended on the assumption just referred to, is weakened. In actual fact the coronal radiation proves to be almost, but not quite, as rich in visible light as the ordinary solar radiation coming from points 0.7 radius from the center of the sun's disk, as shown by the measurements of 1908 made with and without the screen.

Probable Nature of the Corona

The nature of the radiation of the inner corona has been supposed by some to be principally reflected solar radiation; by others, principally due to the incandescence of particles heated by reason of their proximity to the sun; by others, principally luminescence, perhaps similar to the aurora; and by some as a combination of all these kinds of radiation.

A satisfactory theory of the corona must take cognizance of the following facts at least:

1. The color of the corona does not appear to change at varying distances from the limb of the sun, and the transmissibility of its rays to the asphaltum screen is the same at 1.5′ and 4′ from the limb.

2. Its brightness is very small and falls off rapidly with increasing distance from the limb.

3. Its spectrum is mainly continuous near the limb, but shows dark Fraunhofer lines, more and more distinctly, at increasing distances therefrom. A few not very conspicuous bright spectral lines are present near the limb and perhaps in the outer corona also.

4. Its light is polarized in the outer regions, but polarization grows less marked, and at length disappears near the limb.

5. Its brightness is almost, but not quite, as little transmissible to the asphaltum screen as that of the sun itelf, and is far less so than the reflected brightness of the moon, but far more so than the reflected brightness of the sky.

6. Any kind of matter so near the sun must be hot and must also reflect solar rays.

7. There is no evidence of high pressure in the corona.

The considerations (3), (5), and (7), taken together, are hard to satisfy; for if the inner corona were hot enough to give out a spectrum of incandescence satisfying (5), the matter composing it must be gaseous, if it is like any matter we know of.[1] Accordingly we should expect a bright line spectrum like that of the chromosphere if the inner corona shines chiefly by incandescence,[2] and, furthermore, we should expect its rays to increase in transmissibility to the screen and grow red to the eye with increasing distance from the sun.

If we may suppose that the temperature of the corona is everywhere low enough to allow solid or liquid particles to be formed, then all the specifications excepting (3) are easily satisfied by the hypothesis of a corona of reflection.[3] Our knowledge is not sufficient to enable us to prove that the particles even of the inner corona would be too hot to be mainly liquid (that is to say, above 3,000° to 3,500°). If the particles were all gaseous, the rays reflected would probably be richer than sun rays in visible light, and this would be contrary to (5). May it not be that while a large proportion of the particles of the inner corona is gaseous, a considerable proportion is liquid or solid? Then may not the light of the inner corona be mainly reflected, like that of the outer corona, but with the bright line spectrum of incandescent gases present in sufficient strength to nearly obliterate the dark Fraunhofer lines of the reflected sun rays? The continuous spectrum of the incandescent solid and liquid particles present would tend to increase the transmissibility of the coronal brightness to the asphaltum screen; so that the opposite tendency of the diffuse reflection of the gaseous particles present would be counteracted. At increasing distances from the limb we may suppose the particles would be cooler, and mainly solid or liquid, so that incandescence would wane and a dark line spectrum would gradually appear. Still, the transmissibility and color would remain nearly unchanged, because the light would be still mainly reflected sunlight, and the particles now so large as not to enrich the proportion of blue light, but rather slightly to decrease it.

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[1] Arrhenius computes a possible temperature of 4,620° at 0.7′ from the limb, and then suggests that the matter there may be liquid drops. How is this possible?

[2] The gaseous material of the sun itself is under enormous pressure, so that its spectrum is thereby made continuous. Not so the corona.

[3] Specification (4) is no obstacle, because the particles near the sun receive light from a solid angle of nearly a whole hemisphere, and would therefore show no polarization in any particular direction, because partially polarized in all.

As for the attractive hypothesis of electrical discharge luminescence, like that of the aurora, one hesitates to recommend recourse to a source so little known. So far as known, too, this hypothesis, like the others, has difficulty to reckon with the character of the photographic coronal spectrum.

The cause of the corona-brightness seems very difficult to decide, in view of conflicting considerations; but in the judgment of the writer the hypothesis that it is mainly due to the reflection of ordinary sun rays, but modified by radiation of incandescence and perhaps also luminescence, seems most tenable.

In conclusion, it is a pleasure to acknowledge the great aid afforded by the director and staff of the Lick Observatory Expedition; the conscientious and able work of my assistant, Mr. Moore; the intelligent and faithful assistance rendered on the day of the eclipse by Chief Yeoman Chase, of the *Annapolis;* the aid furnished by the owners and manager of Flint Island, and the uniformly cordial and courteous attentions of Governor Moore and the officers of the *Annapolis,* and of many others during the time when the expedition was in transit.

REPORT ON A TRIP FOR THE PURPOSE OF STUDYING THE MOSQUITO FAUNA OF PANAMA

By AUGUST BUSCK

In order to gain some knowledge of the mosquitoes of Panama, heretofore practically unknown, Dr. L. O. Howard, Chief of the Bureau of Entomology of the U. S. Department of Agriculture, instructed the writer to proceed to the Canal Zone on this mission.

It was arranged that I should report to Col. W. C. Gorgas, Chief Sanitary Officer of the Canal Commission, in order that the work might be carried out in conjunction with the Sanitary Department with reference to the economic aspects of the subject.

I left Washington April 12, 1907, and sailed the following day from New York on S. S. *Advance*, arriving in Colon a week later. After a few days of general inspection, during which I made myself acquainted with the general lay of the land, I made my headquarters in Tabernilla, about midway between the Atlantic and the Pacific coasts. A very suitable tent was constructed and equipped for me, which I occupied during the following three months, except when my work temporarily caused me to take other quarters.

Most of my work was done in the country around Tabernilla, but numerous trips to other localities along the Panama Railroad from Panama to Colon were made, and two more extended excursions were undertaken outside the Canal Zone, up the Chagres River in native dugouts.

In accordance with the time limit of my authorization, I was prepared to leave the Isthmus on July 21, but prolonged my stay on a telegraphic request from the chairman of the Commission in order to be able to give a preliminary verbal report to Colonel Gorgas, who had been absent from the Zone during the latter part of my sojourn there. I finally left Colon July 30 and reached Washington August 6, 1907.

During my stay I was given every courtesy and constant help in my work by the officers of the Sanitary Inspector's Department, especially by its Chief, Mr. J. Le Prince, and the Associate Chief, Dr. Herman Canfield, who thoroughly entered into the spirit of my investigations and fully realized their important bearing on the practical work of their department.

Mr. Allen H. Jennings, of the department, was detailed to be with me as much as possible in order to learn our methods in the routine work of collecting, breeding, and taking care of the mosquitoes; his frequent companionship in the field and in the laboratory was very pleasant and facilitated my work in many ways. He was good enough to take charge of my living larvæ on two occasions of more prolonged absence.

The several local sanitary inspectors along the Zone line gave me much assistance by collecting material and giving me facilities for work when I visited their stations.

Through the foresight of Doctor Canfield, a system was inaugurated whereby each sanitary inspector sent me weekly a bottle of mosquito larvæ, and though this material could not be expected to be of especial value, it furnished additional localities for the common species and occasionally yielded rarer ones. I must especially mention Mr. C. H. Bath, sanitary inspector at Las Cascadas, whose careful and regular sendings yielded several interesting larvæ.

The number of species of mosquitoes secured was 83, of which 30 species were new to science. Most of the species were bred from the larvæ. Besides these I have included in the following list, in order to make it as complete as possible, 7 additional species, previously received by the U. S. Department of Agriculture from Panama through other collectors, bringing the total number of species at present known from Panama up to 90. The collection was determined by Dr. H. G. Dyar and Mr. F. Knab.[1] All the types of new species are deposited in the U. S. National Museum, as well as all the other material, with the exception of a duplicate set presented to the Isthmian Canal Commission.

Large as this number of species is—the largest number recorded from any one limited locality—there is yet much work to be done before the entire mosquito fauna of the Zone is known.

It was impossible to work up thoroughly so large an area within three months, and only the immediate region around Tabernilla was at all adequately investigated. Even here additional species will undoubtedly be found, because the fauna changes considerably with the season, and some species may not have been active at all during the period of my visit, though this was intentionally arranged so as to cover both the end of the dry season and the early part of the rainy season. The appearance of different species of tropical mosquitoes at different seasons is a well-marked phenomenon and was repeatedly observed even during my short stay.

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[1] The new species were described in Journ. N. Y. Ent. Soc., vol. xv, 1907, pp. 197–214.

Aside from obtaining a more complete list of the species of mosquitoes, much additional work is needed on the biology of the species now known, both from a scientific standpoint and for practical reasons in connection with the fight against the mosquitoes in the Canal Zone.

The anti-mosquito work of the Sanitary Department is considered of prime importance and is carried on throughout the Zone. It is a gigantic undertaking, but even now shows remarkable results in the constantly improving health conditions, apparent from the health reports, which are more gratifying every month.

The Canal Zone proper is about 50 miles long by ten miles wide. It includes, as far as sanitation is concerned, the cities of Panama and Colon. The population of the Zone is about 100,000, of which the city of Panama has about 33,000, Colon 14,000, and the Zone proper 52,000. In the Zone proper this population centers at the towns La Boca, Ancon, Coracal, Miraflores, Pedro Miguel, Paraiso, Culebra, Empire, Las Cascadas, Bas Obispo, Matashin, Mamei, San Pablo, Tabernilla, Frijoles, Bohio, Lion Hill, and Gatun, with several native towns and camps for employees between, all of which lie along the line of the Panama Railroad. Anti-mosquito work is carried on throughout the area covered by these towns and settlements. The routine method is to brush, drain, and oil the whole area of a town or camp and its surroundings to a distance of not less than 200 yards from the last house in the town or camp. The same rule applies to isolated houses or native towns, but outside of this area no attempt is made to control the mosquitoes, on the correct supposition that these normally do not fly such a distance.

In the beginning the land is cleared by the removal of all brush, undergrowth, and grass; only shade and fruit trees are left, and these are thinned out to admit sunlight and free ventilation. Where possible, swamps and low land are filled in, the immense excavations at the Culebra cut furnishing abundant material. Then the whole area is drained to carry off the surface water or any constant flow from springs or seepage from the hills. This drainage is extended to all new work in the canal cut and to railroad work or dumps near settlements. The drainage is accomplished by subsoil tile drains, open ditches, and open concrete or stone and cement ditches. Drain tiling or cement ditches are made where possible, as they require very little care afterwards, while the open dirt-ditches must be constantly cleaned and regraded to prevent "pocketing" and the consequent formation of breeding pools for mosquitoes. In open dirt-ditches the algæ will form in two or three days after cleaning, and to prevent this drip-cans are placed at the head of those ditches with a solution of sulphate of copper, five pounds to a barrel of fifty gallons of water. This is also used in all running streams after the removal of algæ.

Open ditches in which the water flows sluggishly have oil drip-cans at their heads. These oil drip-cans are raised three feet above the water to give a wide spread to each drop, and are arranged to drop about twenty drops to the minute. The oil used is a rather heavy dark grade, which costs the department $4.34 a barrel. About 3,200 barrels of oil were used within the last year.

All streams are kept free from algæ and are kept within restricted banks as far as possible; this is done by blowing out the rapids or falls to produce a uniform flow, and the edges are filled in by hand.

All swamps, pools, or even temporary collections of water are oiled at least weekly, and in the rainy season oftener; this applies to the smallest collection of water, even animal tracks, ruts from wagon wheels, and crab-holes. It entails a great amount of work, which is done by colored labor under continual supervision.

All receptacles holding water must be screened or oiled. Water barrels are screened by covering with a board with a small screened opening in the center for the inflow. Below this board are two screened holes for overflow, and the water is drawn from a faucet at the bottom. Buckets and pails in daily use in a household are not permitted to stand filled more than twenty-four hours. All tin cans, bottles, etc., must be buried. No gutters are allowed on houses. There is a daily inspection of all water receptacles, and weekly the inspector at the head of the station must make a personal inspection and report any receptacle found containing mosquito larvæ. The second offense, after a warning, means the arrest and fine of the householder.

All old machinery, which is found in great quantity all over the Canal Zone, left from the French occupation, is drained by punching holes in any part that will hold water, or where this is not possible, such places are filled with dirt. Even patent car couplings on the trains in use must be inspected and oiled, as they are often found to contain mosquito larvæ.

When any house or camp is found to contain any number of mosquitoes, it is fumigated with sulphur by the dry method. All cracks or openings are pasted over with paper; enough pots, each containing five pounds of sulphur, are placed at intervals on the floors to make about one pot for each 1,000 cubic feet of space. After fumigation, the house is left closed from three to four hours.

All barracks, whether for white or black laborers, bachelor quarters, married quarters, offices, churches, lodge-rooms, and other rooms used for sleeping, living, or eating quarters are screened; the Sanitary Department is responsible for all repairs of this screening and employs a large force of carpenters for this purpose.

The physicians in each district make a weekly report on the number of cases of malaria in the different camps; these reports are tabulated in the central office of the Sanitary Department and compared with the previous records, and if an increase of even a fraction of one per cent is shown for any locality, the local inspector is telephoned and ordered to locate the point of infection and eradicate the breeding places. Long-continued statistics show how nicely this system works. If any more serious increase occurs, a special mosquito inspector is sent out from the central office to locate the trouble and report on the best measures to be taken.

The difficulties of this work are numerous. The constant increase of population requires new sites for camps to be made in the unimproved brush-covered country; the ever-changing conditions due to the canal work are a continued source of trouble; the progress of each steam shovel or of each of the extensive dumps produces new problems to be solved in the way of drainage; and, above all, the recurring deluges of the rainy season cause rising creeks and rivers and overflow of lowlands so irregular as to be impossible to foresee.

The Sanitary Department has, aside from its office force, about thirty sanitary inspectors and employs between 1,200 and 1,300 laborers. The total cost of the Sanitary Inspector's Department is between three and four hundred thousand dollars.

With all due credit to the truly excellent work and the undeniably brilliant results achieved, the work is nevertheless done more or less in the dark, at present, from lack of accurate knowledge of the enemy. It could undoubtedly be made both more effective in some ways and less expensive in others through a more intimate knowledge of the mosquitoes concerned, toward which the present investigation has made but a small beginning.

At present the department deals with all mosquitoes as a nuisance to be done away with, whether they are good, bad, or indifferent; but the work could be more profitably done with an accurate knowledge of those species which are infectious, those which are merely annoying, and those which are harmless or even beneficial.

It is true that special attention is given the supposed malaria-carrying species, but even here there is little definite knowledge, and inferences may not prove reliable.

Thus, it is generally supposed that all the species of *Anopheles* are capable of carrying malaria; but no accurate experiments have been made to prove it in the case of most of the species occurring in the Canal Zone. One of the species, *Anopheles eiseni,* has an abnormal life history. It breeds in tree-holes and similar places instead of open puddles. It is quite possible that this species is not infectious; but it is most important for the practical work that this should be investigated, as the usual methods of destruction by drainage and oiling of the ponds does not affect this species.

Another large group of mosquitoes not affected by the present methods are those breeding in the parasitic plants high up in the branches of trees. None of these are supposed to carry disease,[1] though it might be rash to take this for granted, with our present limited knowledge about them. At all events, the species of the genus *Wyeomyia,* which almost exclusively breed in such places, are among the few day-biting mosquitoes and are decidedly noxious, where they abound, as in the case of *Wyeomyia adelpha* around the I. C. C. Hotel in Tabernilla.

It might be difficult to arrange the work of extermination so as not to destroy the predaceous, and therefore beneficial, species of *Megarhinus, Psorophora* and *Lutzia;* in fact, this discrimination would be somewhat doubtfully warranted, as some of these are themselves aggressive biters. Some mosquitoes are known not to bite man, as the true crab-hole mosquito of the genus *Deinocerites.* The tedious and at best uncertain work of oiling these numerous holes, as it is now done, might be saved if it were definitely ascertained, as it is reasonable to suppose, that the other crab-hole-inhabiting species also are harmless.

It would seem within the scope of the work of the Sanitary Department to utilize the unique opportunities on the Zone to work out some of the hundreds of problems of a similar nature which must be solved before our knowledge of these insects, so intimately connected with human welfare, is complete. With easy access to abundant material of many species of mosquitoes, now that the life histories of most of them have been studied; with the constant influx of malarial patients in the hospitals available for observation and experimentation, and with the large staff of medical men, among whom talents for bacteriological and systematic scientific work can not be wanting, the Sanitary Department on the Canal Zone has great opportunities to acquire knowledge which can not be gained except on the spot, and thus contribute this nation's full share in the solution of the world's problems in this important part of tropical medicine.

Such knowledge, though in its nature merely theoretical and purely scientific, would be of great practical value and would alone enable

[1] See footnote page 98.

truly intelligent work against this scourge of the tropics. When the Panama Canal is finished, most of the localities in which the present work is going on will disappear, submerged under the lakes of the canal. Even then these problems will not cease to exist, but will, if possible, be of added importance on account of the traffic through the canal and the possibility of carrying infectious diseases between two hemispheres.

It may be of value for the rediscovery of the many new species of mosquitoes obtained during the trip and for the continued study of these insects by the Sanitary Department that some general description of the localities in which the collections were made should be given as well as some of the methods employed in obtaining and rearing the mosquitoes.

The neighborhood of Tabernilla, in which most of the work was done, is low: from the Panama Railroad line the ground slopes gradually down toward the Chagres River. In the intervening country is the bed of the old French sea-level canal, which even in the dry season is covered by a series of shallow lakes connected by low meadows. Between this and the river the land is covered with tall bamboo, sparsely interspersed by large hardwood trees; the crowns of these latter are thickly covered with parasitic plants, such as Tillandsia and Agave, which constitute in themselves a thickly populated world for several species of mosquitoes.

A few neglected trails wind their way through the heavy underbrush to native villages on the other side of the river, where patches of land are burned off and cleared for pastures or for sugar-cane and banana fields. When passing through this region one finds, as everywhere on the lowland of the Zone, the old narrow-gauge railroad tracks left from the French works and quantities of old French machinery completely overgrown by heavy underbrush.

During the rainy season the Chagres River rises, and this entire area is covered with water and is only accessible by wading knee deep.

Here in the bamboo woods swarms of mosquitoes seek one out, and many species can be secured as adults, when they come to bite; but their larvæ are rarely accessible in nature, occurring as they do in broken bamboo joints filled with rain-water or in tree-holes, sometimes high up in the branches or difficult to reach through the tangle of underbrush and fallen bamboos. A good way to secure these larvæ is to clear spaces in the woods with a machete, fell a couple of bamboo trunks, and cut them up in short joints, which are then placed upright in the ground and filled with water. These bamboo joints make ideal breeding places for the mosquitoes, and a large majority of the species, which have been attracted to you during this work, are induced to lay their eggs in these traps. The larvæ can be easily secured by a suction bulb or by turning the contents of the joints into a white enameled plate. Numerous larvæ of *Joblotia, Carrollia, Aedes, Sabethes, Hæmagogus*, and the bamboo *Megarhinus* were obtained in this way, which otherwise could not have been found at all or only by hard work, in small numbers.

In the small pools in the woods and in the water-filled old French machinery, various *Culex* and *Anopheles* species were found, the former commonly preyed upon by the larvæ of *Lutzia bigottii*.

On the other side of Tabernilla the country is higher and hilly, partly cultivated and sprinkled with small native settlements. In the still pools of small sluggish streams between the hills, good collecting grounds are found, which yielded several *Culex*, *Uranotænia*, and *Anopheles* larvæ. The trees in and around the villages, covered as they are by water-bearing epiphytic plants, furnish a rich fauna of mosquitoes, especially species of *Wyeomyia, Phoniomyia,* and *Megarhinus*. The best way to secure the larvæ in these plants is to carefuly cut the plant off with a machete and turn it over and wash it out into a bucket half filled with water. In the case of the tall trees in the lowlands, the whole tree was felled in order to secure the epiphytic plants and their mosquito population. The corners of the leaves of the Spanish bayonet and other similar leaves holding water afford breeding places for several species of mosquitoes. The sharp spines on the leaves of these plants make it difficult to reach the mosquito larvæ. The best results in obtaining these are secured by cutting all the leaves off close to the stem, cutting the plant off near the ground, and turning the contents out into a bucket.

On excursions to more remote localities, where a bucket can not well be carried along, one must depend upon a suction bulb with a long glass tube with which to suck up the larvæ from these and other similar plants; but the small amount of water found in most of these plants makes it difficult to use the rubber bulb, and it is advisable to carry a bottle of water along from which to replenish the leaf corners and thus enable repeated suctions. The suction bulb is indispensable in many other cases, as with tree-holes too narrow to admit a dipper.

Once secured, the mosquito larvæ should be taken home as soon and with as little shaking as possible, each lot in a separate bottle. In the laboratory each lot is given a serial number referring to the notes on their habitat; the larvæ are placed singly in breeding tubes with cotton stoppers. Each larva receives a separate isolation number. When it pupates, the cast skin is carefully preserved in alcohol in a small tube with this isolation number, which the adult specimen also will bear. In this way only is it possible to be sure of associating the adult with the correct larva.

Family CULICIDÆ

Subfamily Culicinæ

Genus ANOPHELES Meigen

ANOPHELES PSEUDOPUNCTIPENNIS Theobald

This appears to be the commonest and most widely distributed *Anopheles* on the Zone, at least during the season of the year in which the present observations were made.

It was bred from larvæ from the edges of a slowly running stream near Gatun; from a large ill-smelling stagnant pool near Tabernilla, caused by dumping dirt across a small stream; from a small swamp near Culebra; from still pools of a clear, cold mountain brook near the Culebra cut at Empire; from the borders of a large stream near Empire; from a large open pool in a bend of the upper Chagres River, and from a stagnant pool near Panama City. Adults were collected at Las Cascadas, Culebra, Tabernilla, La Boca, and Colon.

ANOPHELES ALBIMANUS Wiedemann

This species was bred from stagnant pools at La Boca and near Panama City. After my departure, Mr. A. H. Jennings bred it from water in an old boat on Taboga Island, where we both had failed to find any *Anopheles* six weeks before, though we carefully searched for them. This is a striking example of the repeatedly observed periodicity in the activity of tropical mosquitoes.

Adults were also collected in large numbers by Mr. Jennings in the barracks at Gatun, and by the writer in houses at Tabernilla, Pedro Miguel, and Panama City. From its persistence in seeking human habitations for the purpose of biting, it is reasonable to suppose this species particularly concerned in the distribution of malaria.

At one time in July during my stay the species became excessively abundant in La Boca, breeding in a temporarily dammed-up swamp near the laborers' quarters. The subsequent increase of malaria in these barracks caused considerable anxiety as well as extra work for the Sanitary Inspector's office.

ANOPHELES TARSIMACULATA Goeldi

Two specimens were attracted to my tent at Tabernilla by the light. These specimens appear to have flown at least three hundred yards from the nearest possible breeding place, which was in the swamp back of the residence hill at Tabernilla. Their flight, however, was aided by the shelter of intervening trees and houses.

ANOPHELES EISENI Coquillett

This large white-kneed *Anopheles* was bred from larvæ taken in water in hollow trees and in bamboo-joints near Tabernilla. It was also bred from a palm leaf, lying on the ground and filled with rain-water, on the banks of the upper Chagres River. Other *Anopheles* larvæ, taken in water in the leaf corners of Spanish bayonet near Tabernilla, were not bred, but possibly belonged to this species.[1] The supposed *Anopheles* larvæ, reported to have been found in the leaf-corners of the banana, are probably all larvæ of small flies belonging to the genus *Corethrella*. The small, triangular, often reddish, larvæ have a certain resemblance to those of *Anopheles* and were sent me from sanitary inspectors as such on two occasions. They are very abundant on the Zone and are sometimes found in bananas as well as in tree-holes and bamboo-joints, feeding in part at least on young mosquito larvæ.

The possibility of *Anopheles* breeding between the leaf-stalks of the banana might at times be of importance in the practical work against mosquitoes and has at least in one instance caused extra work and expense for the Sanitary Department on the Zone; but I have personally never found *Anopheles* larvæ in these plants, though I made it a point to investigate them, whenever an opportunity presented itself.

It would be of advantage in the practical mosquito work on the Canal Zone to ascertain whether this tree-hole-inhabiting *Anopheles* is capable of transmitting malaria. Its circumscribed breeding places necessarily limit its abundance, and the species can therefore at most not be a very important factor in the spread of the disease. The

[1] *Anopheles bellator* D. & K. was bred from the leaf corners of Spanish bayonet in Trinidad, and this species may have to be added to the list. The present larvæ were not bred; no adults of *bellator* were captured. As this is going to press, Mr. Jennings has sent in an example of *Anopheles lutzii* Theob. (not Cruz), which he bred from larvæ in the water in *Tillandsia* leaves. If this should prove to be a malaria-carrying *Anopheles*, the removal of epiphytic plants from trees in the vicinity of habitations would be imperative.

specialized life habits and the consequent modifications in the anatomy of the larva suggests that this species also differs from the pool-inhabiting species in disease-carrying power.

ANOPHELES MALEFACTOR Dyar and Knab

Bred from black-headed larvæ in a still pool of drying mountain stream along the upper Chagres; also from a slow-running spring, full of leaves, near Tabernilla, containing numerous small fish, so many that each dip of the cup would bring one or several of the fish. Evidently the fish did not play any important rôle in the extermination of these mosquito larvæ.[1] The *Anopheles* larvæ and the larvæ of *Culex elevator* D. & K., found in the same spring, were present in considerable numbers.

Mr. Jennings obtained adults of this species inside the barracks at Gatun.

ANOPHELES GORGASI Dyar and Knab

Collected as adult at La Boca by Mr. A. H. Jennings. The larva is as yet undiscovered.

This species is named in honor of Colonel W. C. Gorgas, head of the Sanitary Department of the Canal Zone.

ANOPHELES APICIMACULA Dyar and Knab

A single specimen was collected at night on the outside of my mosquito-screened tent in Tabernilla.

ANOPHELES PUNCTIMACULA Dyar and Knab

There is a single specimen of this species in the collection of the U. S. National Museum from Colon, Panama, collected by Major W. M. Black.

ANOPHELES ARGYRITARSIS Desvoidy

Bred from larvæ in water in an old dump car near the Culebra cut. The water in this car was recent, clear rain-water with no trace of algæ; also bred from a shaded pool covered with algæ in the native village near Pedro Miguel and from a swampy pasture near Empire.

[1]Thirteen specimens of these fishes were submitted to Dr. E. B. Evermann, who determined them as four species, *Tetragonopterus panamensis* Günther, *Rivulus godmani* Regan (?), *Gambusia episopi* Steindacher and *Platypœcilus mentalis* Gill, of which the two latter were the predominating species.

Genus MEGARHINUS Desvoidy

MEGARHINUS TRINIDADENSIS Dyar and Knab

Bred during May from water in bamboo near Tabernilla. The larvæ were feeding upon those of *Joblotia.*

MEGARHINUS HYPOPTES Knab

Bred from the identical bamboo-joints near Tabernilla from which the foregoing species was obtained; the larvæ of this species also were observed feeding upon *Joblotia* larvæ.

The present species appeared a month later than *trinidadensis,* thus not interfering with it. Presumably another interesting example of the seasonal occurrence of mosquitoes in the tropics, though hardly convincing from the comparatively small number of specimens (seven of both species) reared.

The female of this species was not previously known.

MEGARHINUS SUPERBUS Dyar and Knab

Bred near Tabernilla from larvæ in the leaf corners of bromelia, growing on a calabash tree. The larvæ feed on those of *Wyeomyia circumcincta* and probably on the other mosquito larvæ present (*Culex jenningsi* and *Phoniomyia scotinomus*). The adult with its brilliant red abdominal tufts was seen on the wing in the tree-top, while I secured the larvæ.

Genus MANSONIA Blanchard

MANSONIA TITILLANS Walker

Several adult specimens were captured in the palm-shaded swamp near Lion Hill, where they came in numbers to bite. Nothing is known of the life history of this common tropical mosquito; the larval habits must be peculiar to have so long escaped observation.

MANSONIA PHYLLOZOA Dyar and Knab

A small, very striking-looking species with spotted wings, bred from larvæ from water in the leaves of a bromeliaceous plant growing on a tree in the native village near Tabernilla.

Genus DEINOCERITES Theobald

DEINOCERITES MELANOPHYLUM Dyar and Knab

This species is a geographic variety of the common West Indian crab-hole mosquito, *Deinocerites cancer,* but it appears very distinct, owing to its dark brown color.

It is identical in life-mode with the West Indian form and is found only near the crab-holes in which the larvæ live. During the day the adults remain within the holes. They come out in a swarm, if a stick is inserted into the hole, but return quickly to their hiding place when left alone. At dusk they come out and swarm above the hole for copulation. Though a few specimens alighted on my hand, which was held close to the hole, when I disturbed the mosquitoes, none attempted to bite, and I do not believe this species ever molests man. This is abundantly corroborated by earlier observations on *Deinocerites cancer* by Mr. Knab and the writer in Central America and the West Indies, against the observation of Dr. Grabham in Jamaica that "it is a voracious bloodsucker."

There are even good grounds for believing that none of the other crab-hole mosquitoes associated with this species bite man. This could be very easily determined by further observations on the spot, and if they should be found to be harmless, it would save considerable labor and expense at present spent by the Sanitary Department in oiling these crab-holes.

The species was bred and collected from crab-holes at La Boca and back of the wireless telegraph station at Colon.

The mosquitoes found associated with this species in the crab-holes, and whose proclivity for biting should be tested, are *Dinomimetes epitedeus* and *Culex extricator*.

Genus URANOTÆNIA Arribalzaga

URANOTÆNIA GEOMETRICA Theobald

Bred from larvæ in the pool of a clear, cold mountain brook back of the Culebra cut, near Empire. The larva looks curiously like an *Anopheles* larva, but furnished with a long tube. I bred this species also from a slow-running stream near Gatun and from a swamp near Culebra. Mr. A. H. Jennings bred it from streams near Gatun and on Taboga Island.

In the U. S. National Museum there is also a single specimen of this species from Panama received from Dr. A. J. Kendall.

URANOTÆNIA CALOSOMATA Dyar and Knab

This pretty little species is one of the smallest mosquitoes found in the Canal Zone; it is easily recognized by its size and by the silvery lateral line and the silvery edging around the eyes on the otherwise dark body. It was bred from deep hoof-prints in a swampy meadow near Tabernilla. The larvæ are very elongate, with reddish body, deep black head, and comparatively short tube; they are easily overlooked, as they go down at the least disturbance and remain at the bottom for a long time, burrowing in the mud.

URANOTÆNIA LOWII Theobald

This species, which is still smaller than the foregoing, was bred from similar black-headed larvæ in a small semi-stagnant stream near Las Cascadas.

URANOTÆNIA TYPHLOSOMATA Dyar and Knab

Bred by Mr. A. H. Jennings from a still pool in the small stream supplying the water-tanks of the Pacific Mail Steamship Company on Taboga Island.

Genus PSOROPHORA Desvoidy

PSOROPHORA IRACUNDA Dyar and Knab

The large predaceous larvæ of this species were taken in numbers near Las Cascadas in a newly flooded meadow covered with bushes and tall grass. They were preying upon the larvæ of *Culex lactator* and *Janthinosoma posticata,* which were very abundant in these temporary pools. The larvæ are very voracious, biting and even eating each other if confined together. Apparently their development is quick. All the larvæ taken pupated within a day, and adults issued from all of them within the next two days. This species was taken in May.

PSOROPHORA SÆVA Dyar and Knab

The larvæ of this species occurred sparingly at the same time and together with those of the foregoing species, but a month later it was the greatly predominating species in the same locality. It is a similar but longer and more slender larva, with longer tube than that of *iracunda.*

Genus TÆNIORHYNCHUS Arribalzaga

TÆNIORHYNCHUS COTICULA Dyar and Knab

A single specimen, caught, as it came to bite, in the black swamp near Lion Hill.

The larvæ of this and the following species may be expected to have a similar specialized life-mode to our *Tæniorhynchus perturbans,* which baffled entomologists for several years, before Prof. J. B. Smith lately discovered that it lives several inches down in the mud at the bottom of certain ponds, attached to the roots of plants.

The types of this species in the U. S. National Museum came from Bocas del Toro (P. Osterhaut, collector).

TÆNIORHYNCHUS FASCIOLATUS Arribalzaga

In the U. S. National Museum are specimens of this species from Panama (J. W. Ross, collector), from Colon (A. C. H. Russell, collector), and from Bocas del Toro, Panama (McKenney, collector). It was not met with by me.

Genus AËDES Meigen

AËDES TRIVITTATUS Coquillett

The extension of the range of this species to the tropics is interesting. It has hitherto been recorded only from the eastern United States. It was bred from large, dark, fat-tubed larvæ, which were found in enormous numbers, together with *Janthinosoma posticata,* in a newly flooded meadow near Las Cascadas.

The adult was also taken repeatedly at La Boca, Pedro Miguel, and at Colon.

AËDES TÆNIORHYNCHUS Wiedemann

Bred from larvæ occurring in countless numbers in the brackish swamp at La Boca. Adults were collected by Mr. Jennings in the barracks at Pedro Miguel. The species is a well-known inhabitant of brackish marshes on both the Atlantic and Pacific coasts of the United States.

AËDES POSTICATA Wiedemann

The large, fat-tubed larvæ of this species were taken and bred in numbers from a recently flooded meadow near Las Cascadas; also from still pools of a nearly dried-up mountain stream emptying into the upper Chagres River and from a shallow pool formed by a slow-running stream on Taboga Island. The adults were repeatedly captured, when they came to bite, in the bush around Tabernilla and Lion Hill.

AËDES LUTZII Theobald

Several adults were taken in the bamboo and palm swamps around Tabernilla and Lion Hill, where they came to bite. The larvæ were not found, nor have they been bred in the United States.

AËDES NIGRICANS Coquillett

The types of this species in the U. S. National Museum came from Panama (J. W. Ross, collector). No other record of its capture has been made and I did not meet with it.

AËDES LITHŒCETOR Dyar and Knab

Bred from larvæ in a pot-hole in a rock at the edge of the upper Chagres River between Allehuela and San Juan. It is probable that the species breeds only in rock-holes, as in the case of the North American *Aedes atropalpus* Coq.

AËDES INSOLITA Coquillett

Bred from larvæ in hollow trees in two localities along the upper Chagres River far from civilization. The larvæ are known to be normally inhabitants of hollow trees.

AËDES SERRATUS Theobald

Bred by Mr. A. H. Jennings from a pool near Pedro Miguel.

Genus HÆMAGOGUS Williston

HÆMAGOGUS REGALIS Dyar and Knab

The larvæ of this brilliant blue mosquito were taken in bamboo-joints and in several tree-holes near Tabernilla. One of these was a mere knot-hole holding only a spoonful of water. It was also bred from very foul water in old French machinery and from a wooden box near a house at Las Cascadas; also from a pot-hole in a rock, inhabited by a crab, along a small stream on Taboga Island, and from the rotten center of a cut banana trunk, filled with slimy juice, near Lion Hill.

The short-tubed larva reminds one of that of *Stegomyia* by its slow, snaky movements.

HÆMAGOGUS SPLENDENS Dyar and Knab

Bred from *Stegomyia*-like larvæ in a tree-hole along the upper Chagres River, far from civilization; also from bamboo-joints and tree-holes near Tabernilla.

HÆMAGOGUS AFFIRMATUS Dyar and Knab

Adults, collected as they came to bite in the palm-shaded black swamp near Lion Hill.

Genus STEGOMYIA Theobald

STEOGOMYIA CALOPUS Meigen

The scarcity of this, the yellow-fever mosquito, on the Canal Zone illustrates better than any other example the efficiency of the mosquito-work done by the Sanitary Department. To a person who has traveled in other parts of the tropics and who has experienced the noxious abundance of *Stegomyia* everywhere—in the best hotels as well as in the humblest negro hut—it is indeed gratifying to be able to live for weeks in the Canal Zone without encountering a single *Stegomyia*.

The yellow-fever mosquito is a strictly domestic animal, which is never found outside of man's immediate environment, and which only breeds in artificial receptacles, such as barrels, water-coolers, bottles, tin cans, etc., in and around human habitations. Due to these circumscribed habits, its control is comparatively easy, and it would be quite possible, with slight augmentation in the well-organized force of sanitary inspectors, to absolutely eliminate this dangerous mosquito from the Zone. The suggestion of such a radical attempt was enthusiastically received by the chiefs of the department, and their efforts will undoubtedly produce conditions within another year under which it can confidently be asserted that a yellow-fever epidemic on the Canal Zone is impossible, due to the total absence of the fever-carrying agent.

The two coast cities, Panama and Colon, the sanitation of which is as yet only nominally under American control, constitute the only really difficult localities to treat. The constant danger of infection through these cities should be sufficient reason for an arrangement under which the Sanitary Department of the Canal Zone should be given full power and responsibility in them.

The larvæ of *Stegomyia* was met with in barrels and tin cans in native villages near Pedro Miguel and Tabernilla; in a barrel with rain-water in Bas Obispo; in a barrel in a house in San Pablo; in water-holders in a private house in Panama; in several receptacles in a large hotel in Colon; in the bottom of an old boat, and in barrels on Taboga Island.

The adults were also taken in small numbers at La Boca, Panama, Las Cascadas, Culebra, Bohio, and occasionally on the passenger trains across the Isthmus. In Colon they were found in large numbers in several places, notably in one of the largest hotels.

Genus LUTZIA Theobald

LUTZIA BIGOTII Bellardi

This large yellow species is prevalent on the Zone and comes quickly and unhesitatingly to bite whenever one visits shady places. The predaceous larvæ are found quite as commonly in artificial receptacles of water around human habitations as in shallow pools in the woods. The larva is easily recognized by its size and by the peculiar curved position it assumes, looking as if about to spring upon its prey. The larvæ are unquestionably beneficial in destroying other mosquitoes, though they are not a dependable factor for their control. They are very voracious during their growth, and they have, like the larvæ of *Megarhinus,* the habit of killing all surrounding larvæ before they pupate, so as to have quiet during the pupal period. In many cases I found *Lutzia* larvæ which had completely cleared the receptacle in which they lived of other mosquito larvæ. If the food supply runs short before they are ready for pupation, the *Lutzia* larvæ become cannibalistic, and thus in a measure counteract the value of the species by materially diminishing their own numbers.

The species was bred from the following localities: From hoof-prints in a meadow near Tabernilla, where the larvæ were feeding upon those of *Uranotænia calosomata;* from an open lagoon south of San Pablo; from a rusty iron bucket near a house at Las Cascadas, with no other mosquito larvæ present; from a small temporary pool near Bohio, without any other mosquito larvæ present; from old French machinery in the woods south of Tabernilla; here again a few full-grown *Lutzia* larvæ alone remained; from larvæ in an old tin can near a house in Pedro Miguel, feeding on *Stegomyia* larvæ; from large unused sugar boilers near Tabernilla; here the *Lutzia* larvæ were present by the hundreds, preying upon those of *Culex coronator.* In one of the boilers all the *Culex* larvæ had been eaten and the nearly full-grown *Lutzia* larvæ were feeding upon their weaker companions.

Genus CULEX Linnæus

CULEX INQUISITOR Dyar and Knab

Bred from larvæ taken along the edges of a slowly running stream near Pedro Miguel; larvæ were also taken in a shaded pool of a drying-up mountain stream along the upper Chagres River. The adults were obtained at Las Cascadas by Mr. Jennings.

CULEX CUBENSIS Bigot

Bred from larvæ taken in very foul water in some old French machinery near Las Cascadas. It was also bred, both by Mr. Jennings and myself, from old boats on Taboga Island associated with *Culex coronator* and *Stegomyia calopus.*

CULEX CORONATOR Dyar and Knab

Bred near Tabernilla, from a stagnant ill-smelling pool, caused by recent dirt dumping, and from a rain-water barrel near there; from hoof-prints along a stream and from an old iron sugar boiler; also from a stream back of Culebra prison; from a cement trap containing sink-water in Las Cascadas; from a still pool of a shaded stream along the upper Chagres River; from a drinking-water tank at Allehuela; from a rain-water pool near Bohio; from a barrel in Pedro Miguel, and from an old boat on Taboga Island. Mr. Jennings also obtained this species from a boat on Taboga Island.

CULEX REGULATOR Dyar and Knab

Bred from an old boat on Taboga Island, and also by Mr. Jennings from a tub with water used for cattle, on the same island.

CULEX LEPRINCEI Dyar and Knab

Bred from larvæ taken from the grassy edges of a slowly running stream near Pedro Miguel, where it was associated with *Culex inquisitor*, and from a large ill-smelling pool caused by dumping of dirt near Tabernilla; associated with *Culex coronator* and *Culex conspirator.*

The species is named in honor of Mr. J. A. Le Prince, whose remarkable work against mosquitoes in Cuba and Panama is well known.

CULEX EQUIVOCATOR Dyar and Knab

Bred from larvæ taken near Lion Hill in the water-filled center of a cut banana trunk, where they were found together with the larvæ of *Culex lactator* and *Hæmagogus regalis.* The water was foul and slimy.

CULEX INTERROGATOR Dyar and Knab

Bred from larvæ associated with those of *Culex coronator* in a barrel with rain-water near Tabernilla, and from a stagnant pool near the same place, from which *Culex coronator* and *Culex leprincei* were also bred.

The species was also bred by Mr. Jennings and the writer on Taboga Island from larvæ taken in a boat filled with rain-water.

CULEX CONSPIRATOR Dyar and Knab

Bred together with *Culex leprincei* from grassy edges of a slow-running stream near Pedro Miguel.

CULEX LACTATOR Dyar and Knab

Bred from a barrel, from bamboo, and from a stagnant pool near Tabernilla; from a metal washtub and from recently flooded meadow at Las Cascadas; from a tin can and from a rotten banana trunk in the black swamp near Lion Hill; from a hollow tree-stump in an open field near Gatun, and by Mr. Jennings from a water-tub used for cattle on Taboga Island.

CULEX EXTRICATOR Dyar and Knab

The larvæ of this species were taken in crab-holes near the wireless telegraph station at Colon, and the species is clearly closely associated with these crabs, the adults remaining in the holes during daytime like those of the genus *Deinocerites*. A large series was bred, but neither adults nor larvæ were obtained in other localities.

This species was described from the larvæ collected and bred by the writer two years ago in Cedros, Trinidad. It is one of the several convincing examples justifying Messrs. Dyar and Knab in their classification of the mosquitoes, even to the extent of erecting new species on the immature stages alone. The closer study of the adults proved the distinctness of this species from the composite species "*pipiens*," and now the study of the habits of the species further emphasizes the correctness of the deduction from larval characters.

This species also illustrates the importance of exact observations of superficially unimportant details. The Trinidad specimens were bred from larvæ found in a small bucket used for holding live crabs; it was, in other words, an artificial crab-hole and thereby alone attractive as a place to oviposit for this crab-hole-inhabiting species.

The importance for practical work on the Canal Zone of definitely ascertaining, by further observations, whether this species sucks blood from man or not, has been commented upon under the genus *Deinocerites*.

CULEX JUBILATOR Dyar and Knab

Bred by Mr. A. H. Jennings from larvæ taken in an old tub in a pasture and from a slow-running stream on Taboga Island. Neither this nor the following species were secured by Mr. Jennings and the writer during our visit to Taboga Island, six weeks previously to Mr. Jennings' last visit. As our investigations were careful and covered practically every water accumulation on the island, including the above-mentioned tub, this can only be explained by the periodicity of the activity of these mosquitoes. On Mr. Jennings' second visit he failed to secure several of the species I took during my stay on the island, which is not so large, but that it can be thoroughly explored in a few days.

CULEX REVELATOR Dyar and Knab

Bred by Mr. Jennings from an old rain-filled boat on Taboga Island.

CULEX HESITATOR Dyar and Knab

Bred from a small swampy stream near Las Cascadas.

CULEX ELEVATOR Dyar and Knab

The larvæ of this species are dark prettily marked with black, "zebra-striped." They were taken in a slow-running spring, full of leaves and small fishes, which evidently did not seriously interfere with the mosquito larvæ; it was also bred from the edges of a small stream full of fishes, near Tabernilla.

CULEX TÆNIOPUS Dyar and Knab

A single adult specimen was taken.

CULEX CORRIGANI Dyar and Knab

Bred from small larvæ with very long, slender tubes, taken in bamboo-joints near Tabernilla.

The species is named in honor of my friend, Mr. J. Corrigan, Sanitary Inspector at Tabernilla, whose efficient work has made that place one of the healthiest settlements in the Canal Zone. His constant courteous attention to my needs greatly facilitated my work and made my sojourn in Tabernilla very pleasant.

CULEX JENNINGSI Dyar and Knab

Bred from larvæ taken in water in the leaves of bromelias, *Tillandsia* sp., in a tree in the native village near Tabernilla, associated with *Phoniomyia scotinomus* and *Wyeomyia circumcincta,* and with these was preyed upon by the larvæ of *Megarhinus superbus.* This species is named in honor of my friend, Mr. Allen H. Jennings.

CULEX GAUDEATOR Dyar and Knab

Very close to and possibly merely a color variety of the preceding species, together with which it was found in a *Tillandsia* species on a tree near Tabernilla.

The eggs of this species are very remarkable, quite different from any mosquito-eggs at present known. They are laid in an egg-shaped gelatinous mass about 6 by 10 mm., which suggests a mass of frogs' eggs. The mass contained about twenty-five eggs, each of which is oblong, more pointed at one end and rounded at the other, and each surrounded by its own spherical gelatinous envelope, about 2.5 mm. in diameter. The egg-mass floats at the surface of the water, kept buoyant by small air-bubbles, one near the end of each egg. The gelatinous substance is consumed at least partly by the newly hatched larvæ.

CULEX FACTOR Dyar and Knab

Bred from leaf corners of a *Tillandsia* species, on a tree overhanging the water on the upper Chagres River. It was there associated with the larvæ of *Wyeomyia macrotus.* Also bred from bromelia water near Tabernilla.

CULEX FUR Dyar and Knab

The type of this species is in the U. S. National Museum and came from Colon, Panama (A. C. H. Russell, collector). I did not find the species.

CULEX (CARROLLIA) IRIDESCENS Lutz

This pretty, easily recognized little mosquito was bred on several occasions in large numbers from my bamboo traps in the neighborhood of Tabernilla. The species was not hitherto represented in the collection of the U. S. National Museum.

Subfamily SABETHINÆ

Genus SABATHES Desvoidy

SABETHES UNDOSUS Coquillett

A common species bred in large numbers from bamboo at Tabernilla, Lion Hill, and Gatun. The larva has a long air-tube and hangs perpendicularly from the surface of the water when at rest.

Adults of this species were also collected as they came to bite in the bamboo woods.

SABETHES IDENTICUS Dyar and Knab

The large, fat, milky-white larva of this species is strongly segmented and has a short tube; it hangs perpendicularly from the surface film when breathing; the adults were bred in two localities near Tabernilla, from my bamboo traps, and are very similar to those of the preceding species.

SABETHES LOCUPLES Desvoidy

A single specimen of this species, very conspicuous by its long-tufted legs, was caught by my friend Mr. H. Simms, Sanitary Inspector at Empire. Nothing whatever is known of the life history or larva of this curious species.

SABETHES LONGIPES Fabricius

Also one of the species with heavy tufts of scales on its legs. A single specimen in the U. S. National Museum was received from Bocas del Toro (P. Osterhaut, collector). The early stages are entirely unknown.

SABETHES CANFIELDI Dyar and Knab

This large, striking species, dark bluish green, with silvery belly, was the common mosquito in the black swamp from Ahoga Lagarto to Gatun, and came in numbers to inflict its rather severe sting, whenever one stepped into the shade of the brush. I was not able to locate its larvæ. These will probably be found to inhabit tree-holes or bamboo, or still more probably the inaccessible leaf corners of some palm.

This species was named in honor of my friend, Dr. Herman Canfield, whose broad comprehension of the problems of sanitation in general and of the bearings thereon, which insects may have, greatly adds to the efficiency of the work done by the Sanitary Department.

Genus SABETHOIDES Theobald

SABETHOIDES CYANEUS Fabricius

Bred from larvæ taken in leaf corners of Spanish bayonet in a native village near Tabernilla.

Genus WYEOMYIA Theobald

WYEOMYIA APORONOMA Dyar and Knab

Bred from larvæ in a hollow tree-trunk lying in the open field near Gatun, surrounded by a few bushes. The larvæ are long, slender, and moniliform, with yellow head, short tube, and long anal appendages; they hang perpendicularly from the surface of the water when breathing, but can remain very long under water and burrow down into the sediment on the bottom when disturbed; they are thus easily overlooked.

WYEOMYIA ADELPHA Dyar and Knab

Bred from *Tillandsia* on a calabash tree near the railroad station in Tabernilla.

The mosquitoes of this genus are small sombre-colored insects, with silvery-white bellies, and generally escape detection, though they are very persistent biters during the daytime.

While nothing is known about this group of mosquitoes as possible carriers of disease, they are, on account of this day-biting habit, to be reckoned with as a nuisance and consequent detriment to humor and health, and it might be well worth while for the Sanitary Department to direct their efforts against them. The oiling and draining of surface water does not affect this group at all. Trees infested with plant parasites, as *Agave* and *Tillandsia*, should not be permitted in the immedite neighborhood of residences or working districts, or, if they are desired for shade, should be cleared of the water-bearing growth. The single small tree, now cut down, from which the present species was bred, contained about a hundred specimens of epiphytic plants, and the resulting mosquito fauna was large enough to be distinctly felt in the surrounding area, which in this case happened to be about the most frequented lounging place for the workmen in Tabernilla during noon hours.

WYEOMYIA GALOA Dyar and Knab

The very specialized larvæ of this species live in the conspicuous red flower-sheaths of a Bihai (*Heliconia*) species, common on the Zone. These flower sheaths contain but little water and that of a slimy character, but they harbor a number of dipterous and coleopterous insects. The mosquito larvæ of the present species are slender, flattened, strongly segmented with yellow head, short tube, and long anal appendages; they have the ability to move head foremost, more crawling than swimming through the sometimes thick fluid, in which they live; they are even able to crawl head first up the sides of the calyx above the fluid, and undoubtedly seek another lower and wetter flower sheath in this way, if for some reason the sheath in which they are goes dry.

This species looks very much like and has identically the habits of *Wyeomyia pseudopecten* D. & K., bred from similar flowers in Trinidad and Santo Domingo. As in this species, the eggs, which are black, smooth, and elliptical, are laid singly, but in large numbers, in the uppermost, just-opening, and yet dry flower sheath, where they await a rain for their development.

WYEOMYIA LEUCOPISTHEPUS Dyar and Knab

Bred from *Tillandsia* on branches of a tree near Tabernilla.

WYEOMYIA CODIOCAMPA Dyar and Knab

Adults of this species were repeatedly taken in the bamboo woods near Tabernilla, where they came to bite. Only two larvæ were taken, both in the bamboo traps. These were the most extraordinary-looking mosquito larvæ, which have come under my observation, and resemble more young caterpillars than dipterous larvæ; they are short, fat and rotund, and covered with many long black spines in closely set clusters. The movement of the body is therefore short and slow, and they remain for long periods under water, quietly feeding in the decomposed vegetable matter on the bottom.

WYEOMYIA MACROTUS Dyar and Knab

The larvæ of this species were found, together with those of *Phoniomyia scotinomus,* in *Tillandsia* on trees along Bogueron River. Only a few specimens survived the upsetting accident on my way home. They have a very long, thin tube and lie on their backs, with the tube downward for long periods at a time. The species was also bred from bromelia water near Tabernilla. The pupæ of this species have very remarkable long, thread-like breathing tubes, quite different from the short, stout tubes normally found in mosquito pupæ. The length of these tubes keeps the pupa well under the surface of the water when it takes air, and this may likely be of value to the species in the limited and often crowded surface area of its habitat.

WYEOMYIA HOSAUTUS Dyar and Knab

Bred from bamboo near Tabernilla.

WYEOMYIA MELANOCEPHALA Dyar and Knab

Bred from a single larva taken, together with *Culex* and *Anopheles* larvæ, in a nearly quiet pool of a slow-running, cold, clear brook in the mountains back of Empire.

This is a very unusual breeding place for a larva of this genus, and it is probable that this single larva had been washed out by a rainstorm from a *Tillandsia* on an overhanging branch or from an overflowing tree-hole or bamboo-joint.

WYEOMYIA CHALCOCEPHALA Dyar and Knab

Bred from bamboo near Tabernilla.

WYEOMYIA BROMELIARUM Dyar and Knab

Bred in numbers from the bamboo traps around Tabernilla.

WYEOMIA CIRCUMCINCTA Dyar and Knab

Bred from larvæ in *Tillandsia* in trees along the Bogueron River and in a native village near Tabernilla.

WYEOMYIA PANAMENA Dyar and Knab

Bred from larvæ in bamboo near Tabernilla.

WYEOMYIA HOMOTHE Dyar and Knab

The adults were collected in bamboo woods near Tabernilla in the act of biting. The larvæ were not discovered.

WYEOMYIA AGNOSTIPS Dyar and Knab

Adult, collected, while biting, in bamboo woods near Tabernilla. No larvæ were found.

WYEOMYIA AUTOCRATICA Dyar and Knab

A single specimen of this species was received from Culebra (Wm. Black, collector). I did not meet with the species.

Genus LIMATUS Theobald

LIMATUS DURHAMI Theobald

This widely distributed little mosquito, which is easily recognized by its brilliant golden and royal-blue thorax, was bred from larvæ found in rain-water collected in a fallen palm-leaf on the bank of the upper Chagres River, where it was associated with *Anopheles eiseni*. It was also bred from an old tin can, full of rain-water and rotten leaves, in the woods near Tabernilla, and from a small wooden barrel in a native village near Tabernilla.

The larvæ are very long and slender and have a snaky movement; they are only found in water rich in decomposed vegetable matter.

Genus PHONIOMYIA Theobald

PHONIOMYIA PHILOPHONE Dyar and Knab

Bred from larvæ in *Tillandsia* on a tree near Tabernilla. The adults were also collected on Taboga Island by Mr. A. H. Jennings.

PHONIOMYIA CHRYSOMUS Dyar and Knab

Bred, together with the foregoing species, from *Tillandsia* in a native village near Tabernilla.

PHONIOMYIA SCOTINOMUS Dyar and Knab

Bred from leaf corners of *Tillandsia* on branches of trees along the Bogueron River, Panama. This species was secured and bred in large numbers, but most of my material was lost by the upsetting accident on the return trip; a vial with a few live larvæ had fortunately been placed in my valise, which was ultimately recovered after floating for a few miles through the rapids of the upper Chagres River, and they were bred to adults at my headquarters in Tabernilla. A single specimen of this species was also bred from Bromelia water in a native village near Tabernilla, where it occurred together with *Wyeomyia macrotus.*

Genus DINOMIMETES Knab

DINOMIMETES EPITEDEUS Knab

This peculiar mosquito, at once distinguished from all others except *Deinocerites* by the very long antennæ, was bred from crabholes near the wireless telegraph station at Colon, where it was found associated with *Deinocerites melanophylum* and *Culex extricator.*

Though possessing a well-developed proboscis, this species probably does not bite man; but this should be definitely ascertained by observations. (See note under *Deinocerites melanophylum.*)

Genus LESTICOCAMPA Dyar and Knab

LESTICOCAMPA ULOPUS Dyar and Knab

Taken at Lion Hill and near Tabernilla. The larva lives between the stalk and the leaf stalk of a juicy large-leaved dark-green plant, which reminds one of *Monstera deliciosa.* The space in these leaf corners is so limited and the amount of water they hold so small and so slimy from the plant's juice that it would hardly be suspected to harbor mosquitoes; and yet the plant probably has another Sabethid peculiar to it upon which the present species preys.

LESTICOCAMPA CULICIVORA Dyar and Knab

The larvæ are predaceous on those of *Wyeomia galoa* in the red flower-sheaths of a Bihai (*Heliconia*) species. (See note under *Wyomyia galoa.*)

LESTICOCAMPA LEUCOPUS Dyar and Knab

In the U. S. National Museum are four specimens of this species received from Bocas del Toro (P. Osterhaut, collector). I did not meet with it.

Genus JOBLOTIA Blanchard

JOBLOTIA DIGITATUS Rondani

This and the following two species of this genus were abundant in bamboo woods. The adults were sure to come to bite, and the very similar looking, fat, short-tubed larvæ were to be found in any bamboo-joint, which contained the thick, saturated, often ill-smelling fermenting fluid, to which they seem partial.

The present species, which is the *Trichoprosopon nivipes* of Theobald, has a wide distribution within the moist tropics. The writer bred it in Trinidad from cacao husks, in which the fluid was as thick as gruel. Transferred to water, which is less rich in food, these larvæ remain alive unchanged for long periods. Some of my Trinidad larvæ lived for four months after reaching Washington, and some of the Panama material did nearly as well. The normal development, under natural conditions, with abundant food, takes about two weeks.

Eggs of the following species, which were laid May 1, produced the first adults on May 14, 1907:

JOBLOTIA TRICHORRYES Dyar and Knab

Bred commonly together with the above somewhat larger species from bamboo near Tabernilla. The eggs are laid singly on the surface of the water. They are elliptical, black, with four longitudinal fringes of short white hairs from tip to tip. The larva issued from one end. In a bamboo-joint, which I prepared and filled with water at 5 o'clock on the evening of May 1, I found the next morning at 9 o'clock some twenty such eggs, kept floating on the surface by the hair fringes. Some of these eggs were submerged during transit to the laboratory, and with the fringes once wet remained under water, but these hatched nevertheless successfully, together with the non-submerged eggs, during the afternoon of the same day. The young larvæ were white, with black mouth-parts and black lateral hairs pointing forward on the anterior half of the body. They remained under water for several hours, eating of the vegetable matter at the bottom of the jar to which they had been transferred. The next morning the larvæ had doubled in size, and on the third day they attained their full size; they came regularly, though not very frequently, to the surface to breathe. When feeding on the bottom they would lie in the soft residue of vegetable matter in different positions, sometimes on their back, sometimes with the back up, or on the side. The first adult from this lot issued May 14.

The adults of this and other species of *Joblotia* are conspicuous objects in the bamboo woods, when they approach to bite, gracefully floating their long white-tipped middle and hind legs.

JOBLOTIA MOGILASIA Dyar and Knab

Bred with the two preceding species from bamboo near Tabernilla. While the larva and adult in a general way look much like the two other species, the pupa of this species is easily distinguished from the somber, dark pupa of the others; it is bright yellow, prettily marked with black cross-bands on the back of the abdominal segments.

CARL LUDWIG ROMINGER

By GEORGE P. MERRILL

Head Curator of Geology, U. S. National Museum

Carl Ludwig Rominger, the son of Ludwig and Johanna Dorothea (Hoecklin) Rominger, was born at Schaitheim, in Würtemberg, December 31, 1820, and died at Ann Arbor, Michigan, April 27, 1907.

He was matriculated at the University of Tübingen in the fall of 1839, receiving his diploma as a doctor of medicine in the fall of 1842. His record as a student was that of a painstaking, detailed worker and the winner of two academic prizes, one for a research demonstrating the mode of ascension and distribution of the sap in plants, and the other for making a detailed geological map of the environs of Tübingen.

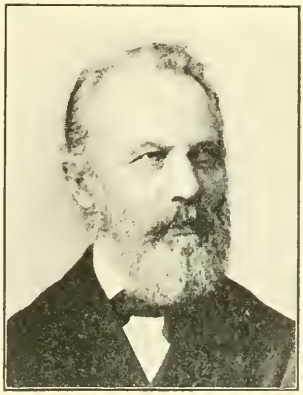

Fig. 23. Carl Ludwig Rominger

From 1842 to 1845 he remained at Tübingen as an assistant in the chemical laboratory of Chr. Gmelin, and at the same time devoted considerable attention to the study of geology and paleontology under the guidance of Professor Quenstedt. From 1845 to 1848, under an annual grant of four hundred florins from the government of Würtemberg, he traveled extensively on foot over a great portion of Germany, Austria, Hungary, Switzerland, and France, his main object being the study of the geological structure of these countries. At the outbreak of the Revolution in 1848, fearing an interruption of his studies, he crossed the Atlantic with the idea of continuing his work in America, though, as it subsequently proved, the step was premature and ill-advised, owing to his being poorly equipped for such an undertaking and mainly on account of his slight knowledge of the English language. He shipped in a sailing vessel from Bremen in April, 1848, arriving in New York some fifty days later. Being unable to understand the language or make himself understood; without letters of introduction or knowledge of the manners and customs of the people, and without funds, he was obliged to follow his medical profession for a livelihood. After a few months of travel through the coal regions of Virginia and Kentucky, he finally arrived in Cincinnati, to which locality he was attracted by the rich paleontological nature of the underlying formations.

His financial condition, however, was such that the only choice left open to him was to establish himself in his profession, which he continued to practice for the ensuing twenty-four years, in the meantime perfecting himself in his English studies as best he might and occupying his leisure hours with a study of the natural sciences, particularly the fresh-water mollusks and invertebrate fossils with which the region abounded. After a few months' residence at Cincinnati he removed to Chillicothe, Ohio, where he remained for eleven years, though only fairly prosperous. In 1860 he removed to Ann Arbor, Michigan, where he resided for the remainder of his life. During the first twelve years' residence here he continued his medical practice, and was pecuniarily somewhat more successful than at Chillicothe.

The Geological Survey of Michigan was reorganized in 1869, with Professor Alexander Winchell as director. On the recommendation of the numerous friends he had made through his paleontological studies, and especially through the influence of Professor James Hall, of Albany, Dr. Rominger was engaged by the survey as paleontologist in 1870. Professor Winchell resigned in 1871, and Rominger remained in full charge, first of his particular department and finally, after the withdrawal of Brooks and Pumpelly, of the entire survey, until, with a change in the political administration in 1883, he was succeeded by Professor Charles E. Wright.

During all this time his chief interests were paleontological, though circumstances naturally caused him to devote attention also to stratigraphy. Among the reports of this survey, the third part of volume I (1873), volumes III (1876) and IV (1881) in their entirety, and the first part of volume V (1895) are of his authorship. The third part of volume I related to the Paleozoic rocks in the upper peninsulas. Of volume III, two hundred and twenty-five pages and fifty-five plates were devoted to paleontology—mainly to fossil corals. The reports of 1881 and 1895 dealt almost entirely with economical problems relating to the iron and copper regions of the Upper Peninsula.

Rominger's life was typical of that of many of the earlier geological workers, and that he accomplished so much, considering the difficulties under which he labored, is one of the many impressive facts brought out by the study of the history of early American geology. Aside from financial considerations, his ignorance of the language offered a great obstacle to his progress. Indeed, he never became a ready writer of English. German was his native tongue and to it he resorted whenever conditions would allow. Even when writing or talking, his form of construction was more German than English, and the force and point of his remarks and criticisms were often wholly lost on this account.

The following quotation from a personal memorandum to the present writer, made a few years before his death, and referring to his work on corals (vol. III of the Survey reports), will illustrate both of these points:

"It was my original intention to continue the work I had begun under the auspices of the Geological Survey, but the installation of Governor Alger made a sudden end of my position, which I had filled for fourteen years. . . . . To continue this work on my own expense I became totally discouraged after I had made the experience with the extra copies I had printed of the third volume on my own expense. Urged to do it by more than one hundred letters of persons wishing to obtain it from me after the State had no more of this volume to give away, I ordered two hundred fifty copies printed, and paid for each volume $4.75; wanted to sell them for the same amount, but to my surprise most of the persons ordering the volume were expecting it as a donation. With difficulty I could sell at the rate of $3.00 about fifty volumes, and one hundred fifty I gave away, and about one hundred are left in my hands unsold. This experience cost me about $800.00 direct loss and cured me of every attempt to edit a book at my own expense."

Dr. Rominger is described by those who knew him as a genuine scientist of the old school—brusque in his manner, not always too patient toward those who asked what seemed to him foolish questions, but withal generous and unpretentious.

He was an indefatigable collector and spared neither time nor energy in the pursuit of his favorite study. His tremendous physique enabled him to make collections in regions which were practically inaccessible to those having less power of endurance. In illustration of this, attention may be called to the extensive collections of choice Silurian corals made by him in the Glade regions of west Tennessee. These glades even today are penetrated with difficulty, and at that time the entire journey had to be made on foot.

Rominger left two important paleontological collections, the first being now the property of the University of Michigan, at Ann Arbor, and the second of the National Museum, at Washington. The first collection was especially rich in corals—in fact, it was the most complete set from the Paleozoic extant at the time it was made, and was the basis of his monograph (vol. III of the Michigan Survey). The second collection was of a more general biological nature and included a particularly fine set of Stromatoporoids. Unlike many of the earlier paleontologists, Rominger was most careful to accurately label his material, giving the exact horizon and locality. This, of course, added enormously to the value of his collections.

He will be remembered by paleontologists, particularly those who appreciate the importance of such methods, as being one of the first, if not the first, to study fossil corals, Stromatoporoids and Bryozoa, by means of thin-sections. Many species of fossils and one genus, the unique coral *Romingeria,* are named in his honor.

He was married in 1854 to Frederika Meyer, of Tübingen, by whom he had two daughters, Louise and Marie, and one son, Dr. Louis Rominger, now of Louisville, Kentucky.

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EDWARD TRAVERS COX

By GEORGE P. MERRILL

Head Curator of Geology, U. S. National Museum

Edward Travers Cox was born in Culpeper County, Virginia, April 21, 1821, and died at Jacksonville, Florida, January 6, 1907.

The family, when the boy was but four years of age, moved to New Harmony, Indiana, joining the communistic colony founded by Robert Owen. Here he was educated, pursuing his geological studies under David Dale Owen, whose assistant he subsequently became on the geological surveys of Arkansas and Kentucky. After the death of Owen, in 1860, Cox became engaged in commercial work, and in 1864, in company with R. E. Owen, made examinations of mining properties in New Mexico, including the Spanish Peaks and Raton coal fields and the copper and iron mines at the upper Gila River. In 1865, at the request of State Geologist Worthen, he made an examination of the coal beds of Gallatin County, Illinois, and later those of the southern portions of the same State, the results being published in the reports of the State survey for 1875. In 1869, with the organization of a fourth attempt at a systematic survey, he was appointed State Geologist of Indiana, which office he continued to hold until 1880, in the meantime occupying also the chair of geology in the University of Indiana.

Fig. 24. Edward Travers Cox

Annual reports were issued for each of the ten years which marked the life of this survey. Those of 1869 and 1872 were accompanied by county maps, though no geological map of the State in its entirety was furnished. A colored section across the State from Greencastle to Terre Haute accompanied the report for 1869.

Cox was assisted during the entire period or for a part of it by Frank H. Bradley, Rufus Haymond, G. M. Levette, B. C. Hobbs, R. B. Warde, W. W. Borden, M. N. Elrod, John Collett, and E. S. McIntire, the fossil flora being described by Leo Lesquereux and the fauna of Wyandotte Cave by E. D. Cope. Zoölogical and botanical subjects were treated by D. S. Jordan, J. M. Coulter, and J. Schenk.

These reports as a whole contained little that was new or impressive. In the eighth, which was the most comprehensive so far issued, Cox himself called attention to the fact that the geological history of the State "appears tame and devoid of the marvelous interest which attaches to many other regions, and that there is not a single true fault or upward or downward break or displacement of the strata thus far discovered." The oldest rocks of the State were found in the southeastern portion, extending from the Ohio River near the mouth of Fourteen Mile Creek to the eastern boundary line. These are the so-called Hudson River rocks of Hall, which Cox correlated with Safford's Nashville group, and which Worthen and Meek had included under the name of Cincinnati group. He regarded the Silurian strata as uplifted, not by a local disturbance, but "by an elevating force that acted very slowly and extending over the entire central area of the United States." The seat of greatest force, he thought, however, was not limited to southwestern Ohio, but was to be looked for in Kentucky.

Cox accepted the general theory of glacial drift as at present understood, and conceived that the climatic changes might be due to the relative position of land and water, possibly a change in the course of the Gulf Stream. He could find no evidence of a subsidence of the land to terminate the glacial period, nor could he find in Ohio, Indiana, or Illinois anything to militate against the commencement of a glacial period in Tertiary times and its continuation "until brought to a close by its own erosive force, aided by atmospheric and meteorological conditions. By these combined agencies acting through time the mountain home of the glacier was cut down and a general leveling of the land took place."

After retiring from the survey, in 1880, Cox once more resumed private work, making New York City his headquarters. Becoming interested in the phosphate deposits of Florida, he removed to that state, taking up his residence at Albion, in Levy County. For a time he was employed as chemist of the Portland Phosphate Company, and from 1896 to 1902 served also as postmaster at Albion. In the latter year he retired from active work and removed to Jacksonville, where he died on January 6, 1907, at the ripe age of eighty-five years.

AN APPARENTLY NEW PROTOBLATTID FAMILY FROM THE LOWER CRETACEOUS

By EVELYN GROESBEECK MITCHELL

The following description is based on a single nearly perfect wing found in association with numerous species of plants in the Kootanie beds (Lower Cretaceous) of the Great Falls coal field, Montana. It is noteworthy that all other Protoblattids appear to be from the Carboniferous, the American forms coming from the Alleghany stage. It was detected by Dr. F. H. Knowlton while studying the plants, and by him placed in my hands for investigation. It has been carefully compared with such specimens of the Protoblattoidea as are contained in the collection of the United States National Museum, as well as with the available literature on the subject, especially the recent work of Handlirsch, with the result that it appears to represent not only a new genus and species, but a new family. It may be named and characterized as follows:

Superfamily PROTOBLATTOIDEA Handlirsch

Family Lygobidæ, new family

This family seems intermediate between Oryctoblattinidæ Handlirsch and Eucænidæ Handlirsch of the Carboniferous. The main venation would seem to place Lygobius among the Eucænidæ, but the latter entirely lacks intercalary and cross-venation, which are prominent characteristics of the former. This last venation much resembles that of some of the Oryctoblattinidæ, but the strongly compound radial sector of the latter family is in distinct contrast to the almost simple radius of the new family.

The Lygobidæ is also characterized by the extension of the cubital area, which comprises nearly half the width of the wing; the comparatively few-branched medius; almost complete intercalary venation and numerous cross-veins, especially regular in the distal half of the wing, and a costal area apparently broad, especially at the base.

LYGOBIUS, new genus

Cubitus strongly compound, with branches directed obliquely backward and presenting a typical forking, with strong intercalary venation and regular cross-veins; medius free and with three main branches; radius once forked distad of the middle. Cross-veins irregular in areas proximad of intercalary veins and in costal area,

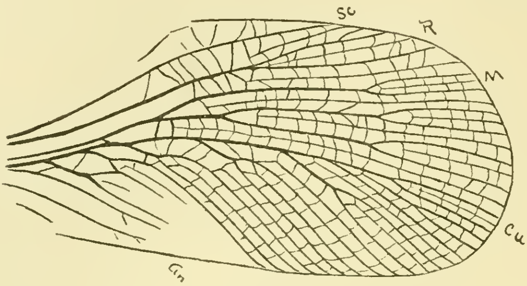

FIG. 25.—*Lygobius knowltoni*

otherwise fairly regular and closer spaced. Apex of wing bluntly rounded. Costal margin nearly straight, and, in distal half of wing, almost parallel to the posterior margin.

LYGOBIUS KNOWLTONI, new species

LOCALITY.—Meriditt mine, 6 miles southwest of Geyser, Cascade County, Montana. Kootanie formation (Lower Cretaceous).

LENGTH OF WING.—6.5 mm.

GREATEST WIDTH.—3.3 mm.

Subcosta reaching decidedly beyond middle of wing, rather sinuous, originating caudad of middle of base of wing. The two simple branches of the radius extend to the costal margin, near to the beginning of the apical border. Medius forking somewhat proximad of middle of wing, lower branch forking again at about the middle of wing, all three branches forking again at about distal fourth of wing. Cubitus ending in a fork beyond distal fourth of wing; proximad of this are a fork, a simple branch, and five forked branches. At least three slightly sinuous anal veins. Anal area defective.[1]

Type, U. S. N. M., Cat. No. 50,461.

[1] The drawing was made by the author with camera lucida. No restoration was attempted, save in the case of the cubital cross-veins, which are somewhat obliterated and difficult to see.

NECESSARY CHANGES IN THE NOMENCLATURE OF STARFISHES

By WALTER K. FISHER,
of Leland Stanford Junior University

A number of generic names of starfishes are being incorrectly used. In view of the general acceptance of the International Code of Nomenclature there is now no valid excuse for the retention of such names as *Cribrella* Agassiz, *Palmipes* Agassiz, *Ctenaster* Perrier, *Crenaster* Perrier, *Asteropsis* Müller and Troschel, *Gymnasttria* Gray, *Pentaceros* Schulze, *Patiria* Gray, and a few others listed below. The case of *Cribrella*[1] and of *Palmipes*[2] has already been argued, and need now only be mentioned in passing. *Cribrella* Agassiz, 1835, is a pure synonym of *Linckia* Nardo, 1834. *Cribella* Forbes, 1841 (not of Agassiz) is antedated by *Henricia* Gray, 1840, the correct name for the group of which *Asterias sanguinolenta* O. F. Müller is the type. *Palmipes* Agassiz, 1835, is antedated by *Anseropoda* Nardo, 1834. The fact that *Anseropoda* is of mixed derivation has no bearing on its tenability as the name of the genus of which *Asterias placenta* Pennant is type. The other cases follow.[3]

Anasterias Perrier (Revision des Stellérides, 1875, 81), type, *Anasterias minuta* Per.

Leipoldt (Vettor-Pisani Asteroidea, Zeitschr. Wiss. Zool., Bd. 59, 1895, 570-571) considers *Anasterias minuta* a synonym of *Sporasterias rugispina*. Ludwig (Seesterne, Voy. S. Y. Belgica, 1903, 42) takes essentially the same view. *Anasterias*, being monotypic, thus becomes a synonym of *Sporasterias*. But Ludwig, excluding the type, retains the name for 5 species: *A perrieri* Studer, *A. studeri* Perrier, and 3 new forms. Ludwig's genus is therefore not *Anas-*

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[1] Bell, Ann. and Mag. Nat. Hist., ser. 6, VI, 1890, 472; Fisher, The Starfishes of the Hawaiian Islands, Bull. U. S. Fish Comm. for 1903, Part III, 1906, 1089.

[2] Bell, Loc. cit., VII, 1891, 233; Fisher, Loc. cit., 1088.

[3] It is a pleasure to acknowledge the kindness of Dr. Theodore Gill, with whom I discussed the merits of nearly all the cases mentioned in this paper. In the matter of Schulze's names Dr. L. Stejneger and Mr. H. C. Oberholser have also given helpful advice. I also wish to acknowledge the coöperation of the Librarians of the National Museum and Philadelphia Academy of Sciences.

terias Perrier, but is new. Being nameless, it may be called *Lysasterias*, with *Anasterias perrieri* Studer as type.

ASTEROPSIS Müller and Troschel (Archiv für Naturgeschichte, 6 Jahrg., Bd. I, Sept., 1840, 322), type, *A. carinifera* (Lamarck).

This name, which was published in 1840, and not in the System der Asteriden, 1842, as invariably quoted, has exactly the same signification as Gray's *Gymnasteria* (Dec., 1840), but is in turn antedated by *Asterope* Müller and Troschel, as explained below under *Gymnasteria*. The Archiv für Naturgeschichte appeared in 3 parts to each volume. The article "Ueber die Gattungen der Asterien (Auszug aus dem Monatsber. der König. Akad. der Wiss. Monat, April, 1840)" was very probably in the beginning of the third part, which would make the date about September, 1840. The genus is monotypic, and the name can not therefore be restricted to *Asteropsis vernicina* (Lamarck), as has been done by Perrier (Rev. Stell., 1875, 282) and authors since. *Asteropsis* is a synonym of *Asterope*, along with *Gymnasteria*. *Asteropsis vernicina* (Lamarck) Perrier becomes *Petricia vernicina*. The genus *Petricia* Gray (Proc. Zool. Soc., pt. XV, 1847, 81) has for type *P. punctata* Gray, which equals *Asterias vernicina* Lamarck.

CRENASTER Perrier (Ann. Sci. Nat. Zool., Art. 8, XIX, 1885, 71), type, *C. mollis* Per.

This name is invalidated by *Crenaster* d'Orbigny (Prodrome de Paléontologie, t. i., 1850, 240), a synonym of *Astropecten* Gray. *Crenaster* Perrier is very doubtfully distinct from *Dytaster* Sladen. The only difference is the absence of pedicellariæ in *Crenaster*. The same character has been unsuccessfully used by Perrier in attempting to distinguish *Pontaster* from *Cheiraster*.

CTENASTER Perrier (Bull. Mus. Comp. Zool., IX, 1881, 18), type, *Ctenaster spectabilis* Per.

L. Agassiz, in the Memoirs Soc. Scientif. Neuchatel, I, 1835, 192, used *Ctenaster* as a substitute name for *Asterina* Nardo, 1834. Its status corresponds to that of *Cribrella*. This prior use of *Ctenaster* ("Once a synonym, always a synonym") leaves Perrier's genus without a name. It may be called *Lætmaster*, the type and only known species being *Ctenaster spectabilis* Perrier.

DIPLASTERIAS Perrier (Compt. Rend., CVI, No. 11, 1888, 765; Mission Scientif. du Cap Horn, VI, Zoologie, Echinodermes, 1891, 77), type, *Asterias sulcifera* (Perrier), first species.

In the first citation the name is mentioned so casually that it must in all probability be disregarded as a *nomen nudum*. Perrier, in an appendix on page 160 of the second reference, gives precedence to Sladen's *Cosmasterias* (type, *Asterias sulcifera*), which was published while Perrier's paper was in press. Thus Perrier relegated his own genus to synonymy. The group was a very artificial one, and, strictly speaking, was not coextensive with *Cosmasterias*. But by reason of its type the name, at least, can be restricted to a definite aggregation of species, namely, the *Cosmasterias* of Sladen. This name, however, is long antedated by *Pisaster* Müller and Troschel,[1] type, *Asterias ochracea* Brandt. I have examined *Asterias sulcifera* (Perrier), and find that it is a *Pisaster*, as indicated by the peculiar large pedicellariæ and numerous rows of actinal intermediate plates. *Podasterias* Perrier (type, *Diplasterias lütkeni* Per.[2]) also seems to be typical *Pisaster*, making a third synonym. Since Perrier himself repudiated *Diplasterias*, the name should then and there have died a painless death. Kœhler, however, has resurrected it for two new species in his report on the echinoderms of the Expedition Antarctique Française (1906, and again in Zoologischer Anzeiger, Sept. 17, 1907, 141. This use of the name is incorrect.

GONIODON Perrier (Expeditions Scientifique du Travailleur et du Talisman, Echinodermes, 1894, 244), type, *Pentagonaster dilatatus* Perrier.

This name is antedated, and therefore invalidated, by *Goniodon* C. L. Herrick, Denison Univ. Scientif. Laboratories, Bull. III (April), 1888, 4; type, *G. ohioensis*, a mollusc. *Goniodon* Perrier may be called *Diplodontias*.

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[1]Archiv f. Naturgesch. 6 Jahrg., Bd. 1, 1840, 367; System der Asteriden, 1842, 20. Type *Asteracanthion margaritifer* M. & T. (=*Asterias ochracea* Brandt). This name was used by Prof. L. Agassiz on display labels in the Museum of Comparative Zoölogy, Cambridge. The reference, in A. Agassiz's "North American Starfishes," to the genus *Pisaster* "as recognized by Professor Agassiz" probably refers to these labels, as I find nothing in the latter's writings bearing on the subject.

[2] In Proc. Bost. Soc. Nat. Hist., VIII, 1861, 265, Stimpson described from the Coast of Oregon *Asterias lütkenii*, which is a *Pisaster*, thus antedating Perrier's name.

GYMNASTERIA Gray (Ann. and Mag. Nat. Hist., VI, Dec., 1840, 278), type, *Gymnasteria spinosa* Gray=*Asterias carinifera* Lamarck.

Within the year 1840 *Asterias carinifera* Lamarck was made the type of three genera: *Asterope* Müller and Troschel, *Asteropsis* Müller and Troschel, and *Gymnasteria* Gray. The first was described in April (Monatsber. d. k. Akad. d. Wiss. Berlin, 104), the second in September (Archiv f. Naturgesch., 322), and the last in December. Müller and Troschel thought that their *Asterope* was invalidated by *Asterope* Philippi (for a crustacean), published the same year in Archiv f. Naturgeschichte, part 2, June, 186, so that they changed the name to *Asteropsis* in their article "Uber die Gattungen der Asterien," published about September in the same journal, page 322. Investigation proves, however, that Philippi's name was published fully two months after that of Müller and Troschel, the evidence being a reprint of Philippi's article in the Annals and Magazine of Natural History, VI, September, 1840, 89. This translation states that it is reprinted from Wiegmann's Archiv, Part 2, *June*, 1840, thus fixing the date. There is no reason why *Asterope* should not replace *Gymnasteria*. The family *Gymnasteriidæ* will become *Asteropidæ*.

PATIRIA Gray (Ann. and Mag. Nat. Hist., VI, Dec., 1840, 290), type, *Patiria coccinea* Gray=*Asteriscus coccineus* M. and T., 1842=*Asterina coccinea* (Gray) Perrier, 1875.

Patiria was monotypic when described, and since its type is an *Asterina*, it naturally becomes a synonym of that genus. Gray, however, in Proc. Zool. Soc., 1847, 82, extended the genus to include *granifera*, *ocellifera*, *obtusa*, and *crassa*. Perrier, 1875, then restricted *Patiria* to *ocellifera* and *crassa*, relegating *coccinea*, *granifera*, and *obtusa* to *Asterina*. Sladen, in 1889, added a third species. It will be seen that Perrier, with his usual freedom of treatment, excluded the type from his genus *Patiria*, which is therefore not the *Patiria* of Gray. Perrier's genus may be called *Parasterina*, the type being *Patiria crassa* Gray.

PARARCHASTER Sladen (Narr. Chall. Exp., I, 1885, 610, Fig. 204), type, *P. pedicifer* Sladen.

This name is still employed by Ludwig, Kœhler, and others. It is a synonym of *Benthopecten* Verrill (Amer. Journ. Sci., XXVIII, 1884, 218, footnote).

PENTACEROS, PENTAGONASTER, and ASTROPECTEN.

Until recent years, and long after it had been agreed to abandon pre-Linnæan names, these three genera were attributed to Linck's "De Stellis Marinis," 1733. Even Ludwig, in "Die Seesterne des Mittelmeeres," 1897, followed the same course. Sladen, in 1889 ("Challenger" Asteroidea), adopted many of Linck's specific names, and the three generic names noted above. When it became evident, however, that adherence to generally accepted rules of nomenclature would be necessary, and that Linck's pre-Linnæan and non-binomial names would have to be relinquished, Schulze's booklet, "Betrachtung der Versteinerten Seesterne und ihrer Theile" (Warschau und Dresden, 1760, 58 pp., 3 plates), was hastily invoked to save *Pentaceros*[1] and *Astropecten*. Then *Pentagonaster* was attributed to Schulze, but the author who accomplished this commendable piece of research inconsistently overlooked *Pentadactylus* (since acceptance of that name would invalidate *Linckia*).

I recently examined for the first time, in Washington, a copy of Schulze's work, and showed it to Dr. Theodore Gill, Dr. Leonhard Stejneger, and Mr. H. C. Oberholser, all experts in matters of nomenclature. Each gave his opinion independently and emphatically that Schulze's names are not tenable.

These names are mostly derived from Linck's "De Stellis Marinis." There is no evidence that Schulze knew anything about binomial nomenclature, for he does not conform to the Linnæan system, and his so-called binomials are greatly outnumbered by single names. Both kinds are used in a specific or descriptive sense, as "Der Lederartige, *coriacea*" [=genus V, Stella coriacea, Linck, p. 30]. Those names in binomial form, such as *Pentagonaster regularis* and *Astropecten regularis*, are not genus and species, but are a more elaborate descriptive term, in imitation of Linck. They are really the modifying portion of a trinomial, of which the "generic" name is mentioned previously (*quinquefidæ*). Schulze has no real genera. He divides (p. 49) his starfishes into two classes, *fissæ* (=Asteroidea) and *integræ* (=Ophiuroidea). The former he subdivides into three genera (Geschlechte), according to the number of arms. In the first genus he places all which have less than five rays (*stellæ oligactæ*), and details several kinds, as der Dreistral, *Trisac-*

[1] Sladen first called attention to *Pentaceros* Schulze, but did so, rather disdainfully, for the benefit of those who refused to accept Linck's names. Sladen said that *Pentaceros* was used by Schulze "exactly in Linck's sense," overlooking the fact that "Linck's sense" of *Pentaceros* was a combination of *Hippasteria, Oreaster,* and *Asterina!*

tis, der Vierstral, *Tetractis*, etc. All 5-rayed forms are grouped in the second genus (*quinquefidæ*), under which he mentions numerous species or kinds, as das Fünfeck *Pentagonaster*, das reguläre Fünfeck, *Pentagonaster regularis*, das gesternte Fünfeck mit ausgerundeten Seiten, *Pentagonaster semilunatus*.

Further, he says: "Der fünfhornichte, *Pentaceros*, hat fünf tiefe, ausgeschweifte Seiten, und lange, kolbichte oder zugespitzte Strahlen. Die hierher gehörigen Arten sind entweder platt, *planæ*, oder aber hockericht und bauchicht, *gibbæ*."

Then are mentioned: Der eingekerbte Fünfstral *Astropecten*, der eingekerbte reguläre Fünfstral *Astropecten regularis*, der eingekerbte irreguläre Fünfstral *Astropecten irregularis*, der Gänsefussformige *Palmipes*, der lederartige *coriacea*, die stumpfwinklichte *obtusangulæ*, spitzwinklichte *acutangulæ*, fünfblattrichte *pentapetalæ*, die Meersonne *Sol marinis*, die Sternhand *Pentadactylus aster*. Besides those mentioned, there are numerous other single names referring to starfishes and ophiurans.

The absurdity of Schulze's names for other than historic purposes is well exemplified in *Pentadactylus aster*, which is Linck's *Pentadactylosaster* divided, possiby because it appeared too long. As a recognizable description accompanies this name, those writers who accept *Pentaceros* can hardly avoid adopting *Pentadactylus* also.

Sherborn, who has given the weight of his authority in favor of Schulze, misquotes in two instances in the "Index Animalium." *Palmipes* Schulze [=*Anseropoda* Nardo] has, according to Sherborn (l. c., 1151), the following species: *coriacea*, *obtusangula* (sic), *acutangula* (sic), and *pentapetala* (sic). Schulze mentions no names under his *Palmipes* (p. 51). Those quoted by Sherborn have nothing to do with *Palmipes*, and, with one exception, are inrectly spelled in the bargain. *Coriacea*, for instance, is coordinate with *Palmipes*, and is a descriptive term ("der lederartige"). The other names occur in the plural. So under *Pentaceros* Sherborn cites "*gibbus*" and "*planus*." Schulze says: "Die . . . arten sind entweder platt, *planæ*, oder aber hochericht und bauchicht, *gibbæ*."

These are not specific terms, either in form or intent—that is, not as we now employ specific names. But if *Pentaceros* "*planæ*" were taken as a binomial, equivalent to *Pentaceros planus* Linck (the type of *Pentaceros*), then *Hippasteria* Gray would become *Pentaceros* and *Oreaster* would replace *Pentaceros* Gray, Sladen, *et al.* As a matter of fact, *Pentaceros* Schulze is not a genus, and if it were it has no species name, being in the same class with *Palmipes*, *Coriacea*, *Tetractis*, *Hexactis*, *Heptactis*, *Octactis*, *Enneactis*, *Decactis*, *Dode-*

cactis, Triscædecactis. No efforts are being made to replace *Solaster* Forbes by *Octactis* Schulze, yet the identification by means of Linck, table XIV, n. 25 (the source of Schulze's name) is certain. Similarly if *Pentaceros* is valid, so is *Decactis* for *Crossaster;* or if there is any doubt about *Decactis,* none can be urged against *Triscædecactis!* In some cases Linck's plates are singularly good.

Schröter, in 1782 (Musei Gottwaldiani Testaceorum, Stellarum marinum, etc., Nürnberg, 58), used *Pentaceros,* but he is not a consistent binomialist, and his "generic" names are not tenable.

Pentaceros Schulze should be changed to *Oreaster* Müller and Troschel, 1842. *Pentaceros,* for starfishes, was given binomial standing by Gray in 1840, but Cuvier and Valenciennes adopted the name for fishes in 1828. The family becomes the *Oreasteridæ.* The type of *Oreaster* is *Asterias reticulata* Linn. (=*O. reticulatus* M. and T.).

Fortunately *Astropecten* was given binomial standing by Gray in 1840, and its signification does not change. *Stellaria* Nardo, 1834, another name for the same group, is invalidated by *Stellaria* Mœller, 1832, for a mollusk. Gray's *Astropecten* includes *Ctenodiscus, Astropecten,* and *Chætaster. Chætaster* was described a few months previously by Müller and Troschel, and *Ctenodiscus* was eliminated in 1842. No type was designated by Gray; as it is desirable to have one, *A. aurantiacus* (Linn.) may be so considered.

Pentagonaster Schulze is superceded by *Goniaster* Agassiz (type,[1] *Asterias tessellata* Lamarck). The name *Pentagonaster* was given validity by Gray, 1840, for a small and different group of which *P. pulchellus* is type. Ayres' *Stephanaster,* adopted by Perrier, is long antedated by this name, while *Phaneraster* Perrier is similarly invalidated by *Goniaster.*

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[1] Indicated by Agassiz. Mem. Soc. Sc. Neuchatel, t. i, 1835, 145.

IDENTITY OF A SUPPOSED WHITEFISH, *COREGONUS ANGUSTICEPS* CUVIER & VALENCIENNES, WITH A NORTHERN CYPRINID, *PLATYGOBIO GRACILIS* (RICHARDSON)

By WILLIAM CONVERSE KENDALL

Scientific Assistant, Bureau of Fisheries

To Cuvier and Valenciennes[1] is credited a name interrogatively applied by Valenciennes to a fish represented in a drawing made by himself. He supposed that it was a salmonoid, but was uncertain regarding the genus, and at the end of his description hesitatingly asks if it might not be called *Coregonus angusticeps*.

If the drawing was puzzling to Valenciennes, his description has been no less so to subsequent ichthyologists, who, while accepting it as applying to a *Coregonus* have been uncertain what species should bear the name or to what the synonymy should be assigned.

In the general ichthyological works since Cuvier and Valenciennes, it has been but briefly or doubtfully referred to or omitted entirely. Günther[2] mentions it in a footnote as known from a figure only and as one of the species so imperfectly described as to be worthy of only passing notice.

Jordan and Gilbert[3] do not notice it, while Jordan and Evermann[4] have placed it in the synonymy of *Coregonus labradoricus*, although with doubt. This disposition of it has been followed by Evermann and Smith[5] and by Evermann and Goldsborough.[6]

Regarded as a whitefish, notwithstanding the fact that the description, which was stated to be "brief and erroneous," did not fit the species, this perhaps was a natural conclusion for two reasons: Because the original description of *Coregonus angusticeps* appears

[1] Histoire Naturelle des poissons, XXI, 1848, 534.

[2] Catalogue of the Fishes in the British Museum, VI, 1866, 172.

[3] Synopsis of The Fishes of North America. <Bull. 16, U. S. Nat. Mus. 1882 (1883).

[4] Fishes of North and Middle America. <Bull. 47, U. S. Nat. Mus., part I, 1896, 466.

[5] The Whitefishes of North America. <Rept. U. S. Fish. Comm. 1894 (1896), 302.

[6] A Check List of the Freshwater Fishes of Canada. <Proc. Biol. Soc. Washington, XX, 1907, 100.

with the description of *Coregonus labradoricus*[1] almost as though it were continuous with the brief description of that species; and because the Saskatchewan River, from which the fish came, belongs to the Hudson Bay drainage, in the eastern portion of which, at least, *Coregonus labradoricus* was supposed to be the most common species of whitefish.

Recent investigations by the present writer, however, show that the description of "*Coregonus angusticeps*" is erroneous only in its erroneous application, and that the mysterious fish is not a whitefish at all, but a very common cyprinid of the far north, now known as *Platygobio gracilis* (Richardson).

A careful consideration of Valenciennes's description of *Coregonus angusticeps* shows that this fish, with so few scales in a longitudinal

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[1] "La Coregone du Labrador (*Coregonus labradoricus*, Richardson).

"Je ne connais aussi ce poisson que d'après M. Richardson. Il se rapproche du précédent par ses mâchoires et son palais sans dents, et par les quatre rangées qui sont sur la langue.

"Il en diffère, parce que le museau est tronqué et que la mâchoire supérieure me paraît plu longue que l'inférieure. Les écailes sont orbiculaires et disposées par rangs. L'espèce ressemble en général au *Coregonus quadrilateralis*. Les nombres sont:

"D. 15; A. 15; C. 35; P. 15; V. 11 ou 12.

"Ce poisson vient de la rivière Musguaw, qui se jette dans le golfe Saint-Laurent, près de l'île Mingan.

"Lorsque nous connaîtrons mieux cette espèce et la précedénte, si les naturalistes les réunissent pour en former un genre particuliere nous retrouverons en lui les deux sections que nous avons signalées dans nos Corégones.

"Parmi les dessins que j'ai faits des poissons que nous a communiqués M. Richardson,

"J'en trouve un aussi remarquable par la petitesse de sa tête que par la singulière disposition de sa bouche. La longueur de la tête est du sixième de la longueur totale, tandi que la hauteur du tronc n'y est comprise que cinqfois et quelque chose. La hauteur de la tête, prise à la nuque, mesure la moitié de sa longueur, et l'ouverture de la bouche est due tiers de cette même tête. La pectorale est longue et pointue: elle atteint presque jusqu' à la ventrale. L'anale est presque aussi haute que la dorsale. Les écailles sont de moyenne grandeur: il y en a cinquante-cinq dans la longueur et quinze dans la hauteur. Chacune d'elles est cisselée de huit à dix stries fines et rayonnantes.

"D. 10; A. 10; C. 19; P. 16; V. 8.

"Ce poisson est appelé parles naturels *Nat-chee-gœs*. Il a été pêché dans la riviere de Saskatehewan [*sic*]. L'individu est long d'un pied.

"C'est un curieux poisson que je ne retrouve pas cité dans l'ouvrage de M. Richardson. Je n'ose donner de nom à ce Salmonoïde, parce que je ne puis pas assez préciser la forme des dents, des mâchoires et par conséquent fixer d'une manière assez certaine le genre. Ma première impression avait été cependant d'en faire une Corégone puisque j'avais placé ce dessin à côté des autres espèces du même genre. On pourrait l'appeler *Coregonus angusticeps*?"

series, could not be a whitefish, much less any other salmonoid. This character suggests a cyprinid or a Catostomid, but the character of the mouth precludes the latter. According to Valenciennes, the drawing upon which the description was based was made from a specimen from the Saskatchewan River furnished by Richardson.

The only cyprinid recorded from the Saskatchewan by Richardson[1] is his "*Cyprinus* (*Leuciscus*) *gracilis*," of which he gives a full description and an excellent plate figure. In the following comparison of the essential features given in Valenciennes's account with the corresponding characters shown in Richardson's description and figure, it will be see that they almost exactly agree:

Val.—Remarkably small head.	Rich.—Small head.
" Head 1/6 total length.	" Head 5 in length to tip middle rays of caudal.
" Depth of body something over 5 in total length.	" Depth of body 5 in length to tip middle rays of caudal [from figure].
" depth of head, measured from nape, 1/2 its length.	" Depth of head a little more than 1/2 its length [from figure].
" Length of mouth 1/3 head.	" Length of mouth slightly less than 1/3 head [from figure].
" Pectoral long and pointed, almost reaching ventral.	" Pectoral long and pointed, extending a little over 2/3 the distance from its origin to base of ventral [from figure].
" Anal almost as high as dorsal.	" Longest dorsal ray 1 inch and 10 lines; longest anal ray 1 inch and 7 lines.
" Scales moderate, 55 in length.	" Scales large, 55 in length.
" Fifteen scales in cross-series.	" Seventeen scales in cross-series [only 15 shown in figure].
" Scales grooved with 8 or 10 radiating striæ.	" Scales with 10 or 12 fine streaks radiating from the center.
" D. 10; A. 10; C. 19; P. 16; V. 8.	" D. 9; A. 10; C. 19; P. 16; V. 8.
" Length of specimen 1 ft.	" Length 12 inches and 2 lines.
" Native name, Nat-Chee-Gœs.	" Cree Indian name, Nonathchee-gæs.

The evidence presented by this strikingly close agreement in details justifies the belief that Valenciennes had before him a drawing of the above-mentioned cyprinid of Richardson. Further evidence is

[1] Funa Boreali-Americana, III, 1836, 120, pl. 78.

found in Richardson's work (loc. cit.), where he says "our specimen having been submitted to the inspection of Baron Cuvier, was returned, with the following note attached to it: 'Espèce particuliere de Cyprin voisin de notre *Cyprinus microcephalus.*'"

This specimen was therefore sent to Cuvier and returned with his or Valenciennes's diagnosis prior to the publication of the first volume of the Fauna Boreali-Americana (1836). It seems not improbable, then, that the drawing was made from this specimen some 10 or 12 years before Valenciennes made the description of "*Coregonus angusticeps*," which was published in 1848, and that after so long a time the subject of his drawing was forgotten and he did not recognize the strange fish therein represented, which elicited the remarks and hesitating description quoted in footnote[1], page 96. But to some it will doubtless seem improbable, and even impossible, that an ichthyologist of Valenciennes's attainments should not detect that such a fish, even represented in a drawing only, having so few longitudinal scales and other unsalmonlike peculiarities, was not a *Coregonus*. Moreover, in volume XVII, 1844, p. 324 (Hist. Nat. Poiss.), there is a description of "*Leuciscus gracilis*" copied from Richardson's work and a reference to Richardson's "very pretty" figure of it, while, also, Valenciennes explicitly states in the description of C. *angusticeps* that he does not find it mentioned in Richardson's work.

But the fact that he did not find it mentioned by Richardson indicates that something was amiss; for Richardson would hardly have omitted such a "remarkable" species, especially one concerning which he considered it necessary to seek the opinion of Cuvier and Valenciennes. That Valenciennes did not find the fish mentioned in Fauna Boreali-Americana may possibly be accounted for by assuming that, his attention being concentrated mainly on the head parts, as the original description suggests,[1] he overlooked the above-mentioned discrepancies, and, prepossessed by the idea that it was a salmonoid from its superficial resemblance in form, he searched only among the Salmonidæ for its citation in Richardson's work.

A tracing of the original drawing of Valenciennes, made by a very experienced draughtsman connected with the Museum d'Histoire Naturelle and very kindly furnished by Prof. Leon Vaillant, conclusively proves that no other fish than the previously mentioned cyprinid could have been the subject of the drawing, notwithstanding the fact that the drawing shows an adipose fin, for the

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[1] J'en trouve un aussi remarquable par la petitesse de sa tête que par la singulière disposition de sa bouche.

form of the head and mouth parts and the fins are diagnostic, aside from the characters mentioned in the description.

In a letter accompanying the tracing, Professor Valliant says that it is not to be doubted that the resemblance between the fish represented in Valenciennes' drawing and that of Richardson's plate of *Leuciscus gracilis* is striking, and were it not for the adipose dorsal one would not hesitate to consider them identical. But, he continues, it is not difficult to admit that Valenciennes may have added the fin afterwards.

Professor Vaillant further suggests that, while Valenciennes was a very skillful and conscientious draughtsman, it is possible that he may have been deceived by some accident which happened to the specimen that he had before him.

Either of the above suggestions may be the true explanation of the erroneous presence of the adipose fin in the drawing; which is the more probable is hard to say.

THE MILLERS-THUMB AND ITS HABITS

By THEODORE GILL

I

A quite common and characteristic denizen of the cold streams of the entire northern hemisphere is a small brownish fish with a wide head, which is mostly found recumbent on the bottom of the stream and generally under a stone or some other object used for partial concealment. The name best known is Millers-thumb. It is one of a large family. The species are numerous and constitute a natural group which may advantageously be recognized as a subfamily (*Cottinæ*) closely related to the marine fishes known along the coast of the United States as Sculpins (*Myoxocephalinæ*). Although the species are mostly confined to fresh water, a few may occasionally wander into brackish or moderately salt water, as the Baltic Sea, the Gulf of St. Lawrence, and the North Pacific Ocean. Very little is known to most persons about these fishes, but considerable has been published in a scattered form, and the principal data are for the first time brought together in the present article; these have been arranged so as to facilitate comparison with the account of "the Sculpin and its habits," published in the Smithsonian Miscellaneous Collections in 1905 (vol. 47, p. 348–359).

Fig. 26.—Skull of Sculpin. After Girard.

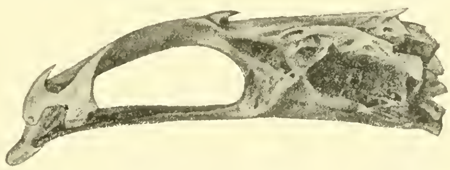

Fig. 27.—Skull of Sculpin. After Girard.

II

The Millers-thumbs, or Cottines, are a subfamily of Cottids[1] distinguished from the Sculpins or Myoxocephalines by the restricted

[1] The characters of the Cottids are given in the article on "the Sculpin" (p. 349).

lateral branchial apertures and the broad isthmus between them. The skull is differentiated into three regions—a broad, subquadrangular, postocular portion, an abruptly contracted, narrow, interocular region, and a wider preocular or rostral region. The armature of the head is weak, only one pair of conspicuous spines being developed, a single one about the hinder angle of the preopercle; there are, however, rudiments of two or three more below. There are a number of genera, especially in northern Asia, several of which are peculiar to the great lake Baikal and others to Japan.[1]

FIG. 28.—Skull of fresh-water Millers-thumb.

FIG. 29.—Skull of Millers-thumb. After Girard.

The name-giving genus, *Cottus,* embraces nearly fifty species, most of which are very much alike and difficult to discriminate. They are most numerous in the northern portions of America and Asia, and less so in Europe; but in the latter continent is to be found the longest and best-known species, *Cottus gobio.*

Millers-thumb is the most generally used name for the species of the genus in England. Yarrell explains how it came into use: "The thumb, by a peculiar movement, spreads the sample over the fingers and, employed with tact, becomes the gauge of the value of the meal produced. Hence the saying, 'Worth a miller's thumb.'" The thumb of the miller of the olden time became thus spread out be-

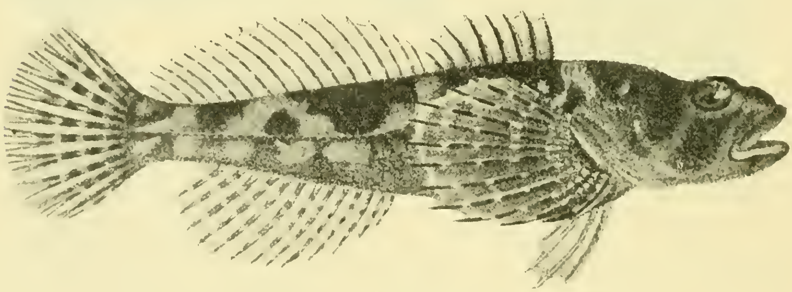

FIG. 30.—*Cottus gobio.* After Smitt (W. v. Wright).

neath the nail, and a likeness was fancied between it and the little fish. The name, however, is not the only one in use in England:

[1] The *Triglopsis thompsoni* of the Great Lakes, often associated with the Cottines or otherwise misplaced, is a typical Myoxocephaline, very closely related to the common *Oncocottus quadricornis* (*Cottus quadricornis* of most authors). The present author indicated this relationship as early as 1862 (Proc. Acad. Nat. Sc. Phila., p. 13).

Bullhead, Bull-knob, Bull-jub, Cob, Cod-pole, Cull, Harbeau, Noggle-head, Tom-cull, and Tommy-logge are applied in various restricted districts. None of these, unless it be Bullhead, was brought over to America by the early settlers, although it is said by Goode (1884, 259) that species are "known in some localities by the English name of Miller's thumb," etc. The name in most general use in the United States appears to be Blob; the primitive use of blob was for a bubble or drop, then for a splotch or blotch, and its transfer to a fish resembling a blotch when seen at the bottom of a stream was not unnatural. Other names applied in various parts of the United States are Bull-head, Muffle-jaws, and Spring-fish. Still more restricted are Stone-fish and Flying-fish, current, according to S. H. Gage, to some extent in central New York, the former being given because "it is found almost exclusively under stones," and the latter "from its rapid movements," which, however, are only manifest as short darts. Another name, Star-gazer, is a book name, originating from Dekay's ignorance of the relations of the fish so named, but adopted by a naturalist (S. H. Gage) of later times (1878). In Maine, according to Kendall (1904), in the Aroostook region, it is known as Rock Cusk, "from a fancied resemblance to the Cusk[1] (*Lota maculosa*); Brook Cusk is also given by Kendall (1908) for the same fish; Goblin is another name recorded by S. A. Forbes (1883) as a term for the *C. meridionalis* in Illinois; Mullhead, according to H. Smith (1907), is used in Virginia.[2]

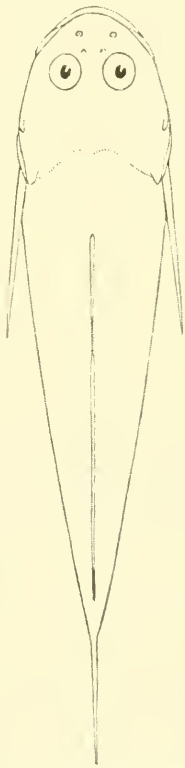

FIG. 31.—*Cottus gracilis.* After Girard.

[1] The same idea seems to be prevalent in Sweden, where one of the names (*Stenlake* or Stone-burbot) recorded by Smith (p. 172) conveys the same idea as Rock-cusk.

[2] Numerous popular names given to species of *Cottus* in various countries of Europe are recorded for the Austrian Empire by Heckel and Kner; for Germany by Siebold and others; for Scandinavia by Smitt, and for France by Blanchard, Rolland, and Moreau.

III

The only species whose habits are known are several of the genus *Cottus*.[1] These have been referred by some authors to two genera, *Cottus* and *Uranidea*, but they are so very closely related that what is true of one may be predicated for the other. They agree in all structural details and size as well as appearance and have only been distinguished because *Cottus* has four soft rays to each ventral fin, while *Uranidea* has only three; the former includes all the European and most of the American species, while the latter, so far as known, is confined to America. Inasmuch, however, as individuals from the same pond may differ in the number of ventral rays, and even the same individual may have four rays in one ventral and three in the other, the groups must be reunited under the name *Cottus*.[2]

The species are so similar in most characters that they can only be distinguished by a close, critical examination. The differences are mainly in the trend and character of the large preopercular spine, the number and condition of the rudimentary spines, the number of rays (especially anal), the relative size of the head and other parts, the presence or absence of palatine teeth (of less significance than in most groups), the spinescence or smoothness of the skin, the size of the mouth, the character of the nostrils, and the color. According to Jordan and Evermann, there are twenty-two species of *Cottus* and nine of *Uranidea* found in the United States and Canada, but no two original investigators, at present at least, would agree as to the exact number. The species are nearly uniform in size, most of them attaining a length of about three to five inches, few less, and few reaching a length of seven inches, or, quite exceptionally, a little more.

There are no such sexual differences in the Cottines as occur among the Myoxocephalines, although the sexes are readily distinguishable by the great development of a genital papilla in the male and its absence in the female; there may also be a difference in the size of the head (it being broader in the mature males than in the females), in the development of teeth on the palatine bones, the

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[1] A singular case of nomenclature occurs in Prevost's article "De la Génération chez le Séchot (*Mulus gobio*)." This name occurs only in connection with the title, but is reproduced in the reprint of the article in the Annales des Sciences Naturelles (XIX) in 1830. *Mulus* may have originated as a printer's mistake for *Cottus*; it could scarcely have been meant for a new generic name.

[2] For extent of variation in number of rays, see appendix to this article.

spinescence, and the size of some of the rays as well as the size of the body. Males appear to attain a larger size than the females, although the reverse is claimed by some.[1] All such probable differences, however, require confirmation and may vary apparently with the species.

The best observations on habits have been made on the *Cottus gobio* of Europe and the *Cottus gracilis* of the United States. The most notable on the former have been published by Newman, Heckel and Kner, Fatio, and Smitt; for the American species the best have been made known by S. F. Baird and Simon H. Gage; by the latter in "Notes on the Cayuga Lake Star Gazer," in "The Cornell Review" for 1878, pages 91–94, which merit exhumation from the obscurity in which they were buried.

IV

The species, numerous as they are, probably differ very little from each other in habits. All are inhabitants of fresh waters, though not all absolutely confined to such, and most of them of clear, cold

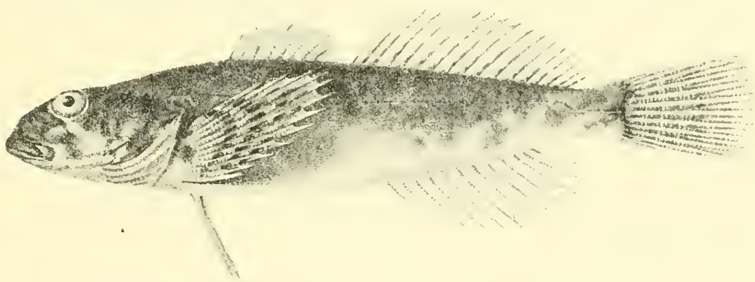

Fig. 32.—*Cottus gracilis* female. After *C. viscosus* Girard (Sonrel).

streams or lakes with a stony or rocky bottom. When in lakes, they affect the mouths of streams discharging into them. They are solitary most of the time, although where one is found, others may be lurking not far away.

S. F. Baird, who explored extensively the fresh waters of the northern United States in the early years of his life, summarized (1851) the results of his investigations of the most common of the

[1] My own observations have led me to believe that the male may attain a larger size than the female. Such was also represented to be the case by J. L. Prevost (1825). Fatio, a most careful observer, however, thought that the female was generally larger; he specified (p. 116): "Mâles présentant une tête plus largement arrondie en avant, avec une taille volontiers un peu moindre que celle des femelles." It is apparently a case of averages.

eastern cottids, *Cottus gracilis*, under the name *C. viscosus:* "These fish usually inhabit clear, spring waters, especially the spring runs which flow through rich meadows, bordered by turf, and having a shallow pebbly bottom. They lie concealed under projecting clods, flat stones, boards, or whatever may serve their purposes of concealment. On being disturbed, they usually hasten off to fresh cover, but sometimes remain motionless. Occasionally they occur in larger bodies of water, of less purity; but we have never seen them in creeks or rivers. Sometimes they are seen lying close to the edge of rivulets formed by leaking embankments, and where the water is far from clear. They always lie close to the bottom, and are never seen poised in the water."

According to Smitt, the common European species (*Cottus gobio*) "frequents shallow beaches and at spots of this nature is seldom

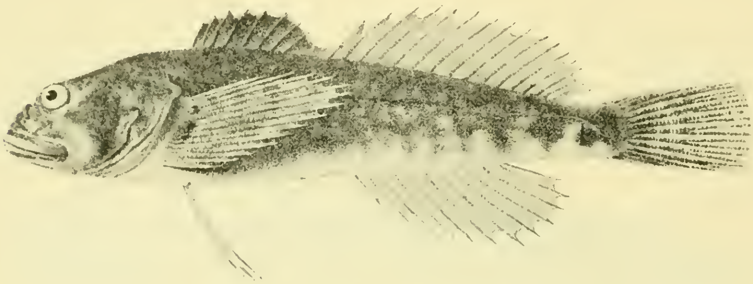

FIG. 33.—*Cottus gracilis* male. After *C. gobioides* Girard (Sonrel).

sought in vain, if one raises the stones. It is under them that it usually passes its time in quiet and inactivity," but watching for prey. Under a stone it may be often seen with its head or pectoral fins just exposed. "Its movements are quick; when driven from shelter, it darts with the speed of an arrow under the nearest stone or other suitable place of refuge." This peculiarity of lurking about stones has given rise to various names by which it is known in different parts of Sweden, as "*Stensugare* (*stone-sucker*)" and the like.

In dart-like movements the species resembles the little Perches of America known as Darters, and its American relatives indeed, to some extent, have been confounded with them. But, aside from the momentary darting movements, its actions are slow and laborious. It has, according to E. Newman (1856), "no power of sustained swimming, and never suspends itself in water like a true swimming fish; but it will occasionally make a forced march to the surface, working its enormous pectorals with great vigour and great labour. Sometimes such efforts extend even to a tour of the globe or vessel in which it is kept, but after such extraordinary exertions it sinks down apparently exhausted to the bottom, and there for hours remains motionless."

Newman's observations have been corroborated by the present writer. The attitudes and movements of the Millers-thumb are, indeed, very characteristic. They contrast with those of the perches and minnows by their attachment to the bottom. There they will remain for minutes and perhaps hours, motionless save for the respiratory movements of the gill and mouth—about 40 a minute. Generally they rest on the exserted ventral or anal rays and the body is more or less tilted forwards and backwards. All the fins are erect and motionless, and the pectorals outstretched sideways. The eyes are lateral, but directed somewhat upwards, and they bulge on each side of the interorbital area. The color is partly accommodated to the ground on which the fish rests, and when that ground is grayish sand, the color closely approximates, although the bands are generally distinct. They are quite apathetic and may not be at all disturbed by some other fish approaching and rubbing against them. Sooner or later, however, one is impelled to move, and with a flirt of the tail darts forwards. It rarely goes more than two or three inches away unless very much frightened. If induced to swim, it does so by a wriggling motion and laborious exercise of the pectoral fins.[1]

Another characteristic early (1856) insisted on by Newman is a certain change of hues. "There is something very remarkable in the changes of colour," and "these changes do not appear referrible to the ordinary tendency which the colour of certain fishes has to assimilate with the colour of the surface on which they are lying, but extraneous causes produce the effect; the swallowing a worm, the effort of a swimming adventure, and, on one occasion, the extrusion of ova, have produced such changes that the fish could not have been recognized under its altered aspect; the colours are various shades of gray and brown, and these are sometimes homogeneous, sometimes varied with great distinctness and brilliancy." Such changes of color surprised Gage, who experimented "over and over again to make sure there was no mistake." The change "from black to gray takes place in five minutes and sometimes even less." The "cause seemed" to Gage "to be the great fright and the light." Further, "upon studying them more carefully in an aquarium it was found that when the water became deprived of its oxygen they would pant like a suffocating animal, and become very pale, just as they did

[1] The observations of the present writer have been chiefly made on fishes in aquariums at close range and repeated very recently (April, 1908).

when frightened. If the water is changed, these pale fish soon regain their natural color and respire slowly and regularly."[1]

According to Gage, "If one be carefully watched at a considerable distance, the respirations, indicated by the alternate opening and closing of the mouth and gill fissures, will be seen to take place about forty times per minute. Now if one suddenly moves up very near the fish, not the slightest motion of the body or of the respiratory apparatus can be detected. If, however, one remains perfectly still for about half a minute and watches the gill-covers, he will see them commence to rise and fall very gently, and in two or three minutes the respirations will be as vigorous as ever. This experiment may be tried over any number of times and always with the same result. This is equivalent to holding the breath with the higher animals, and is apparently for the same purpose, viz, to escape detection."

One of the means of defense resorted to by the Millers-thumb is the puffing sideways of the head and the consequent extension of the preopercular spines. This may not only deter an enemy, but may entail serious consequences on one that attempts to swallow the little fish. Birds have been found dead with a Millers-thumb sticking in the throat.

The species are noted for voracity, and they are indiscriminate feeders. They are most active in search of food during the hours of darkness, as has been remarked by Fatio. "Insects, worms, gammaroids and other small crustaceans, or the fry or even the small fishes of no inconsiderable size" have been noted by Smitt and others as subjects of capture. They are even cannibalistic and do "not object to eating smaller brothers and sisters."

L. Lépinay (1907) records an instance of two individuals which had seized on the same victim, and the smaller, refusing to let go, was taken in by the larger one as far as the head, the greed resulting in death to both. When two or more fishes seize the same object there is a regular tussle and pulling to and fro, which reminds the observer of a couple of dogs tugging at a string.

Girard (1851) found only "insects and larvæ" in the stomachs of fishes he dissected. Six specimens, taken in southern Illinois and examined by S. A. Forbes, had eaten only animal food, about one-fourth of which consisted of fishes, one of which was furnished with ctenoid scales. Undetermined aquatic larvæ (thirty-six per cent) and other insects, were estimated at forty-four per cent of the food.

[1] The changes of color have been also especially noticed by Fatio (1882, p. 116, 117).

Crustacea, all belonging to the genus Asellus, eaten by two of the fishes, composed the remaining twenty-nine per cent."

But they are interesting to man, more especially on account of their destructiveness to fish-eggs. Inhabitants of the same waters as the Trouts, they are notorious for their ravages on the eggs of the latter fishes. They are consequently objects of detestation to pisciculturists and their numbers have sometimes to be reduced by special efforts. They crush the eggshells as well as the horny coverings of crustaceans and insects and reject them. A kind of mastication is thus manifested.[1]

Fatio has well described the manner in which the *Cottus gobio* procures its food. It lays in wait patiently and motionless till a fit victim comes within easy distance, and then springs upon it before the incautious animal is aware of its danger. If the prey is comparatively large—a Minnow, for instance—it will be seized head first, and while it is gradually taken inward, the Cottid looks as if it were chewing with its pharyngeal teeth. At other times, without moving its body, it will blow a current of water against some small body suspended above and in this way make it fall towards itself. Such a feat (which the present writer has never witnessed) was several times observed by Fatio and reminded him of the superior skill of the Archer-fish of Java (*Toxotes jaculator*). The mobility of the eyes upwards is advantageous to the fish for such purpose.[2]

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[1] Quoique doué d'appétits voraces ce petit carnivore paraît, en effet, ne pas goûter beaucoup les proies à enveloppes dures; du moins, je l'ai vu souvent happer par inadvertance et cracher de suite diverses sortes d'articulés. (Fatio, Faune Vert. de la Suisse, IV, 1882, p. 127. See also this article, p. 113.)

[2] Si la proie est grosse, un petit goujon ou un véron, par exemple, l'animal avalé, la tête la première disparaîtra petit à petit dans le gouffre qui l'attire, sans que le Chabot ait l'air d'opérer la moindre mastication avec les maxillaires, probablement sous l'action et la traction des dents pharyngiennes. D'autres fois, enfin, mieux nourri ou plus paresseux, notre *Cottus* usera de petits subterfuges pour amener jusqu'à lui les miettes qu'il désire; sans prendre la peine de bouger, il projetera ou soufflera, par exemple, un courant d'eau contre tel ou tel petit corps suspendu au-dessus de lui et qu'il veut détacher pour le faire rouler jusqu'à lui. Cette petite manœuvre, que j'ai eu l'occasion de voir exécuter plusieurs fois, rappelle, jusqu'à un certain point, l'adresse du *Toxotes jaculator* de Java qui projette, souvent à une distance de trois à cinq pieds, une goutte d'eau sur les insectes posés au-dessus de la surface, dans le but identique de les faire tomber et de s'en emparer (Fatio, op. cit., pp. 126, 127).

VI

Distinctive sexual characters become manifest during winter or spring, varying in time of development with temperature. The color of the males becomes more intense. "The female, the belly of which is almost monstrously distended during pregnancy, lays its eggs in March" in Sweden—both then as well as earlier or later, according to temperature, in other countries.[1] But first preparation is made for the deposit, and a hiding place is prepared by the male or female (it

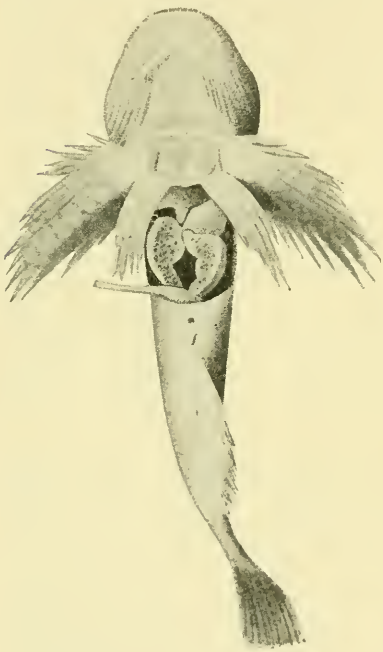

Fig. 34.—*C. gobio* male. After Prevost.

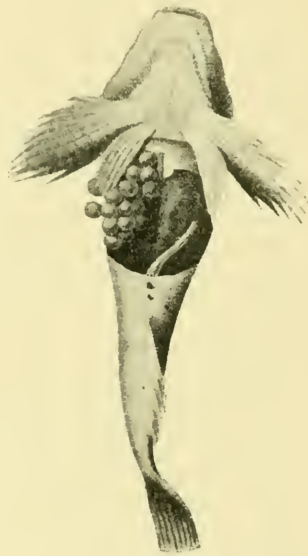

Fig. 35.—*C. gobio* female. After Prevost.

is uncertain which) scraping a hole with its tail under a stone, or it fastens the deposit of eggs (which is in a mass about the size of a "sparrow's egg") to "stones or bridge-piles driven into the bottom."

[1] According to Baird (1851), the eggs of *Cottus gracilis* (*viscosus*) "are laid from the middle of April to the end of May, and are deposited in round packets about the size of an ounce bullet, under boards, stones, and in shallow, springy water. It is possible that they are watched by the parent, as we have frequently found individuals under the same cover as the eggs. The ova are of a rose color, and about the size of No. 3 shot, conveying the impression of disproportionate size."

The female then "deserts them, and the male takes" her "place as their protector and guards them for a month, until the young are able to shift for themselves."

Special data on oviposition or parental care have been published by Edward Newman and Simon Gage.

The fish observed by Newman was a female, and soon after its reception (March) it "extruded during the night a mass of ova, collectively equal in size to a sparrow's egg;" the eggs were "nearly transparent and enclosed in a tough envelope; the mass was closely adherent, somewhat reminding one of frog's spawn, but the ova appeared to have no mucilaginous covering. The number of ova must have been about a hundred." "Two mornings after their extrusion, the unnatural parent had torn the mass asunder and devoured the greater part of the ova, and before night the work of demolition was completed by the combined efforts of the Millers-thumb and two minnows." There was no male to assume guardianship. If there had been, doubtless he would have protected and taken charge of the eggs.

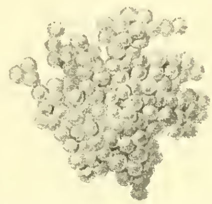

Fig. 36.—Eggs of *Cottus gobio*. After Prevost.

According to Gage, if one goes to the west shore of "Cayuga Lake from April to July, and lifts up flat stones in water twelve to fifteen centimetres deep, there will be found clinging to the under side of many of them an irregular conical mass of beautiful salmon-colored eggs; and under the same stone a Stargazer." Gage thought "the fish seems to have forethought," for the eggs "are never laid above the low-water mark of July; hence in April or May one must look in deeper water for them than in July."

Soland, in a work on the Fishes of Anjou (1869), has affirmed that, after hatching, the male continues his care of the young and remains with them until they are nearly full grown. No other observer has confirmed this claim, which is probably based on some error of observation or deduction.

VII

No detailed observations corresponding to those on the Sculpin have been published about the embryology of the Millers-thumb. J. L. Prevost long ago (1825) noticed the eggs and the newly hatched embryo, 5 millimeters long, but did not carry his observations further. Baird (1851) remarked that he had occasionally "found the eggs with embryos moving freely within the envelope. A set examined April 22d, 1848, had the eye very distinct, and of large size. The fœtal fin extended from the head, by the tail, to the anus. In the course of the day, many became liberated and swam about with the yolk-bag attached. This was sessile, and filled with a transparent, reddish liquid, excepting opposite to the embryo, where was a hard, yellowish cake. All [his] attempts at raising the young, or of development of the egg, failed for want of fresh spring water." No later investigations have been published. From the figure given by Prevost, it appears that *Cottus* has a larger yelk-sac than *Myoxocephalus.*

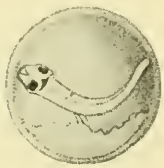

FIG. 37.—Embryo of *C. gobio.* After Prevost.

Growth appears to be moderately rapid, but exact data are wanting. Specimens in the collection of the National Museum are not in sufficient number nor with exact dates of capture enough to enable

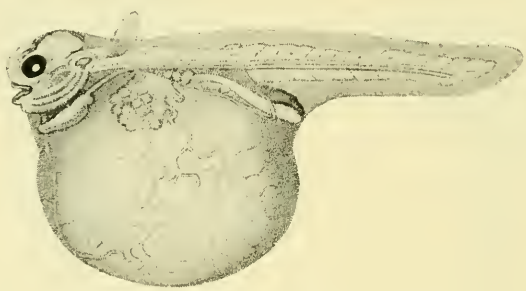

FIG. 38.—Fetus of *C. gobio* 5 mm. long. After Prevost.

one to distribute them according to size at any given period. According to Hartmann and Fatio the common Cottid of Switzerland (*Cottus gobio*) became capable of reproduction at the age of two years—that is, about the beginning of its third year.

VIII

None of the species are utilized for food in the United States, at least by natives. In Europe, however, they are to some extent employed—not in England, but on the continent. Moreau informs us that in France the quality of the flesh is variously appreciated; Smitt remarks that in Scandinavia "it is stated by many to be of extremely good flavour." The flesh is "white, but is said to turn red when boiled," in some localities, but, according to Day, "not so in others." Fatio tells that in Switzerland the fish is much sought for, not only by fishermen for bait for other fishes, but by lovers of dainties as an agreeable food.

In America, as already noted, the Millers-thumbs, under the name of blobs, are best known as destroyers of the eggs of the trouts as well as salmons, and as such do much damage, and are consequently regarded as pernicious pests.

The published data respecting the injury inflicted on piscicultural interests are scanty. Mr. F. M. Chamberlain, in "Some observations on Salmon and Trout in Alaska," compiled for the "Report of the Commissioner of Fisheries" for 1906 (issued December 18, 1907), simply reported that "the Sculpin or Bullhead would seem to be a more dangerous enemy to the Salmon fry than is the trout; it lurks under the stones in just such places as the fry will seek for shelter (p. 108); on the other hand, it has been asserted that the little fish not infrequently falls a victim to the old trouts (p. 107).

An appeal to the U. S. Fish Commission, and especially Dr. B. W. Evermann, Mr. J. W. Titcomb, Dr. W. C. Kendall, Mr. E. L. Goldsborough, and Mr. H. W. Clark, elicited confirmation of the charge against the Cottids. Mr. Goldsborough communicated data which are noteworthy, not only for their bearing on the matter in question, but also confirmatory of the deliberate manner of feeding previously described by Fatio; his communication is herewith given:

"In the fall of 1903 (September), while at the Salmon hatchery of the Alaska Packers Association, located at Loring, Alaska, I was watching and helping the men spawn the fish. We were wading around in the stream (Naha River) and many eggs were dropped into the water. These were at once gobbled up by the blobs (*C. gulosus*), hundreds of which were lurking around among and under the small stones in the stream. They were so voracious as to at once attract my attention. I got a handful of the fresh, soft eggs and pitched them where I could observe what happened. They were devoured in a few minutes by several blobs and sticklebacks. I kept account of the work of one little blob particularly, which was perhaps three or four inches long; it ate twenty of the eggs and hunted for more. The eggs were all devoured in perhaps two or three minutes. The fish would take a single egg in its mouth, puncture it to get the soft contents, then spit out with some force the soft shell, and immediately take another egg and do the same thing.

"The blob has since been recognized by the superintendent of their hatchery, Mr. Fred Patching, as so destructive to salmon fry that he has made a regular and persistent effort to capture them, and by using traps bated with salmon eggs he has caught thousands."

Cottids have been little used in medicine, but in Russia, according to Pallas, dried fishes were used by peasants as charms or amulets worn round the neck as antidotes against fevers.[1]

APPENDIX

While engaged in the examination of Cottids many years ago, I was struck by the fact that there was unusual variation in the number of rays of the ventral fins and was convinced that it had not the systematic value which it might naturally be supposed to have. Recent observations have fully justified the skepticism. Especial observations were made with reference to the value of the number of ventral rays by W. C. Kendall in "Notes on some fresh-water fishes from Maine," published in the Bulletin of the United States Fish Commission for 1902 (XXII, 1904, pp. 361, 362). Dr. Kendall examined a large number of individuals of the *Cottus gracilis*. "Out of 28 specimens otherwise essentially alike from Caribou, 18 had 3 ventral rays in each ventral fin, 6 had 4 rays in each fin, and 4 had 4 rays on one side and 3 on the other. Of 15 specimens from six other localities in northern Maine, 4 had 3 rays in each ventral, 7 had 4 on each side, and 4 had 3 on one side and 4 on the other. Six specimens from Bear River, Newry, in the western part of Maine, had uniformly 3 rays in each fin."

Being desirous to have still fuller statistics respecting the structure of the ventral fins and the development of sexual characters in the genus *Cottus*, I requested Mr. Alfred C. Weed, assistant in the Division of Fishes, to compile certain data. He kindly prepared for me the results of examination of 50 specimens of the *Cottus richardsonii*.

[1] In cibo a nemine adhibetur, sed siccatum, amuleti instar, appendunt collo, ut pectus tangat, creduntque prodesse ad Tertianas abigendas. Pallas Zoögraphia Rosso-Asiatica, 3, 126. No special locality in the Russian empire is mentioned in connection with the superstition.

COTTUS RICHARDSONII[1]

Number of specimens, 50.[2]
Number of males, 32.
Number of females, 18.
Number with ventral rays same on both sides, 45.
Number with ventral rays 3 right and 3 left, 38.
Number with ventral rays 4 right and 4 left, 7.
Number with 3 ventral rays on right side, 42.
Number with 3 ventral rays on left side, 39.
Number with 4 ventral rays on right side, 8.
Number with 4 ventral rays on left side, 11.
Number with more ventral rays on right side than on left, 1.
Number with more ventral rays on left side than on right, 4.

The only asperities found were a small patch of prickles in the axilla of the pectorals, extending caudad as far as the end of the pectoral. In 5 specimens (4 males and 1 female) these were apparently absent.

The sexes showed no noticeable differences in regard to the pectoral and ventral fins.

In the specimens from Labrador the longest dorsal spine was about 1/4 inch in males and about 3/16 inch in females, without regard to the length of the fish.

Males from Labrador were 2 1/8 inches to 3 9/16 inches long.

Females from Labrador were 2 1/4 inches to 3 1/8 inches long.

Males from other localities were 2 11/16 inches to 5 1/2 inches long.

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[1] The *Cottus richardsonii* has been called *Cottus ictalops* in recent ichthyological works by reason of the assumption that it was the species intended by Rafinesque under the name *Pegedictis ictalops*. Rafinesque's fish with "small scales," "thoracic fins with five rays," and "second [dorsal] with twelve" rays was, however, apparently the same as his *Etheostoma flabellare* and *E. fontinalis*.

[2] Number of specimens from Labrador, 42.
" " " " Wytheville, Va., 1.
" " " " White R., Ind., 1.
" " " " Vermont, 1.
" " " " Evanston, Ill., 1.
" " " " Alabama, 2.
" " " " Marshfield, Mo., 2.

A female from another locality was 2 5/16 inches long.

As a whole, the dorsal and anal rays are a little higher in males. Other than this I can see no differences between the sexes except the structure of the post-anal region.

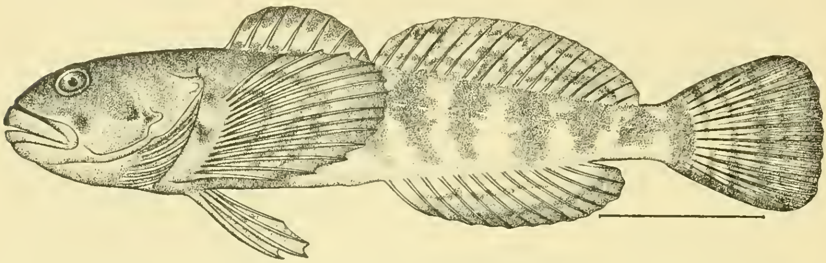

FIG. 39.—*Cottus punctulatus* (Gill).

NOTES

Note on a Fossil Stickleback Fish from Nevada

In the Proceedings of the U. S. National Museum, vol. 32, for 1907, p. 271, fig. 12, Dr. Oliver P. Hay describes a fossil fish from the Lahontan beds of the Truckee irrigation canal near Hazen, Nevada, under the name of *Gasterosteus williamsoni leptosomus.*

In Publications of the University of California, Geology, v, no. 5, p. 131, figs. 25, 26, the present writer has described the same species from the same region, under the name of *Merriamella doryssa.* From the incomplete material, the relationships of this form were thought to be with the *Atherinidæ*, but the photographs given by Dr. Hay show clearly that the little fish is a genuine Stickleback; in fact, the species can not be separated, on the material photographed, from the genus *Gasteröstcus,* the typical group of living Sticklebacks. Its slender form and longer spines sufficiently distinguish it from the living *Gasterosteus williamsoni,* Girard, which is probably a fresh-water form or ontogenetic representative of the common marine *Gasterosteus cataphractus,* Pallas.

As my paper was issued in April, 1907, and Dr. Hay's on May 18, 1907, the species should apparently stand as *Gasterosteus doryssus,* Jordan. I am indebted to Dr. Gill for calling my attention to the identity of these fossils—a fact still earlier noticed by Dr. Merriam and by Dr. Hay.—David Starr Jordan.

Congress of Americanists

At the suggestion of the Smithsonian Institution, the Department of State has designated Prof. Franz Boas, of Columbia University; Prof. Marshall H. Saville, of Columbia University; Prof. George Grant MacCurdy, of Yale University; Prof. Charles Peabody, of Harvard University, and Prof. Paul Haupt, of Johns Hopkins University, to represent the United States at the Sixteenth International Congress of Americanists, to be held at Vienna, September 9–14, 1908. Dr. Franz Boas will be the official representative of the Smithsonian Institution.

Smithsonian Grants

A grant from the Smithsonian fund has recently been approved to enable Dr. George P. Merrill, of the National Museum, to investigate personally the results of further borings in the Meteor crater of Canyon Diablo, Arizona.

A grant has recently been approved in behalf of Miss Alice Eastwood to aid in the re-collecting of the types of genera and species of plants collected by Thomas Nuttall in 1836 at Santa Barbara, California, and subsequently described by him.

Naples Zoölogical Station

The Smithsonian seat at the Naples Zoölogical Station was occupied by Mr. I. F. Lewis, of Johns Hopkins University, during the month of March, and by Prof. F. M. Andrews, of the Department of Botany of Indiana University, during the months of April and May.

Assignments of the Smithsonian seat have already been made for the first six months of 1909. The application of Prof. Charles A. Kofoid, of the University of California, has been approved for the first five months of the year, while through the courtesy of Dr. Anton Dohrn, the director of the station, Prof. Michael T .Guyer, of the University of Cincinnati, will also occupy a seat through the months of April and May, as well as through the month of June.

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1802	Notes to *Quarterly Issue*, Vol. V, Part 1. 1908	M.C. LII	
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1805	WALCOTT, CHARLES D. Cambrian Geology and Paleontology. No. 2—Cambrian Trilobites. 1908	M.C. LIII	.20
1806	Classified List of Smithsonian Publications Available for Distribution, May, 1908	Sp.	
1807	GILMORE, CHARLES W. Smithsonian Exploration in Alaska in 1907 in Search of Pleistocene Fossil Vertebrates. 1908	M.C. LI	.25

HENRY NETTELROTH

VOL. 52 1908

SMITHSONIAN

MISCELLANEOUS COLLECTIONS

VOL. V QUARTERLY ISSUE PART 2

THE NETTELROTH COLLECTION OF INVERTEBRATE FOSSILS

By R. S. BASSLER

(WITH 3 PLATES)

One of the most important accessions in the division of stratigraphic paleontology during the year 1907 was the collection of the late Henry Nettelroth, acquired jointly by the Smithsonian Institution and the U. S. National Museum from his sons, H. H. Nettelroth and Dr. Alexander Nettelroth, of Louisville, Kentucky. The registration and installation of these specimens was recently completed, and it seemed in order, as well as very desirable on account of Mr. Nettelroth's work in science and of the valuable nature of his collection, to publish an article upon the subject. The collection is composed entirely of invertebrate fossils, mainly from the Silurian and Devonian strata of Indiana and Kentucky, although many other American as well as foreign localities are represented. The total number of specimens is rather small compared with the number of species represented, the collection comprising about 8,000 specimens, registered under nearly 1,000 entries; but all of the material is the best that could be had. Mr. Nettelroth prided himself upon the fact that his cabinet contained only choice specimens, representing years of careful selection. Imperfect material was retained only when it showed something of scientific interest. In exchanging, Mr. Nettelroth also insisted upon a few good specimens rather than numerous poor representatives of a species. Likewise he paid particular attention to a class of fossils, the mollusca, which is seldom well represented in the cabinets of even the best collectors. The result of this continual selection was that in the course of years his collection was unequaled along certain lines, and it was only fitting that the specimens should be used for study and illustration in the monograph of "Kentucky Fossil Shells" prepared by Mr. Nettelroth and issued by the State as a memoir of the Geological Survey of Kentucky. Practically all of the specimens figured by Mr. Nettelroth in this work were from his own cabinet and are now preserved in the U. S. National Museum collections. A list of these type specimens is given beginning on page 135.

I am under obligations to Mr. Nettelroth's sons for many courtesies extended to me during my work upon the collection. Dr. Alexander Nettelroth has kindly furnished me with biographical notes from which the following sketch was prepared.

Henry Nettelroth was born in the Kingdom of Hanover, on June 6, 1835. His family from a remote period were land-owners, inhabiting that portion of German territory, with estates located about the village of Nettelrode. Henry Nettelroth attended the German universities and was graduated as a civil engineer just before the war between Prussia and Hanover; he was an engineer officer in the Hanoverian army, but came to America shortly after the battle of Langensalza. Here he took up the practice of civil engineering. His first employment as topographical engineer on the Elizabethtown and Paducah Railroad, then building, taking him to Kentucky, determined his subsequent location in Louisville. In that city he continued the pursuit of civil engineering, both active and consultant, until incapacitated by ill health a few years before his death.

He became an American citizen, having immediately on his arrival in this country renounced allegiance to any European government. In 1867 he was married, in Louisville, Kentucky, to Emma Vassmer, also of Hanover. Mr. Nettelroth died on September 2, 1887, his widow and two sons surviving.

He had been interested in paleontology while still in his native country, and it was but natural that the collection and study of fossils should be continued in connection with a profession which offered such good opportunities. In his spare time, therefore, during more than fifteen years, he enthusiastically collected geological specimens, wisely limiting his cabinets principally to those fossils found in the immediate vicinity of Louisville and the Falls of the Ohio, but including, however, related specimens from other sections of the country. His zeal in this pursuit stimulated the local interest in paleontology, and there appeared a number of collectors, several of whom became known later as capable and discriminating paleontologists. As a result of the enthusiasm of this coterie, a number of excellent collections were brought together and some rich beds and fossil-bearing strata were discovered which are now known universally to geologists.

Mr. Nettelroth's contribution to geological literature consists of a quarto volume of 245 pages and 36 plates, entitled "Kentucky Fossil Shells: A Monograph of the Fossil Shells of the Silurian and Devonian Rocks of Kentucky." This work, which was issued by the Kentucky Geological Survey in 1889, two years after the death of its author, is strictly biological in its scope. Over two hundred species of mollusca from the strata mentioned in the title were described and illustrated, in addition to a few Ordovician brachiopoda, sponges, and bryozoa. A short sketch of geology and paleontology, written for the general reader, introduces the purely descriptive part, but no particular reference is made to the geology of the Ohio Falls region. Forty-three new species were instituted by Mr. Nettelroth, the remainder being for the most part redescriptions and illustrations of forms described by others in various scattered publications.

The care with which the paleontologist of today assigns definite localities and horizons to his species was not always observed in the past, and it is therefore a satisfaction to note Mr. Nettelroth's procedure in this matter. Although geographic names for the several Devonian formations at the Falls were not employed at the time of his studies, still his citations are careful enough to accurately locate most of the species. Thus the registration of a species as from the hydraulic limestone is equivalent to placing it in the Silver Creek formation as we now know it, and likewise the "rotten hornestone in the upper strata of Devonian age" or the "cherty layers on top of the hydraulic limestone" clearly indicate the present Sellersburg formation.

His variety of ways of citing formation and locality is most interesting and entertaining. Thus the formation and locality of *Meristella unisulcata* (page 100, op. cit.) is described as follows:

"Found in the upper strata of the Corniferous group surrounding the Falls of the Ohio, in Kentucky and Indiana, where fractions of this species are pretty abundant in some localities, but fine and well-preserved specimens of the whole shell, as well as of single valves, which are found, are exceedingly rare. My cabinet contains some exquisite examples of this species. The fossils of the Corniferous strata from the neighborhood of the Falls are, on the Indiana side of the river, generally more numerous, and in the average better preserved than those found in Kentucky. The little town, Charlestown, in Clarke County, Indiana, two or three miles off the river, is about the center of one of the richest fields of the Devonian formation, which has furnished a great many cabinets with very choice specimens. A day's rambling in the washes of the fields around Charlestown, after several days' hard rain, is a real treat to any geologist, and never fails to fill his basket with fine shells, beautiful corals, and sometimes, but not very often, with rare crinoids."

These little descriptions sometimes contain matter of a more scientific nature than the one just quoted, in witness of which is the following (*Spirifer gregaria,* page 120):

"This species is found abundantly in the Corniferous limestone at and around the Falls of the Ohio, in Kentucky and Indiana. It appears here silicified, in well-preserved specimens of the whole shell, as well as of the separated single valves. Specimens still inclosed in the limestone are of the same material. From observations made by me at the Falls of the Ohio, and which, undoubtedly, were also made by other geologists, who visited and examined that world-renowned storehouse of Devonian fossils, but of which I never found any notice in print, I am forced to the conclusion that the silicification of the shells and corals is produced by their exposure to water and weather, and that this process requires only a comparatively short time. Whenever, at low stages of the water, the bed of the Falls becomes dry, we find it entirely covered by fossil shells and corals, partly exposed above the solid rock and partly inclosed in the same. All the exposed fossils which have been acted upon by water and weather for some length of time are silicified, as far as they are above the matrix, while the inclosed parts are still limestone, or, if a change in their material has already commenced, the silicification has not sufficiently advanced to resist the dissolving power of muriatic acid, which has not the least influence upon the exposed parts. In the same condition are the fossils found in the fields near the Falls in Kentucky and Indiana. Those which are entirely weathered out, and the parts of others freed from the matrix, are silicious, while the inclosed parts have retained their original material."

This explanation of the silicification of fossils has been held by few geologists, but in the opinion of the present writer Mr. Nettelroth's general idea is correct and can be verified from many other observations.

The most valuable part of the Nettelroth collection was derived from the Silurian, Devonian, and Lower Carboniferous strata outcropping in the vicinity of Louisville. The quarries and other exposures along Bear Grass Creek have long been known to paleontologists for the many fine Silurian and Devonian fossils yielded by them, while the outcrops at the Falls of the Ohio are recognized the world over as a storehouse of Devonian fossils. The accompanying photographs are of some of the best-known fossil localities in the vicinity of Louisville. Of most interest, probably, is the celebrated Falls locality shown in figure 1, plate X. Here, at times of low water, great stretches of Devonian limestone are exposed with a new lot of fossils showing every year. The choicest specimens on

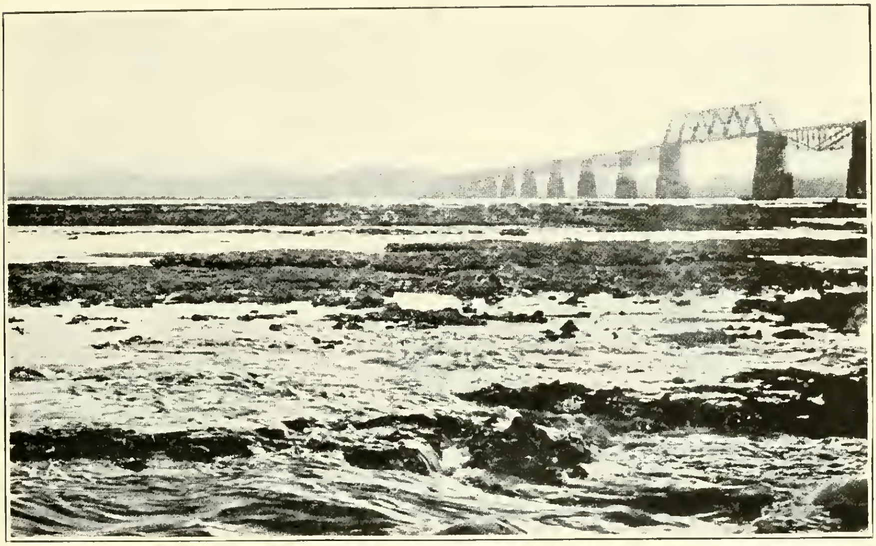

FIG. 1.—THE FALLS OF THE OHIO AT LOW WATER

FIG. 2.—ONE OF THE BEAR GRASS QUARRIES

The uppermost strata are of Devonian age, while the lower rocks are compact argillaceous Niagara limestone

the Falls naturally fell to the first collector on the scene, and there was therefore much rivalry among the paleontologists of the Falls cities. The peculiar conditions of weathering on the Falls left all of the exposed fossils silicious, so that portions still embedded in the limestone had to be carefully chiselled out. This silicification extended a short distance into the limestone, and it was due to this fact that the more delicate forms, when attached to the rocks, could be etched out with acid. In figure 2, plate X, both the Devonian and Silurian limestones are shown in the face of one of the old Bear Grass Creek quarries. Fresh exposures of these limestones show relatively few fossils, but the weathered débris and strippings of the quarry are often crowded with specimens. Other well-known Niagara localities along Bear Grass Creek are represented in figures 1 and 2, plate XI. The Devonian black shale, or New Albany shale, as it is locally known, although usually unfossiliferous, has yielded a few fossils from strata above the river banks at New Albany, Indiana. The youngest Paleozoic rocks in the immediate vicinity of Louisville are of early Mississippian age. They include a representative of the Rockford limestone, which locally separates the black shale from the overlying shales and sandstones of the Knobstone group. The latter forms the upper part of the hills and is well shown at Button Mold Knob, several miles south of the city.

The Silurian and Devonian strata of the Louisville region are probably best known to the scientific world, and the accompanying views are introduced to illustrate some of the localities for fossils.

The strata at the Falls of the Ohio have often been mentioned in the literature since 1827, when they were first described by Lapham. The age and correlation, particularly of the Devonian strata, have often been in question, although now there seems to be general agreement upon the subject.

In 1860 Major Sidney S. Lyon divided the beds of the Falls, according to their fossils, as follows:

	Feet
Black slate	50 to 100
Encrinital limestone	8
Hydraulic limestone	20
Spirifer cultrijugatus bed	3
Nucleocrinus bed	2
Spirifer gregaria and Turbo beds	10
Coral beds	10
Catenipora escharoides beds	40

The Catenipora (Halysites) beds have always been recognized as Silurian, being filled with fossils characteristic of that age. Recently

Mr. Foerste applied the name Louisville limestone to this particular division of the Silurian. The fauna is a large one and is well known through the works of Hall, Lyon, Nettelroth, and others.

The succeeding beds of Major Lyon's classification have offered more difficulty in exact correlation. The scarce and undiagnostic fossil evidence afforded by the Devonian black shale has made it difficult of exact correlation. Following the determination by Hall, and the recent, more detailed studies of Kindle, it is now generally correlated with the Genesee and Portage shales of the New York section. The Devonian limestones, on the other hand, furnish an abundance of fossils; but here the difficulty first arose from a lack of care in the exact location of the fossils in the section. It is only in recent years that the horizons of the various species have been accurately determined, and even now the geologic position of some of the rare forms is in question.

In the vicinity of Louisville the Devonian limestones are now divided into three beds: (1) gray to blue crystalline limestone about 20 feet thick, overlying the Niagaran strata and comprising the four beds in Major Lyon's section between his Catenipora bed and the hydraulic limestone; (2) a fine-grained silicious limestone or cement rock (the hydraulic limestone of Lyon), and (3) a thin bed of purer encrinal limestone which is overlaid by the Devonian black shale. These limestones were originally considered together as of Upper Helderberg age by Hall, but later the lowest division was correlated with the Corniferous (Onondaga) of New York, and the upper two members were referred to the Hamilton.

In 1899 Kindle applied the local name of Jeffersonville limestone to the lowest division and proposed Sellersburg beds for the cement rock and overlying purer strata. The following year Siebenthal introduced the new name Silver Creek hydraulic limestone for the cement rock and restricted the name Sellersburg to the overlying beds.

Mr. Nettelroth and other local collectors used no special geographical names in locating the horizons of their fossils, but the various beds in the section were very well known. Mr. Victor Lyon has kindly furnished me with a list of the local names applied to these beds at that time, and these, in the form of a section with the more recent correlations, are given below.

FIG. 3.—LOUISVILLE LIMESTONE ALONG BEAR GRASS CREEK, IN CHEROKEE PARK, JUST ABOVE BIG ROCK
Niagaran crinoids are most abundant in the strata just above the water level

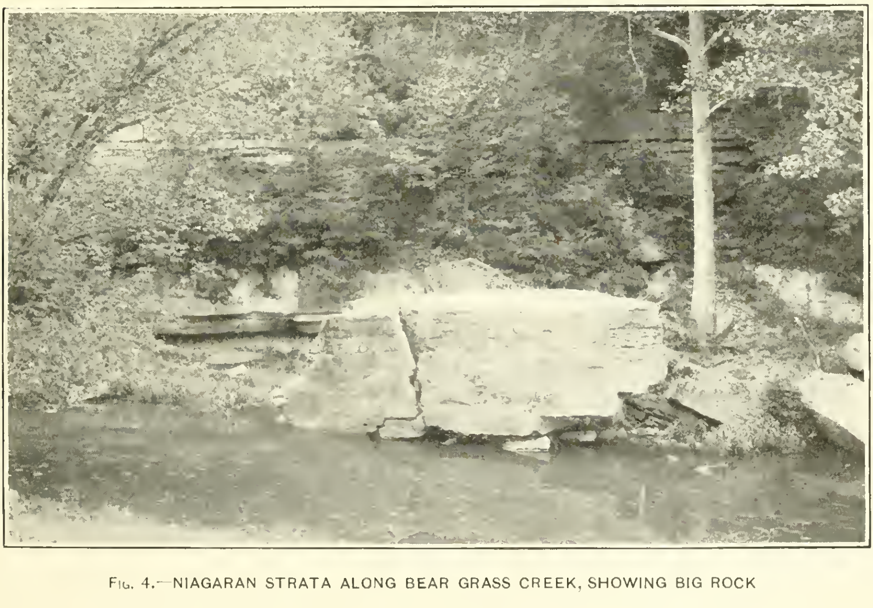

FIG. 4.—NIAGARAN STRATA ALONG BEAR GRASS CREEK, SHOWING BIG ROCK

SECTION OF STRATA, LOUISVILLE, KENTUCKY, AND VICINITY

Sandstone and shale	Knobstone sandstone and shale
Ferruginous limestone and shale	Knobstone shale (New Providence)
Goniatite limestone	Rockford
Devonian black slate or shale	Genesee and Portage
Encrinital bed	Hamilton (Sellersburg)
Corals, shells, and fish bed	Hamilton (Sellersburg)
Upper cherty bed, Middle, Lower — Hydraulic limestone	Hamilton (Silver Creek)
Spirifer acuminatus bed	Onondaga (Jeffersonville)
Bryozoan bed	Onondaga (Jeffersonville)
Nucleocrinus bed	Onondaga (Jeffersonville)
Stropheodonta bed	Onondaga (Jeffersonville)
Turbo bed	Onondaga (Jeffersonville)
White—Upper, Black—Middle, Brown—Lower — Coral beds	Onondaga (Jeffersonville)
Halysites bed	Silurian (Louisville)

The following generalized section of the Paleozoic rocks in the vicinity of Louisville, Kentucky, is introduced to show the stratigraphy of the region as now understood, and also to indicate the faunas chiefly represented in the Nettelroth collection. Indeed, the faunas of the rocks concerned are so well represented that this entire portion of the collection was assigned to the general stratigraphic series of the department. The fossils from foreign and other American localities are too few in numbers of species to represent faunas in the great detail desired for the Museum stratigraphic series, so these particular species were referred to the biologic collection.

Geologic Section, Vicinity of Louisville, Kentucky

Mississippian.

Knobstone group.

	Feet
Knob (Riverside) sandstone:	
More or less pure, soft sandstones and sandy shales, holding the following fauna....................................	75–100

Lingulodiscina newberryi Hall.
Chonetes illinoisensis Worthen.
Chonetes logani Norwood and Pratten.
Chonetes planumbonum Meek and Worthen.
Productella pyxidata Hall.
Productus gracilis Winchell.
Productus newberryi Hall.
Spirifer keokuk Hall.
Spirifer mortonanus Miller.
Reticularia tenuispinata (Herrick).
Spiriferina subelliptica (McChesney).
Syringothyris texta Hall.
Platyceras herzeri Winchell.
Platyceras lodiense Meek.
Conularia micronema Meek.
Conularia newberryi Winchell.
Goniatites greenei Miller.
Goniatites indianensis Miller.
Proetus missouriensis Shumard.

Upper Knobstone shales:	
Soft light gray to green shales with impure fine-grained sandstone at the top. No fauna has been recorded from this division, but in all probability most of the species registered under the New Providence shale below will be found here also	200
Lower Knobstone (New Providence) shale:	
Blue to green, soft clay shales, with occasional thin ferruginous limestone bands holding numerous fossils....................	50–100

These limestone beds are often made up of crinoidal remains; at other times their surfaces are covered with fenestelloid bryozoa. The most common species are:

Palæacis cavernosa Miller.
Zaphrentis centralis Edwards and Haime.
Zaphrentis cliffordana Edwards and Haime.
Zaphrentis declinis Miller.
Cyathaxonia cynodon Edwards and Haime.
Trochophyllum verneuilli Edwards and Haime.

Rhombopora angustata Ulrich.
Rhombopora elegantula Ulrich.
Rhombopora incrassata Ulrich.
Streblotrypa major Ulrich.
Fenestella compressa Ulrich.
Fenestella regalis Ulrich.
Fenestella triserialis Ulrich.
Thamniscus divaricans Ulrich.
Thamniscus sculptilis Ulrich.
Ptilopora cylindracea Ulrich.
Cystodictya americana Ulrich.
Cystodictya pustulosa Ulrich.
Cystodictya lineata Ulrich.
Meekopora ? aperta Ulrich.
Athyris lamellosa L'Eveille.
Spirifer mortonana Miller.
Spirifer suborbicularis Hall.
Syringothyris texta Hall.
Rhipidomella oweni Hall and Clarke.
Productella arcuata Hall.
Chonetes logani Norwood and Pratten.
Chonetes illinoisensis Worthen.
Goniatites brownensis Miller.

Feet

Rockford (Goniatite) limestone (Kinderhook)................. 1–3

Calcareous shale and fine-grained, ferruginous limestone with conchoidal fracture; brown when weathered, but mottled green upon fresh exposure. In places an abundant fauna is preserved, of which the cephalopods *Brancoceras ixion* Hall and *Munsteroceras oweni* Hall are best known. Other species are *Palæacis enorme* Meek and Worthen, *Amplexus rockfordensis* Miller and Gurley, *Spirifer marionensis* Shumard, *Spiriferina solidirostris* White, *Euomphalus lens* Hall, *Prodromites gorbyi* Miller, *Soleniscus rockfordensis* Miller, *Trematodiscus trisulcata* Meek and Worthen, and *Orodus multicarinatus* Meek and Worthen.

Devonian black shale (New Albany shale)...................... 100

Black fissile, often bituminous shale with few fossils. *Leiorhynchus quadricostatum* Hall, *Chonetes lepidus* Hall, *Styliola fissurella* Hall, *Lunulicardium fragile* Hall, *Schizobolus concentricus* (Vanuxem), *Lingula spatulata* Vanuxem, and *Barroisella subspatulata* Meek and Worthen have been noted. The lowest layer of the shale is almost invariably made up of an iron band 2 inches thick; in some places this band is conglomerate, the pebbles being most abundant in the hollows of the underlying limestone.

Devonian limestone:

Sellersburg formation (Hamilton)............................ 8

White to gray crystalline crinoidal limestone with the basal layer frequently arenaceous and containing small phosphatic concretions. The following is a partial list of the fauna of this limestone:

Megistocrinus rugosus Lyon and Casseday.
Megistocrinus depressus Hall.
Ancyrocrinus bulbosus Hall.
Gennæocrinus kentuckiensis Shumard.
Dolatocrinus greenei Miller and Gurley.
Dolatocrinus bulbosus Miller and Gurley.
Favosites placenta Rominger.
Alveolites goldfussi Billings.
Heliophyllum juvene (Rominger).
Heliophyllum corniculum (Lesueur).
Heliophyllum halli Edwards and Haime.
Cystiphyllum americanum Edwards and Haime.
Diphyphyllum archiaci Billings.
Acervularia davidsoni Edwards and Haime.
Dendropora ornata Rominger.
Athyris fultonensis (Swallow).
Spirifer hobbsi Nettelroth.
Spirifer audaculus Conrad.
Spirifer granulosus Conrad.
Stropheodonta perplana Conrad.
Rhipidomella vanuxemi Hall.
Camarotoechia sappho Hall.
Pholidostrophia iowaensis Owen.
Productella spinulicosta Hall.
Platyceras dumosum Conrad.

Feet

Silver Creek hydraulic limestone (cement rock)................ 20

Massive fine-grained limestone with hydraulic properties, breaking with subchoncoidal fracture and varying in color from buff on weathered surface to bluish drab when freshly exposed. *Chonetes yandellana* Hall is the most abundant and characteristic fossil. *Spirifer granulosus* Conrad, *S. fornacula* Hall, *S. varicosus* Hall, *Atrypa reticularis* (Linnæus), *Tropidoleptus carinatus* Conrad, *Stropheodonta concava* Hall, *S. perplana* Conrad, and *Aviculopecten princeps* Conrad are more or less abundant.

Jeffersonville limestone (Onondaga)......................... 22–30

Bluish gray to white crystalline limestone, often crowded with fossils. The upper member of this formation is marked by its many fine specimens of *Spirifer acuminatus* Owen. This Spirifer bed is underlaid by extremely fossiliferous limestone which, when weathered, yields in its cherty débris an abundance of exquisitely preserved silicified specimens of bryozoa and ostracods. *Nucleocrinus verneuili* and its several varieties, or closely related species, are characteristic of the next lower bed, while species of *Stropheodonta* are abundant in the next. The large gastropod *Turbo shumardi* or the abundant brachiopod *Spirifer gregarius* are the diagnostic fossils of the underlying bed, while the many lower Devonian corals described from the Falls of the Ohio come from the lowest division of the Jeffersonville limestone. A few of these corals have been listed below with a partial fauna from the other beds. The bryozoan bed contains a fauna so distinct and prolific that special lists of the bryozoa and ostracods are given. The Devonan rocks forming the Falls of the Ohio are illustrated on the accompanying plate. The following are the more common fossils:

Favosites limitaris Rominger.
Favosites canadensis Billings.
Favosites emmonsi Rominger.
Favosites hemisphericus Troost.
Favosites tuberosus Rominger.
Alveolites mordax Davis.
Cladopora roemeri (Billings).
Eridophyllum arundinaceum Davis.
Blothrophyllum decorticatum Billings.
Acrophyllum oneidaense Billings.
Zaphrentis gigantea Lesueur.
Syringopora hisingeri Billings.
Romingeria umbellifera (Billings).
Hadrophyllum orbignyi Edwards and Haime.
Nucleorinus verneuili (Troost).
Spirifer acuminata Conrad.
Spirifer arctisegmentum Hall.
Spirifer duodenarius (Hall).
Spirifer gregarius Clapp.
Spirifer raricosta Hall.
Cyrtina crassa Hall.
Athyris fultonensis Swallow.
Leptæna rhomboidalis Wilckins.
Atrypa reticularis Linnæus.
Meristella nasuta (Conrad).
Pentagonia unisulcata (Conrad).
Pentamerella arata (Conrad).
Chonetes acutiradiatus (Hall).
Stropheodonta demissa Conrad.
Stropheodonta perplana Conrad.
Stropheodonta concava Hall.
Turbo shumardi Verneuil.
Euomphalus decewi Billings.
Glyptodesma erectum Conrad.
Aviculopecten princeps Conrad.
Paracyclas elliptica Hall.
Platyceras dumosum Conrad.

Fauna of the Bryozoan Beds

Ostracoda

Leperditia ? subrotunda Ulrich.
Isochilina rectangularis Ulrich.
Aparchites inornatum Ulrich.
Beyrichia lyoni Ulrich.
Beyrichia kolmodini Jones.
Ctenobolbina spinulosa Ulrich.
Ctenobolbina armata Ulrich.
Ctenobolbina cavimarginata Ulrich.
Ctenobolbina insolens Ulrich.
Ctenobolbina papillosa Ulrich.
Ctenobolbina informis Ulrich.
Ctenobolbina antespinosa Ulrich.
Kirkbya subquadrata Ulrich.
Kirkbya parallela Ulrich.
Kirkbya semimuralis Ulrich.
Kirkbya cymbula Ulrich.
Kirkbya germana Ulrich.
Bollia ungula Jones.
Bollia obesa Ulrich.
Halliella retifera Ulrich.
Octonaria stigmata Ulrich.
Octonaria stigmata var. *loculosa* Ulrich.
Octonaria ovata Ulrich.
Octonaria clavigera Ulrich.
Bythocypris devonica Ulrich.
Bythocypris punctulata Ulrich.
Bythocypris indianensis Ulrich.
Pachydomella tumida Ulrich.
Barychilina punctostriata Ulrich.
Barychilina punctostriata var. *curta* Ulrich.
Barychilina pulchella Ulrich.

Bryozoa

Botryllopora socialis Nicholson.
Buskopora bistriata Hall.
Buskopora dentata Ulrich.
Buskopora pyriformis Hall.
Chætetes ? ponderosus Hall.
Chætetes? tenuis Hall.
Clonopora semireducta Hall.
Coscinium cribriforme Prout.
Cystopora geniculata Hall.
Cystodictya gilberti Meek.
Cystodictya ovatipora Hall.
Cystodictya vermicula Hall.

Dekayia devonica Ulrich.
Discotrypa ? devonica Ulrich.
Eridopora ? clivulata Hall.
Eridopora denticulata Hall.
Fenestella æqualis Hall.
Fenestella cultrata Hall.
Fenestella curvijunctura Hall.
Fenestella depressa Hall.
Fenestella perplexa Hall.
Fenestella proutana Miller.
Fenestella pulchella Ulrich.
Fenestella serrata Hall.
Fenestella singularitas Hall.
Fenestella stellata Hall.
Fenestella tenella Hall.
Fenestella variapora Hall.
Fenestella verrucosa Hall.
Fenestrapora infraporosa (Ulrich).
Fistulipora alternata (Hall).
Fistulipora conulata (Hall).
Fistulipora geometrica (Hall).
Fistulipora granifera (Hall).
Fistulipora normalis Ulrich.
Fistulipora ovata (Hall).
Fistulipora subcava (Hall).
Fistulipora substellata (Hall).
Glossotrypa paliformis (Hall).
Hederella adnata (Davis).
Hederella canadensis (Nicholson).
Hederella cirrhosa Hall.
Helicopora ulrichi Claypole.
Hemitrypa cribrosa Hall.
Hernodia humifusa Hall.
Intrapora puteolata Hall.
Lichenotrypa longispina (Hall).
Lioclema intercellatum (Hall).
Orthopora regularis (Hall).
Orthopora rhombifera (Hall).
Phractopora cristata Hall.
Phyllopora aspera Ulrich.
Polypora aculeata (Hall).
Polypora blandida Ulrich.
Polypora celsipora minor (Hall).
Polypora intermedia Prout.
Polypora lævistriata (Hall).
Polypora levinodata (Hall).
Polypora quadrangularis (Hall).
Polypora shumardi Prout.
Polypora striatopora (Hall).
Polypora submutans (Hall).
Polypora transversa Ulrich.

Prismopora sparsipora (Hall).
Prismopora triquetra Hall.
Ptiloporella ? bifurca (Ulrich).
Reteporidra adnata (Hall).
Rhombopora lincinoides Ulrich.
Rhombopora lincinoides-humilis Ulrich.
Scalaripora scalariformis Hall.
Scalaripora subconcava Hall.
Selenopora circincta (Hall).
Selenopora complexa (Hall).
Semicoscinium biimbricatum (Hall).
Semicoscinium biserrulatum (Hall).
Semicoscinium interruptum Hall.
Semicoscinium latijuncturum (Hall).
Semicoscinium lunulatum (Hall).
Semicoscinium permarginatum Hall.
Semicoscinium planodorsatum Ulrich.
Semicoscinium rhomboideum Prout.
Semicoscinium semirotundum (Hall).
Semicoscinium tortum (Hall).
Semicoscinium tuberculatum Prout.
Strotopora perminuta Ulrich.
Thamniscus nanus Hall.
Trematella annulata (Hall).
Trematella arborea (Hall).
Unitrypa acaulis (Hall).
Unitrypa anonyma (Hall).
Unitrypa fastigata (Hall).
Unitrypa tegulata (Hall).

	Feet
Silurian.	
Niagaran limestone:	
Louisville formation	38+

Argillaceous, cherty limestone, with the upper 8 feet crowded with fossil corals. Bluish, compact limestone below with few fossils. Pentameroid brachiopods are the prevailing forms in the lower bed.

The molluscan part of the Louisville formation fauna is listed on a succeeding page. The fossil corals have been described or illustrated by Hall, Rominger, Greene, and Davis, particularly. The list is large and no doubt many synonyms exist. The following forms are either very common or characteristic of the upper coral bed:

Alveolites niagarensis Rominger.
Amplexus shumardi (Edwards and Haime).
Anisophyllum trifurcatum Hall.
Calceola tennesseensis Roemer.
Cladopora complanata Davis.
Cladopora equisetalis Davis.
Cladopora reticulata Hall.
Cœnites verticillata (Winchell and Marcy).

Cystiphyllum granilineatum Hall.
Cystiphyllum niagarense Hall.
Dictyostroma undulata Nicholson.
Eridophyllum dividuum Davis.
Eridophyllum rugosum Edwards and Haime.
Favosites cristatus Edwards and Haime.
Favosites discus Davis.
Favosites favosus Goldfuss.
Favosites niagarensis Hall.
Favosites spongilla Rominger.
Favosites venustus (Hall).
Halysites catenulata (Linnæus).
Halysites nexus Davis.
Heliolites interstinctus (Linnæus).
Heliolites megastoma McCoy.
Heliolites subtubulatum McCoy.
Heliophyllum dentilineatum Hall.
Heliophyllum gemmiferum Hall.
Lyellia americana Edwards and Haime.
Lyellia glabra (Owen).
Lyellia parvituba Rominger.
Omphyma verrucosa Rafinesque and Clifford.
Plasmopora elegans Hall.
Plasmopora follis Edwards and Haime.
Rhizophyllum attenuatum Lyon.
Romingeria vannula Davis.
Streptelasma spongiaxis Rominger.
Striatopora huronensis Rominger.
Strombodes pentagonus Goldfuss.
Strombodes mammillaris (Owen).
Strombodes striatus D'Orbigny.
Thecia major Rominger.
Thecia minor Rominger.

Nettelroth Types of Ordovician Fossils

In the following lists the number cited is that of the U. S. National Museum Catalogue. The type terms are those regularly used by the department, holotype and cotypes being primary types, and plesiotypes referring to secondary types:

51342. **CYPRICARDITES HALLI Nettelroth.** Cotypes.
Richmond (Ordovician), Oldham County, Kentucky.
Kentucky Fossil Shells, 1889, p. 206, pl. XXXIV, figs. 1-6.
= *Cyrtodonta halli.*

51187. **ZYGOSPIRA KENTUCKIENSIS James.** Plesiotypes.
Richmond (Ordovician), Taylors Station, Oldham County, Kentucky.
Kentucky Fossil Shells, 1889, p. 138, pl. XXXIV, figs. 21-25.

51377. **PTILODICTYA HILLI (James).** Plesiotypes.
Lorraine (Ordovician), Danville, Kentucky.
Kentucky Fossil Shells, 1889, p. 30, pl. XXXV, figs. 1, 2, 4, 5.
= *Escharopora hilli.*

51375. **RHYNCHONELLA INCREBESCENS Hall.** Plesiotype.
Trenton (Ordovician), Frankfort, Kentucky.
Kentucky Fossil Shells, 1889, p. 83, pl. XXXIV, figs. 26-29.
= *Rhynchotrema inæquivalve.*

51186. **ORTHIS LINNEYI James.** Plesiotypes.
Trenton (Ordovician), Danville, Kentucky.
Kentucky Fossil Shells, 1889, p. 41, pl. XXXIV, figs. 7-13.
= *Orthorhynchula linneyi.*

51189. **ORTHIS BOREALIS Billings.** Plesiotypes.
Trenton (Ordovician), Frankfort, Kentucky.
Kentucky Fossil Shells, 1889, p. 36, pl. XXXIV, figs. 14-20.
= *Hebertella borealis.*

Silurian Types

Unless otherwise noted, all the species listed under this heading are from the Louisville limestone division of the Niagaran at Louisville, Kentucky.

Brachiopoda

51336. **ANASTROPHIA INTERNASCENS Hall.** Plesiotypes.
Kentucky Fossil Shells, 1889, p. 47, pl. XXXII, figs. 17-20.

51331. **ATRYPA CALVINI Nettelroth.** Holotype.
Kentucky Fossil Shells, 1889, p. 89, pl. XXXII, figs. 64-66.
= *Atrypa rugosa.*

51314. **ATRYPA RETICULARIS NIAGARENSIS Nettelroth.** Cotypes.
Kentucky Fossil Shells, 1889, p. 92, pl. XXXII, figs. 5-8, 44-47.

51340. **CAMARELLA CONGESTA (Hall).** Plesiotype.
Kentucky Fossil Shells, 1889, p. 48.

51326. **CYRTIA EXPORRECTA (Wahlenberg).** Plesiotype.
Kentucky Fossil Shells, 1889, p. 93, pl. XXVII, fig. 20.

51327. **CYRTIA EXPORRECTA ARRECTA Hall and Whitfield.** Plesiotypes.
Kentucky Fossil Shells, 1889, p. 94, pl. XXVII, fig. 21; pl. XXXIV, fig. 35.
= *Cyrtia myrtia.*

51322. **LEPTOCOELIA HEMISPHERICA (Hall).** Plesiotypes.
Kentucky Fossil Shells, 1889, p. 152, pl. XXXII, figs. 21-23, 36-39.
= *Anoplotheca hemispherica.*

51315. **MERISTINA MARIA (Hall).** Plesiotypes.
Kentucky Fossil Shells, 1889, p. 101, pl. XXIX, figs. 7-10.

51332. **MERISTINA NITIDA Hall.** Plesiotype.
Kentucky Fossil Shells, 1889, p. 102, pl. XXXIII, figs. 10, 11.
= *Whitfieldella nitida.*

51324. **NUCLEOSPIRA ELEGANS Hall.** Plesiotypes.
Kentucky Fossil Shells, 1889, p. 104.

51367. **NUCLEOSPIRA PISIFORMIS Hall.** Plesiotypes.
Kentucky Fossil Shells, 1889, p. 104, pl. XXXIII, figs. 7-9.

51348. **ORTHIS BIFORATA (Schlotheim).** Plesiotype.
Kentucky Fossil Shells, 1889, p. 35, pl. XXIX, figs. 18-22.
= *Platystrophia biforata,* var.

51345. **ORTHIS ELEGANTULA Dalman.** Plesiotypes.
Kentucky Fossil Shells, 1889, p. 37, pl. XXXII, figs. 52-57.
= *Dalmanella elegantula.*

51349. **ORTHIS FLABELLUM Sowerby (Hall).** Plesiotype.
Kentucky Fossil Shells, 1889, p. 38, pl. XXXIV, fig. 30.
= *Orthis flabellites.*

51346. **ORTHIS HYBRIDA Sowerby.** Plesiotype.
Kentucky Fossil Shells, 18889, p. 39, pl. XXXII, figs. 32-35.
= *Rhipidomella hybrida.*

51347. **ORTHIS NISIS Hall and Whitfield.** Plesiotype.
Kentucky Fossil Shells, 1889, p. 42, pl. XXVII, fig. 4.

51353. **PENTAMERUS COMPLANATUS Nettelroth.** Cotypes.
Kentucky Fossil Shells, 1889, p. 53.
= *Conchidium tenuicosta.*

51339. **PENTAMERUS GLOBULOSUS Nettelroth.** Cotypes.
Kentucky Fossil Shells, 1889, p. 54.
= *Gypidula globulosus.*

51352. **PENTAMERUS KNAPPI Hall.** Plesiotype.
Kentucky Fossil Shells, 1889, p. 55.
= *Conchidium knappi.*

51312. **PENTAMERUS KNIGHTI Sowerby.** Plesiotypes.
Kentucky Fossil Shells, 1889, p. 57, pl. 29, figs. 1, 2, 17.

51354. **PENTAMERUS KNOTTI Nettelroth.** Holotype.
Kentucky Fossil Shells, 1889, p. 56, pl. XXXII, figs. 9-12.
= *Gypidula knotti.*

51328. **PENTAMERUS NUCLEUS Hall and Whitfield.** Plesiotypes.
Kentucky Fossil Shells, 1889, p. 59, pl. XXXIII, figs. 31-33.
= *Gypidula nucleus.*

51310. **PENTAMERUS OBLONGUS Sowerby.** Plesiotype.
Kentucky Fossil Shells, 1889, p. 60, pl. XXXIII, figs. 15-17.

51311. **PENTAMERUS OBLONGUS CYLINDRICUS Hall and Whitfield.** Plesiotype.
Kentucky Fossil Shells, 1889, p. 61, pl. XXX, figs. 2-4.

51355. **PENTAMERUS PERGIBBOSUS Hall and Whitfield.** Plesiotype.
Kentucky Fossil Shells, 1889, p. 62, pl. XXIX, figs. 23, 24.

51337. **PENTAMERUS UNIPLICATUS Nettelroth.** Holotype.
Kentucky Fossil Shells, 1889, p. 63, pl. XXXIII, figs. 25, 26.
= *Gypidula uniplicata.*

51323. **PENTAMERUS VENTRICOSUS Hall.** Plesiotype.
Kentucky Fossil Shells, 1889, p. 64, pl. XXXIII, figs. 12-14.
= *Clorinda ventricosus.*

51366. **RHYNCHONELLA ACINUS Hall.** Plesiotypes.
Kentucky Fossil Shells, 1889, p. 73, pl. XXVI, figs. 6, 13, 14; pl. XXXII, figs. 13-16.
= *Camarotœchia acinus.*

51338. **RHYNCHONELLA BELLAFORMA Nettelroth.** Holotype.
Kentucky Fossil Shells, 1889, p. 73.

51330. **RHYNCHONELLA INDIANENSIS Hall.** Plesiotype.
Kentucky Fossil Shells, 1889, p. 76, pl. XXXIII, figs. 18-20.
= *Camarotœchia indianensis.*

51325. **RHYNCHONELLA PISA Hall and Whitfield.** Plesiotype.
Kentucky Fossil Shells, 1889, p. 78, pl. XXXII, figs. 24-27.

51320. **RHYNCHONELLA RUGÆCOSTA Nettelroth.** Holotype.
Kentucky Fossil Shells, 1889, p. 78, pl. XXXII, figs. 48-51.

51350. **RHYNCHONELLA SAFFORDI Hall.** Plesiotype.
Kentucky Fossil Shells, 1889, p. 79, pl. XXXIII, figs. 4-6.
= *Wilsonia saffordi.*

51316. **RHYNCHONELLA SAFFORDI DEPRESSA Nettelroth.** Holotype.
Kentucky Fossil Shells, 1889, p. 80, pl. XXXIII, figs. 1-3.
= *Wilsonia saffordi depressa.*

51356. **RHYNCHONELLA STRICKLANDI Sowerby.** Plesiotype.
Kentucky Fossil Shells, 1889, p. 81, pl. XXIX, figs. 3-6.
= *Uncinulus stricklandi.*

51333. **SPIRIFER CRISPUS SIMPLEX Hall.** Plesiotype.
Kentucky Fossil Shells, 1889, p. 111, pl. XVII, figs. 36, 37.

51334. **SPIRIFER DUBIUS Nettelroth.** Holotype.
Kentucky Fossil Shells, 1889, p. 115, pl. XXXIII, figs. 23, 24.

51317. **SPIRIFER FOGGI Nettelroth.** Holotype.
Kentucky Fossil Shells, 1889, p. 117, pl. XXXII, figs. 28-31.

51218. **SPIRIFER RADIATA Sowerby.** Plesiotype.
Kentucky Fossil Shells, 1889, p. 130, pl. XXIX, figs. 13-16.

51318. **SPIRIFER ROSTELLUM** Hall and Whitfield. Plesiotypes.
Kentucky Fossil Shells, 1889, p. 129, pl. XXVII, figs. 17-19; pl. XXIX, fig. 25.

51313. **STREPTORHYNCHUS SUBPLANUS** (Conrad). Plesiotype.
Kentucky Fossil Shells, 1889, p. 141, pl. XXIX, figs. 11, 12.
=*Schuchertella subplanus.*

51329. **STREPTORHYNCHUS TENUIS** Hall. Plesiotype.
Kentucky Fossil Shells, 1889, p. 142.
=*Schuchertella tenuis.*

51319. **STRICKLANDINIA LOUISVILLENSIS** Nettelroth. Holotype.
Kentucky Fossil Shells, 1889, p. 65, pl. XXXIV, figs. 31-34.

51309. **STROPHODONTA PROFUNDA** (Hall). Plesiotypes.
Kentucky Fossil Shells, 1889, p. 148, pl. XVII, figs. 20, 21; pl. XXIX, fig. 26.

51335. **STROPHODONTA STRIATA** Hall. Plesiotypes.
Kentucky Fossil Shells, 1889, p. 149.
=*Stropheodonta striata.*

51321. **TREMATOSPIRA HELENA** Nettelroth. Holotype.
Kentucky Fossil Shells, 1889, p. 137, pl. XXXII, figs. 40-43.
=*Rhynchospira helena.*

Gastropoda

51362. **CYCLONEMA RUGAELINEATA** Hall and Whitfield. Plesiotype.
Kentucky Fossil Shells, 1889, p. 187.

51342. **PLATYCERAS UNGUIFORME** Hall. Plesiotypes.
Kentucky Fossil Shells, 1889, p. 168.

53232. **PLATYOSTOMA NIAGARENSE** Hall. Plesiotype.
Kentucky Fossil Shells, 1889, p. 185, pl. XXXIII, fig. 30.

51341. **PLEUROTOMARIA CASII** Meek and Worthen. Plesiotype.
Kentucky Fossil Shells, 1889, p. 171, pl. XXVI, fig. 11.

Cephalopoda

51378. **LITUITES MARSHI** Hall. Plesiotype.
Kentucky Fossil Shells, 1889, p. 195, pl. XXX, fig. 1.

Devonian Types

In this list, the faunas of the four Devonian formations, Jeffersonville, Silver Creek, Sellersburg limestone, and New Albany shale, are not given separately because of the occurrence of a number of species in two or more of the divisions. Moreover, the exact horizon of a few of the types is uncertain, so that this would have prevented the preparation of exact faunal lists.

BRACHIOPODA

51235. **AMBOCOELIA UMBONATA (Conrad).** Plesiotype.
Sellersburg (Devonian), Louisville, Kentucky.
Kentucky Fossil Shells, 1889, p. 86, pl. XVII, figs. 25, 26.

51182. **ATHYRIS VITTATA Hall.** Plesiotypes.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 87, pl. XVI, figs. 25-32.
= *Athyris fultonensis.*

51214. **ATRYPA ASPERA Schlotheim.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 88, pl. XIV, figs. 1-11.

51179. **ATRYPA ELLIPSOIDEA Nettelroth.** Cotypes.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 90.
= *Atrypa reticularis ellipsoidea.*

51229. **ATRYPA RETICULARIS Linnæus.** Plesiotypes.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 91, pl. XIV, figs. 12-22.

51228. **CENTRONELLA GLANSFAGEA (Hall).** Plesiotype.
Sellersburg (Devonian), Louisville, Kentucky.
Kentucky Fossil Shells, 1889, p. 153, pl. XXXI, figs. 14-17.

51222. **CHONETES ACUTIRADIATUS (Hall).** Plesiotype.
Sellersburg (Devonian), Indiana side, Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 66, pl. XVIII, figs. 18-20.

51223. **CHONETES SUBQUADRATUS Nettelroth.** Holotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 67.

51364. **CHONETES YANDELLIANA Hall.** Plesiotype.
Silver Creek (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 68, pl. XVII, figs. 16-19.

51296. **CRANIA BORDENI Hall and Whitfield.** Plesiotypes.
Sellersburg (Devonian), Watson's Station, Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 32, pl. II, fig. 14.
= *Crania sheldoni.*

51178. **CYRTINA CRASSA Hall.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 95, pl. XIII, figs. 21-24.

51176. **CYRTINA HAMILTONIAE (Hall).** Plesiotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 96, pl. XIII, figs. 4-12.
= *Cyrtina hamiltonensis.*

51177. **CYRTINA HAMILTONIAE RECTA Hall.** Plesiotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 97, pl. XIII, figs. 13-16.
= *Cyrtina hamiltonensis recta.*

51212. **DISCINA DORIA Hall.** Plesiotype.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 32.
= *Orbiculoidea doria.*

51215. **DISCINA GRANDIS (Vanuxem).** Plesiotype.
Sellersburg (Devonian), Watson's Station, Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 33, pl. III, fig. 3.
= *Roemerella grandis.*

51231. **LEIORHYNCHUS QUADRICOSTATUM (Vanuxem).** Plesio-
51232. types.
New Albany shale (Devonian), Lexington, Indiana, and Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 71.

51218. **LINGULA TRIANGULATA Nettelroth.** Holotype.
Silver Creek (Devonian), Kentucky side, Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 34, pl. XXVI, fig. 1.
= *Glossina triangulata.*

51308. **MERISTELLA NASUTA (Conrad).** Plesiotypes.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 98, pl. XV, figs. 2-8.

51207. **MERISTELLA UNISULCATA Conrad.** Plesiotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 99, pl. XV, figs. 9-16.
= *Pentagonia unisulcata.*

51368. **NUCLEOSPIRA CONCINNA (Hall).** Plesiotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 103, pl. XXXII, figs. 1-4.

51184. **ORTHIS GOODWINI Nettelroth.** Holotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 39, pl. XVII, figs. 30-32.
= *Rhipidomella goodwini.*

51185. **ORTHIS LIVIA Billings.** Plesiotypes.
Sellersburg (Devonian), Louisville, Kentucky.
Kentucky Fossil Shells, 1889, p. 40, pl. XVI, figs. 23, 24.
= *Rhipidomella livia.*

51188. **ORTHIS PROPINQUA Hall.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 43, pl. XVI, figs. 1-3, 7-11.
= *Schizophoria propinqua.*

51183. **ORTHIS VANUXEMI Hall.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 45, pl. XVI, figs. 4-6, 12-14.
= *Rhipidomella vanuxemi.*

51361. **PENTAMERELLA ARATA (Conrad).** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 49, pl. XIII, figs. 17-20.

51238. **PENTAMERELLA PAPILIONENSIS (Hall).** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 50.

51216. **PENTAMERELLA THUSNELDA Nettelroth.** Holotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 51, pl. XXXI, figs. 26-28.

51236. **PRODUCTELLA SEMIGLOBOSA Nettelroth.** Holotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 70, pl. XXVI, fig. 7.

51237. **PRODUCTELLA SUBACULEATA CATARACTA Hall and Whitfield.** Plesiotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 69, pl. XVII, figs. 5-9.
= *Productella spinulicosta.*

51210. **RHYNCHONELLA CAROLINA Hall.** Plesiotypes.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 75, pl. XIII, figs. 1-3, 34, 35.
= *Camarotœchia carolina* and *Cyclorhina nobilis.*

As pointed out by Kindle, figures 1-3 are of *Cyclorhina nobilis*, while figures 34 and 35 refer to *Camarotœchia carolina.*

51365. **RHYNCHONELLA GAINESI Nettelroth.** Cotypes.
Jeffersonville (Devonian), Jefferson County, Kentucky.
Kentucky Fossil Shells, 1889, p. 76, pl. XXXI, figs. 6-9.

51224. **RHYNCHONELLA LOUISVILLENSIS Nettelroth.** Holotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 77, pl. XXXI, figs. 1-4.

51225. **RHYNCHONELLA TENUISTRIATA Nettelroth.** Holotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 82, pl. XVIII, figs. 27-29.

51209. **RHYNCHONELLA TETHYS Billings.** Plesiotypes.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 83, pl. XIII, figs. 25-33; pl. XXXI, figs. 22-25.
= *Camarotœchia tethys.*

51196. **SPIRIFER ACUMINATUS (Conrad).** Plesiotypes.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 105, pl. VIII, figs. 1-8.

51194. **SPIRIFER ARCTISEGMENTUM Hall.** Plesiotype.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 108, pl. XII, figs. 14, 15.

51193. **SPIRIFER ATWATERANA Miller.** Plesiotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 107, pl. IX, figs. 1-5.
= *Spirifer iowaensis.*

51194. **SPIRIFER BYRNESI Nettelroth.** Cotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 109, pl. X, figs. 1-5, 31-34, 36-39.

51211. **SPIRIFER CONRADANA Miller.** Plesiotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 110, pl. VII, figs. 11-13.
= *Reticularia fimbriata.*

51197. **SPIRIFER DAVISI Nettelroth.** Holotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 112, pl. XII, figs. 1-4.

51190. **SPIRIFER DIVARICATUS Hall.** Plesiotypes.
51191. Jeffersonville (Devonian), Lebanon, Kentucky, and Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 113, pl. XI, figs. 6-11; pl. XII, figs. 5-11.

51220. **SPIRIFER DUODENARIUS (Hall).** Plesiotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 114, pl. XII, figs. 12, 13, 16.

51203. **SPIRIFER EURUTEINES Owen.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 115, pl. VI, figs. 1-8, 11, 17, 21, 22.
= *Spirifer fornacula.*

51204. **SPIRIFER EURUTEINES FORNACULA Hall.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 117, pl. VI, figs. 9, 10, 18-20.
= *Spirifer fornacula.*

51198. **SPIRIFER GREGARIA Clapp.** Plesiotypes.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 119, pl. VIII, figs. 9-13; pl. X, figs. 6-10.

51192. **SPIRIFER GRIERI Hall.** Plesiotypes.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 120, pl. IX, figs. 8-14.

51195. **SPIRIFER HOBBSI Nettelroth.** Cotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 121, pl. X, figs. 21, 22, 26-30, 35, 40.

51206. **SPIRIFER KNAPPIANA Nettelroth.** Holotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 122, pl. VII, fig. 14.
= *Reticularia knappiana.*

51200. **SPIRIFER MACCONATHII Nettelroth.** Holotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 123, pl. XI, figs. 1-5.

51205. **SPIRIFER MEDIALIS Hall.** Plesiotype.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 125, pl. XXVI, figs. 2-5.
= *Spirifer audaculus.*

51201. **SPIRIFER OWENI Hall.** Plesiotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 126, pl. VII, figs. 1-10.
= *Spirifer granulosus.*

51226. **SPIRIFER SCULPTILIS Hall.** Plesiotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 132, pl. XXXI, fig. 13.
= *Delthyris sculptilis.*

51219. **SPIRIFER SEGMENTUM Hall.** Plesiotype.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 132, pl. XIII, figs. 36-38.

51202. **SPIRIFER VARICOSUS Hall.** Plesiotypes.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 134, pl. X, figs. 11-20, 23-25.

51233. **STREPTORHYNCHUS ARCTOSTRIATA (Hall).** Plesiotype.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 140, pl. XXXI, figs. 31-33.
= *Schuchertella chemungensis arctistriata.*

51230. **STROPHODONTA DEMISSA (Conrad).** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 143, pl. XVIII, figs. 10, 16.

51180. **STROPHODONTA HEMISPHERICA Hall.** Plesiotypes.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 144, pl. XVIII, figs. 4-6, 7-9.

51221. **STROPHODONTA INEQUISTRIATA (Conrad).** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 145, pl. XVII, figs. 10, 11.

51240. **STROPHODONTA NACREA Hall.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 146.
= *Pholidostrophia iowaensis.*

51208. **STROPHODONTA PERPLANA (Conrad).** Plesiotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 147, pl. XVIII, fig. 17.

51239. **STROPHODONTA PLICATA Hall.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 149.

51223. **STROPHOMENA RHOMBOIDALIS (Wilckens).** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 150, pl. XVIII, figs. 1-3.
= *Leptæna rhomboidalis.*

51217. **TEREBRATULA HARMONIA Hall.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 154, pl. XVII, figs. 1-4.
= *Eunella harmonia.*

51227. **TEREBRATULA JUCUNDA Hall.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 154.

51241. **TEREBRATULA LINCKLAENI Hall.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 155, pl. XVII, figs. 22-24.
= *Eunella lincklæni.*

51369. **TEREBRATULA ROEMINGERI Hall.** Plesiotypes.
Jeffersonville (Devonian), Louisville, Kentucky.
Kentucky Fossil Shells, 1889, p. 155, pl. XVI, figs. 20-22.
= *Cranæna romingeri.*

51234. **TREMATOSPIRA HIRSUTA Hall.** Plesiotype.
Jeffersonville (Devonian), Louisville, Kentucky.
Kentucky Fossil Shells, 1889, p. 136, pl. XVI, figs. 15-19.
= *Parazyga hirsuta.*

51181. **TROPIDOLEPTUS CARINATUS Conrad.** Plesiotype.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 46, pl. XVII, figs. 14, 15.

PELECYPODA

51299. **ACTINOPTERIA BOYDI Conrad.** Plesiotype.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 229, pl. III, fig. 2.

51303. **AVICULOPECTEN CRASSICOSTATUS Hall and Whitfield.** Plesiotype.
Silver Creek (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 223.

51302. **AVICULOPECTEN FASCICULATUS Hall.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 224, pl. III, fig. 4.

51290. **AVICULOPECTEN PECTENIFORMIS Conrad.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 225, pl. III, fig. 1.

51289. **AVICULOPECTEN PRINCEPS Conrad.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 225.

51359. **CLINOPISTHA ANTIQUA Meek.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 200, pl. IV, figs. 9-11.

51358. **CLINOPISTHA STRIATA Nettelroth.** Cotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 200, pl. IV, figs. 1, 2.

51360. **CLINOPISTHA SUBNASUTA Hall.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 199, pl. IV, figs. 6-8, 12.

51373. **CONOCARDIUM CUNEUS (Conrad).** Plesiotypes
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 203, pl. V, figs. 10-19.

51297. **CYPRICARDINIA CATARACTA Conrad.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 204, pl. IV, fig. 3.

51305. **CYPRICARDINIA CYLINDRICA Hall and Whitfield.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 205, pl. IV, figs. 13, 14.

51306. **CYPRICARDINIA INFLATA SUBEQUIVALVIS Hall and Whitfield.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 206.

51284. **GLYPTODESMA CANCELLATA Nettelroth.** Holotype.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 227, pl. V, fig. 1.

51283. **GLYPTODESMA OCCIDENTALE Hall.** Plesiotype.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 228, pl. III, fig. 5.

51288. **GONIOPHORA TRUNCATA Hall.** Plesiotypes.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 214, pl. IV, figs. 21-23.

51287. **GRAMMYSIA GIBBOSA Hall and Whitfield.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 208, pl. IV, figs. 16-20.

51285. **LIMOPTERA CANCELLATA Hall.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 198, pl. III, figs. 6-8; pl. IV, fig. 24.

51291. **MODIOMORPHA AFFINIS Hall.** Plesiotypes.
Sellersburg (Devonian), Watson Station, Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 216.

51293. **MODIOMORPHA ALTA Conrad.** Plesiotype.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 217, pl. XXVI, fig. 10.

51292. **MODIOMORPHA CHARLESTOWNENSIS Nettelroth.** Holotype.
Kentucky Fossil Shells, 1889, p. 218, pl. V, figs. 7-9.

51295. **MODIOMORPHA CONCENTRICA (Conrad).** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 219, pl. II, figs. 9-12, 14.

51294. **MODIOMORPHA MYTILOIDES Conrad.** Plesiotype.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 220.

51300. **NUCULA HERZERI Nettelroth.** Cotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 221.

51374. **NUCULA NEDA Hall and Whitfield.** Plesiotype.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 222, pl. V, figs. 5, 6.

51301. **NUCULA NIOTICA Hall and Whitfield.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 222, pl. V, figs. 2-4.

51279. **PARACYCLAS ELLIPTICA Hall.** Plesiotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 209, pl. II, figs. 1-3.

51282. **PARACYCLAS ELONGATA Nettelroth.** Holotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 210, pl. II, fig. 8.

51281. **PARACYCLAS LIRATA (Conrad).** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 211, pl. II, figs. 4-7.

51280. **PARACYCLAS OCTERLONII Nettelroth.** Holotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 212, pl. XXXI, fig. 18.

51305. **PARACYCLAS OHIOENSIS (Meek).** Plesiotype.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 213, pl. V, fig. 20.

51286. **PTYCHODESMA KNAPPIANA Hall.** Plesiotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 201, pl. II, figs. 13, 15, 18.

51298. **YOLDIA ? VALVULUS Hall and Whitfield.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 223, pl. IV, figs. 4, 5.

Pteropoda

53161. **TENTACULITES SCALARIFORMIS Hall.** Plesiotype.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 156, pl. XXXI, fig. 12.

Gastropoda

51262. **BELLEROPHON LEDA Hall.** Plesiotype.
Sellersburg (Devonian), Louisville, Kentucky.
Kentucky Fossil Shells, 1889, p. 158, pl. XVII, figs. 12, 13.

51261. **BUCANIA DEVONICA Hall.** Plesiotype.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 160, pl. XXII, figs. 3, 4.

51263. **CALLONEMA BELLATULA Hall.** Plesiotype.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 175, pl. XX, fig. 7.

51255. **CALLONEMA CLARKI Nettelroth.** Cotypes.
Jeffersonville (Devonian), Louisville, Kentucky.
Kentucky Fossil Shells, 1889, p. 175, pl. XXIV, figs. 2-5.

51254. **CALLONEMA IMITATOR Hall and Whitfield.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 176, pl. XX, figs. 12, 13.

51376. **CYCLONEMA MULTILIRA Hall.** Plesiotype.
Jeffersonville (Devonian), Louisville, Kentucky.
Kentucky Fossil Shells, 1889, p. 188, pl. XXII, fig. 5.

51258. **EUOMPHALUS DECEWI Billings.** Plesiotype.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 181, pl. XXI, figs. 1, 2.

51259. **EUOMPHALUS SAMPSONI Nettelroth.** Holotype.
Sellersburg (Devonian), Watson's Station, Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 182, pl. XXI, figs. 3, 4.

51276. **LOXONEMA HAMILTONIAE Hall.** Plesiotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 177, pl. XXXI, fig. 29.

51265. **LOXONEMA HYDRAULICUM Hall.** Plesiotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 178, pl. XX, figs. 8, 9.

51264. **LOXONEMA LAEVIUSCULUS Hall.** Cotypes.
Sellersburg (Devonian), Falls of the Ohio.
Hall, Nat. His. New York, Pal., V, Py. II, 1879, p. 131, pl. XXVIII, figs. 10, 11.—Nettelroth, Kentucky Fossil Shells, 1889, p. 178, pl. XXII, figs. 8, 9.

51256. **MACROCHEILUS CARINATUS Nettelroth.** Cotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 180, pl. XX, figs. 20-23.

51242. **MURCHISONIA DESIDERATA Hall.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 169, pl. XXVI, fig. 8.

51372. **PLATYCERAS BUCCULENTUM Hall.** Plesiotype.
Sellersburg (Devonian), Louisville, Kentucky.
Kentucky Fossil Shells, 1889, p. 160, pl. XXV, fig. 3.

51270. **PLATYCERAS COMPRESSUM Nettelroth.** Holotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 162, pl. XXV, figs. 8, 9.

51371. **PLATYCERAS CONICUM Hall.** Plesiotypes.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 161, pl. XXV, figs. 2, 11.

51268. **PLATYCERAS DUMOSUM Conrad.** Plesiotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 162, pl. XXIII, figs. 1-6, 12.

51269. **PLATYCERAS DUMOSUM RARISPINUM Hall.** Plesiotype.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 163, pl. XXIII, figs. 7, 8.

51275. **PLATYCERAS ECHINATUM Hall.** Plesiotype.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 164, pl. XXXI, fig. 21.

51272. **PLATYCERAS ERECTUM Hall.** Plesiotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 165.

51274. **PLATYCERAS MILLERI Nettelroth.** Cotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 165, pl. xxv, fig. 1.

51267. **PLATYCERAS MULTISPINOSUM Meek.** Plesiotype.
Jeffersonville (Devonian), Louisville, Kentucky.
Kentucky Fossil Shells, 1889, p. 166, pl. xxv, fig. 4.

51273. **PLATYCERAS RICTUM Hall.** Plesiotypes.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 166.

51370. **PLATYCERAS SYMMETRICUM Hall.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 167, pl. xxiii, fig. 10.

51266. **PLATYCERAS THETIS Hall.** Plesiotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 168.

51271. **PLATYCERAS VENTRICOSUM Conrad.** Plesiotype.
Jeffersonville (Devonian), Louisville, Kentucky.
Kentucky Fossil Shells, 1889, p. 168, pl. xxv, fig. 10.

51245. **PLATYOSTOMA LINEATA Conrad.** Plesiotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 183, pl. xix, figs. 5-8; pl. xxi, figs. 7, 8.

51248. **PLATYOSTOMA LINEATA CALLOSA Hall.** Plesiotypes.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 184, pl. xxi, fig. 14; pl. xxii, figs. 10, 11; pl. xxv, figs. 5, 6, 9.

51246. **PLATYOSTOMA TURBINATA Hall.** Plesiotype.
Sellersburg (Devonian), Louisville, Kentucky.
Kentucky Fossil Shells, 1889, p. 184, pl. xxi, figs. 7, 8.

51249. **PLEUROTOMARIA ARABELLA Nettelroth.** Holotype.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 171, pl. xxvi, fig. 12.

51250. **PLEUROTOMARIA LUCINA Hall.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 172.

51251. **PLEUROTOMARIA PROCTERI Nettelroth.** Cotypes.
51252. Jeffersonville (Devonian), Clark County, Indiana, and Louisville, Kentucky.
Kentucky Fossil Shells, 1889, p. 173, pl. xxi, figs. 9, 10, 13.

51253. **PLEUROTOMARIA SULCOMARGINATA Conrad.** Plesiotypes.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 174, pl. xxi, figs. 11, 12.

51244. **STROPHOSTYLUS VARIANS Hall.** Plesiotype.
Sellersburg (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 186, pl. XXII, figs. 6, 7.

51260. **TROCHONEMA YANDELLANA Hall and Whitfield.** Plesiotype.
Jeffersonville (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 190.

51257. **TURBO SHUMARDI Verneuil.** Plesiotypes.
Jeffersonville (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 191, pl. XIX, fig. 4; pl. XXII, figs. 1, 2.

Cephalopoda

51243. **NAUTILUS MAXIMUS Conrad.** Plesiotype.
Silver Creek (Devonian), Falls of the Ohio.
Kentucky Fossil Shells, 1889, p. 196, pl. XXIV, fig. 1.

51277. **GOMPHOCERAS OVIFORME Hall.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 193, pl. XXI, figs. 17, 18.

51278. **GOMPHOCERAS TURBINIFORMIS Meek and Worthen.** Plesiotypes.
Sellersburg (Devonian), Clark County, Indiana.
Kentucky Fossil Shells, 1889, p. 194, pl. XXI, figs. 15, 16.

Types of Fossil Corals

The following species of fossil corals, illustrated by Davis in his Kentucky Fossil Corals, form a part of the Nettelroth collection:

52754. **ALVEOLITES LOUISVILLENSIS Davis.** Cotype.
Niagara (Silurian), Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. XLVI, fig. 6.

52774. **CALCEOLA PROTEUS Davis.** Cotypes.
Niagara (Silurian), Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. CXXXI, figs. 2, 3, 13.

52639. **CALCEOLA SANDALINA Lamarck.** Plesiotype.
Devonian, Eifel, Germany.
Kentucky Fossil Corals, 1885, pl. CXXXI, fig. 18.

52642. **CLADOPORA EQUISETALIS Davis.** Holotype.
Niagara (Silurian), Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. XLVIII, fig. 7.

52641. **CLADOPORA LAQUEATA Rominger.** Plesiotypes.
Niagara (Silurian), Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. XLVIII, figs. 8, 9.

52640. **CLADOPORA RETICULATA Hall.** Plesiotype.
Niagara (Silurian), Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. XLVII, fig. 2.

51643. **CLADOPORA STRIATA Davis.** Holotype.
Niagara (Silurian), Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. XLVIII, fig. 8.

52776. **ERIDOPHYLLUM DIVIDUUM Davis.** Cotype.
Niagara (Silurian), Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. CIX, fig. 5.

52855. **FAVOSITES AMPLISSIMUS Davis.** Cotype.
Jeffersonville (Devonian), near Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. XVII, fig. 1.

52654. **FAVOSITES FAVOSUS Goldfuss.** Plesiotype.
Niagara (Silurian), Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. VIII, fig. 1.

52658. **FAVOSITES FORBESI Edwards and Haime.** Plesiotype.
Niagara (Silurian), Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. VIII, fig. 5.

52645. **FAVOSITES SPONGILLA Rominger.** Plesiotype.
Niagara (Silurian), Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. VIII, fig. 7.

52660. **PLASMOPORA FOLLIS Edwards and Haime.** Plesiotype.
Niagara (Silurian), Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. I, fig. 10.

52775. **PTYCHOPHYLLUM STOKESI Edwards and Haime.** Plesiotypes.
Niagara (Silurian). Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. XV, fig. 6.

52743. **ROMINGERIA VANNULA Davis.** Cotype.
Niagara (Silurian), Louisville, Kentucky.
Kentucky Fossil Corals, 1885, pl. LXXII, fig. 1.

52638. **THECIA VETUSTA (Hall).** Plesiotypes.
Richmond (Ordovician), Oldham County, Kentucky.
Kentucky Fossil Corals, 1885, pl. XXXIV, figs. 9, 10.
= *Protarea vetusta.*

OPUNTIA VIVIPARA Rose

A NEW OPUNTIA FROM ARIZONA

By J. N. ROSE

(With One Plate)

While going from Tucson, Arizona, to the Pictured Rock some 12 miles to the southwest, my attention was called by Dr. D. T. MacDougal to a peculiar Opuntia resembling the very common *O. versicolor,* but of very different habit, branching and with larger fruit, etc. At first we came upon a large group of these plants where they formed the dominant element in the landscape. Farther on the species was less common and was associated with *O. versicolor* and *O. spinosior,* but it surely does not intergrade with either of them. It is much more open in its manner of growth than *O. versicolor,* while the branches readily drop off and take root about the old plant. This is shown very well in the accompanying illustration.

This species may be technically described as follows:

OPUNTIA VIVIPARA Rose, sp. nov.

Stems 2 to 3.5 meters high, usually several from the base, 8 to 10 cm. in diameter, much branched, but not compactly so; old stems with rather smooth bark; young branches bluish green, slender, 1 to 2 cm. long, 10 to 12 mm. in diameter; tubercles low, oblong, 15 to 20 mm. long; areoles when young forming a dense cushion of yellow wool with few or no glochides; spines 1 to 4, 2 cm. or less long, covered with straw-colored sheaths; leaves small, terete, acutish, purple; flowers numerous, borne in clusters at the top of last year's branches, purplish; ovary strongly tubercled, bearing white deciduous bristles; fruit oblong, 4 to 6 cm. long, smooth with a somewhat depressed umbilicus, yellowish-green, spineless; seeds white, 5 mm. long.

On a mesa near Tucson, Arizona, to the southwestward, J. N. Rose, April 21, 1908 (No. 11836).

Type in U. S. National Herbarium, No. 454,531.

Illustration (Pl. XII) furnished by courtesy of the Carnegie Institution of Washington.

THE STORY OF THE DEVIL-FISH[1]

By THEODORE GILL

I

One of the most remarkable of animals is the great Ray, most widely known as Devil-fish, but which bears also several other names.

Devil-fish is a name by no means restricted to any one of the Rays, for it is well known in connection with the gigantic Cuttlefishes and is also used locally in England for the Angler (*Lophius piscatorius*), and in California for the Gray whale (*Rhachianectes glaucus*). Among the Rays the name is applied not only to all of the same family as the great fish, but also, in some places (for instance, North Carolina and the Gulf of Mexico), to species of Eagle-rays. Sea-devil may be considered to be a natural variant of the same name, but it has also been used for the same animals as Devil-fish and even for those of another family, the species of the Sharks known as *Squatina*.

Vampire originated in the form "Oceanic Vampyre" as a selective name and was given by Dr. Samuel L. Mitchill, in 1823, as the popular name for his *Cephalopterus vampyrus*. He claimed that "this fish being perhaps the largest of the Rays, as the vampyre is of the bats, or vespertilios, the name *vampyrus* may be attached." The name has somehow been taken up and found limited currency in certain localities where the fish abounds. Thus C. F. Holder[2] has recorded that it is in use in southern Florida. When, during a night on the water about Garden Key, he heard "a rushing, swishing sound; then a clap as of thunder," a negro boatman exclaimed "Vampa fish, sah," and later alluded to it as "Sea Vampa" or collectively as "Vampas."

[1] Every well-known fish student is more or less frequently asked some question or questions about the Devil-fish. Not infrequently the student is at a loss for an answer. The requisite information may have been published, but to obtain it perhaps hundreds of articles may have to be examined. After a search through such articles the present paper has been compiled and will furnish answers to many of the questions that may be propounded. It will at least serve as a basis for investigation and a repertory of what has been ascertained or thought to be facts.

[2] Big Game at Sea, 1908, pp. 2, 3, 4.

Sea-bat was found by Holder to be in use in the same locality as Vampire. When the negro Paublo exclaimed "Sea Vampa, sure," the Seminole chief in the same boat corroborated his identification rather than contradicted by exclaiming, "Sea-bat. . . . They

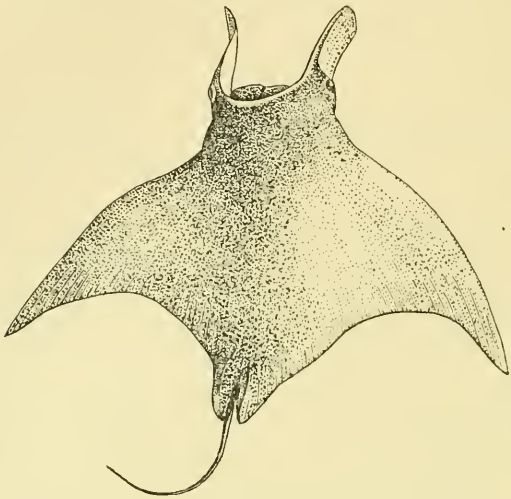

FIG. 40.—The Devil-fish. After a photograph.[1]

[1] The iconography of the Devil-fish is very defective and the figures herewith given are merely provisional. The plate first given by Jordan and Evermann (1900), later reproduced by Fowler (1906), Hugh Smith (1907) and others, is quite inaccurate so far as the tail is concerned. Instead of the tail being much longer than the body, as therein represented, it is only about 6/10 as long. Elliott (p. 101) especially criticized De Kay's "characteristic, viz., tail longer than the body," and affirmed "that the length of the tail is, to that of the body, as six to ten." He had examined "almost twenty individuals." The illustration cited was drawn in Dec., 1894, but the present writer was long unable to learn what was the basis of the figure. He finally traced it to De Kay, who published a composite figure based on Mitchill's and Lesueur's plates. There is no specimen of the Devil-fish in the National Museum. The figures here presented are (1) the old one with the tail modified to suit photographs and Elliott's description; (2) one drawn after the former outline with the under surface represented from a photographic illustration in Holder's work, and (3) a reproduction of a photograph of a fish caught in 1869 or 1870, during a cruise in the Pacific of a revenue cutter (Captain Freeman commanding). The last was taken while the fish was suspended from a tripod and the drooping fins may have been partly at least due to the suspension. That fish was about 13 feet wide. The photograph is very obscure behind and the reproduction consequently is unreliable, as are the other figures. Seven photographs or reproductions are at hand, but all are too obscure behind for guidance. A good one is extremely desirable as are also exact data as to relative proportions and weight. All published are deficient. A special article on the subject will follow.

jump five—yes, eight—feet high." Bat-fish and Black-bat are sometimes used variants.

Another name for the monster Ray has been borrowed from the Spanish. Among the fishermen, and especially the pearl divers of Central America and western Mexico, it is known as the Manta; this is a Spanish term, meaning originally blanket, and was given by the fishermen of parts of Spain and the island of Mallorca to a species of the Mediterranean[1] and extended thence to similar fishes of other regions. It has been explained that the name was given by the Spaniards of America to the Devil-fish because it was alleged to hover over and cover a fisherman at the bottom as a blanket preparatory to killing him for good. The belief, indeed, that the Devil-fish may so attack a man is not only widely spread, but of an ancient origin.

Such an idea, however, is contrary to our knowledge of the fish. Like several other of the gigantic selachians,[2] its diet is in almost inverse ratio to its size.

Inasmuch as Devil-fish is the best known of all these names and has been long current in story as well as in works on natural history, it will be retained here and will be used for the great fish best known as such, as well as for its congeners of smaller size. The species especially called Devil-fish is one of a number having the same essential characters and all designated in a general way as Devil-fishes.

II

The form of the Devil-fishes is extraordinary; the body, exclusive of the tail, is about twice as wide as long; the tail, however, corresponds to the hind part of the body in distant relations of the Devil-fish. Different as the animal is from Sharks generally, there is or has been every gradation from an ordinary Shark to the Devil-fish.

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[1] The Manta of Mallorca, or Majorca, is the *Mobula giorna*, and is the Vacca or Vaca (Cow) with various qualifications of some other localities in the Mediterranean. It is also the Bous of Aristotle. The names Vacca and Bous allude to the horn-like caropteres or head-fins. The species is said sometimes to reach a width of 28 feet. Carus, in his Prodromus Faunæ Mediterraneæ (II, 1893, p. 520), specifies "Longit. 1.5-3 m." Pellegrin in 1901 (Bull. Mus. Hist. Nat., VII, 327) noticed one 5m. 20 wide, and 4m. 15 long. There is record of one 28 feet wide and 21 feet long and "estimated to weigh a ton" (Zoöl., 1899, p. 146). The data are insufficient and a fish of the dimensions noted must have weighed very much more than a ton.

[2] The gigantic Basking Shark (*Cetorhinus maximus*) and the still larger Rhinodon (*Rhineodon typus*) of the Indian Ocean subsist mainly on the minute crustaceans and other animals living near the surface of the ocean.

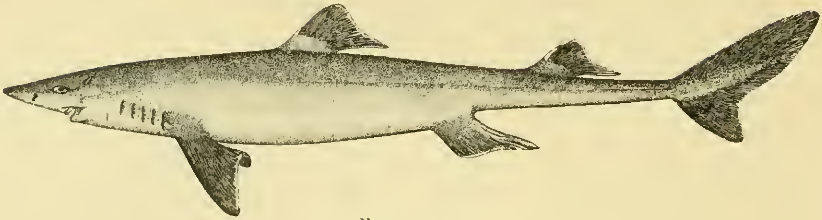

FIG. 41.

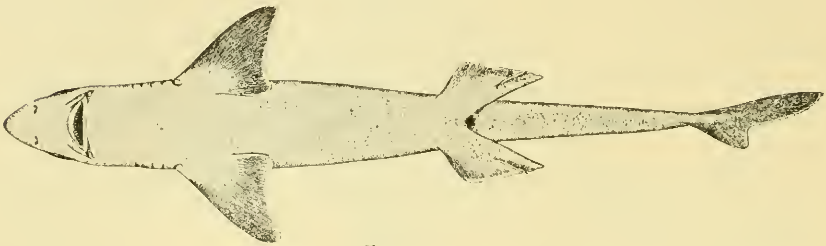

FIG. 42.

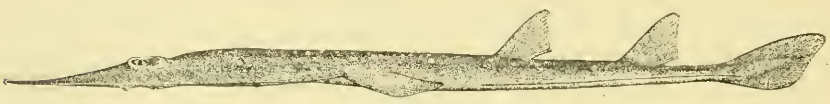

FIG. 43.

FIG. 44.

FIG. 45.

FIGS. 41 AND 42.—*Squalus acanthias.* FIGS. 43 TO 45.—*Rhinobatus lentiginosus.*

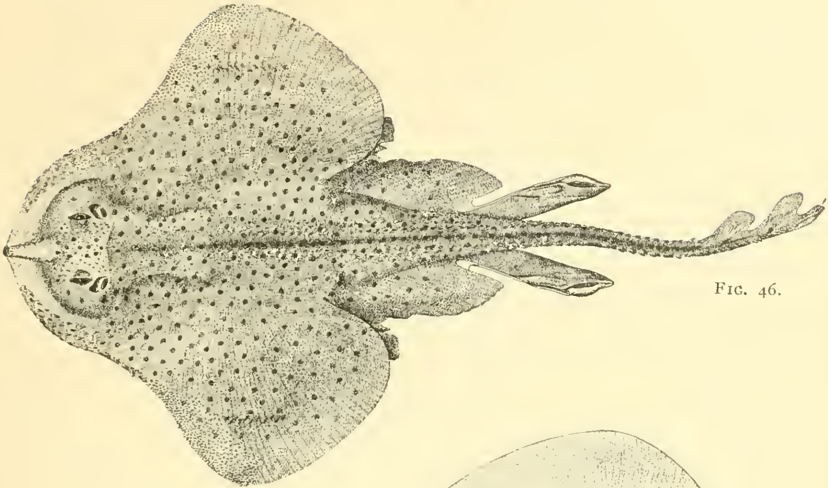

FIG. 46.

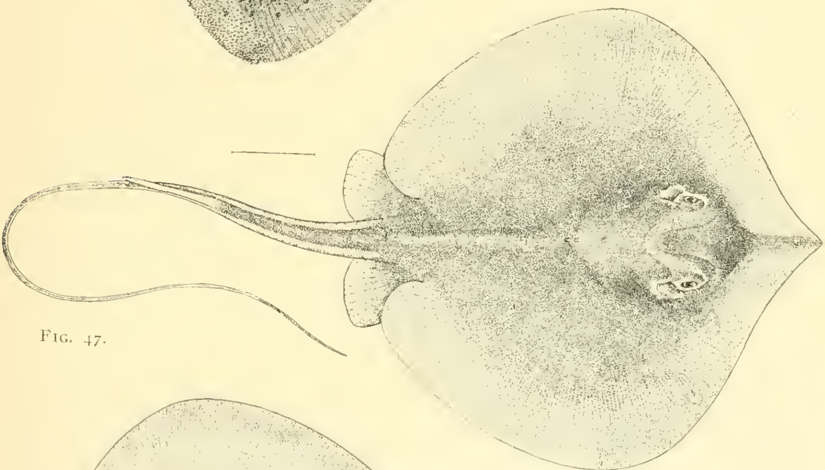

FIG. 47.

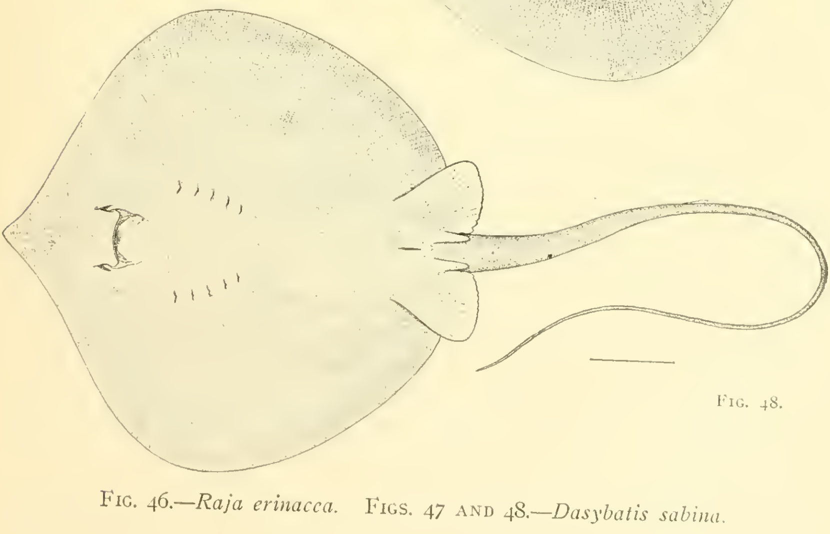

FIG. 48.

FIG. 46.—*Raja erinacea.* FIGS. 47 AND 48.—*Dasybatis sabina.*

A few forms still living exemplify the manner in which the extreme modification of the last has been attained; these forms, it is true, are not in the direct line of descent, but they are not very far off. The common Dog-fish of the New England coast (*Squalus acanthias*) has a slender tail, but there is a regular gradation from the preanal region, or trunk, into the postanal, or tail, and the pectorals have the slender bases characteristic of the Sharks generally. The Guitar-fishes (*Rhinobatidæ*) still have the regular gradation of the trunk into the tail, but the pectorals have a broad basis of union with the body and head, and a narrow disk is thus formed. In the ordinary rays (*Raiidæ*) the tail has become disproportionately slender and the disk wider and more sharply differentiated; in the Sting-rays (*Dasybatidæ*) the tail has almost entirely lost its muscular development, but the disk is much like that of an ordinary ray. The tail of the Sting ray is essentially like that of the Devil-fish, but in the Devil-fish the disk has become extended sideways into acutely angulated and wing-like fins. The homologies of the respective parts are thus evident. In the course of evolution, more and more resort has been had to the pectoral fins for progression and the tail correspondingly disused; the culmination has been reached in the Devil-fishes, which progress by wing-like flapping of their pectorals and the tail is carried inert behind.

The tranformation of shark-like forms into the ray-like type must have commenced early in Mesozoic times, for well-developed representatives of the Dasybatids and Myliobatids were living in the Cretaceous epoch and were abundant in the Eocene. It has been believed that no fossil remains of Devil-fishes have been found, or rather identified. If this had been a fact, it might have been partly explained by the pelagic habitat of the species and partly by the reduction of teeth and spines, the parts most likely to be preserved. There is, indeed, one record of an extinct form which, however, only takes us one stage back in the geological series. The record is of a supracaudal tubercle from the "phosphate beds" of South Carolina, which are supposed to be of post-Pliocene age; the tubercle has been considered by Joseph Leidy to represent an extinct species closely related to the living Devil-fish of the same State and has received from him the name *Ceratoptera unios;* it was described and figured in 1877 in the Journal of the Academy of Natural Sciences of Philadelphia (2nd ser., VIII, 248-9, pl. 34, figs. 1, 2).

The individual development of the fishes is to a large extent parallel with the evolution of the type from the shark-like form to the ray-like one.

The Devil-fishes form a family of ray-like Selachians to which the names *Cephalopteridæ, Pterocephalidæ, Mobulidæ,* and *Mantidæ* have been given. *Mantidæ* is that used for it by most recent Ameri-

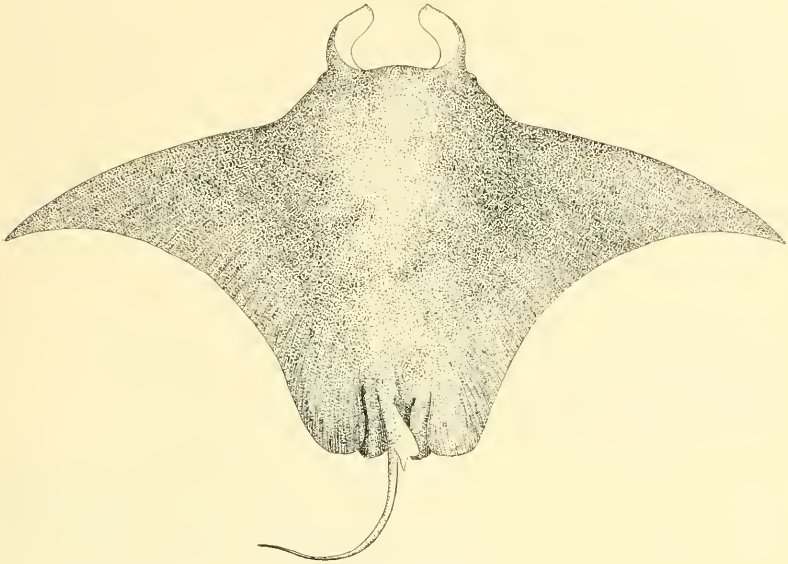

FIG. 49.

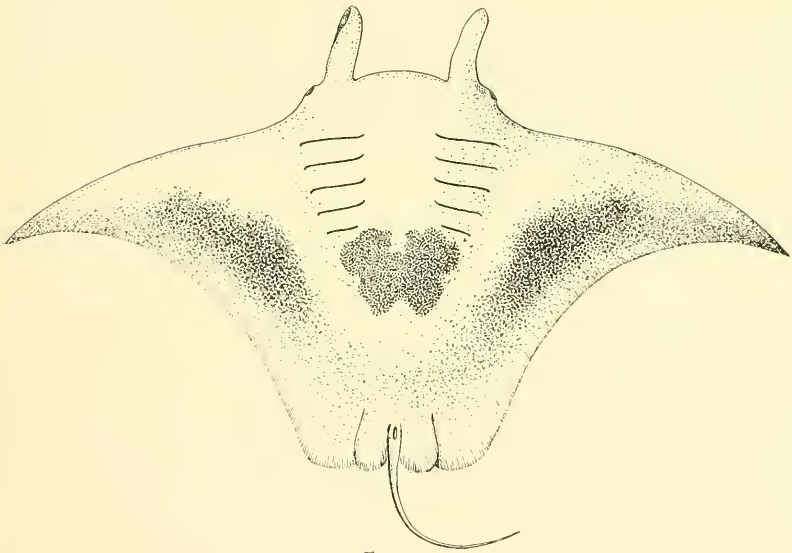

FIG. 50.

FIGS. 49 AND 50.—The Devil-fish. After Jordan and Evermann. (With reduced tail.)

can ichthyologists, as Jordan and Evermann, but it had been previously taken for a family of insects. *Mobulidæ* may be used here. The essential external characters of the family follow:

Mobulidæ

The Mobulids or Devil-fishes include the largest as well as the widest of rays. Behind the anus the tail is abruptly attenuated and developed as a whip-like appendage without efficient spines. The mouth, instead of being inferior, as in other types, is in front, and the jaws have weak teeth or are partially toothless. The pectoral fins are extended outward in a wing-like manner, and long, flexible, horn-like processes or fins are developed on each side of the head and bound a preoral space. These processes (caropteres, head-fins, or horns) can be used for grasping, and a number of cases have been

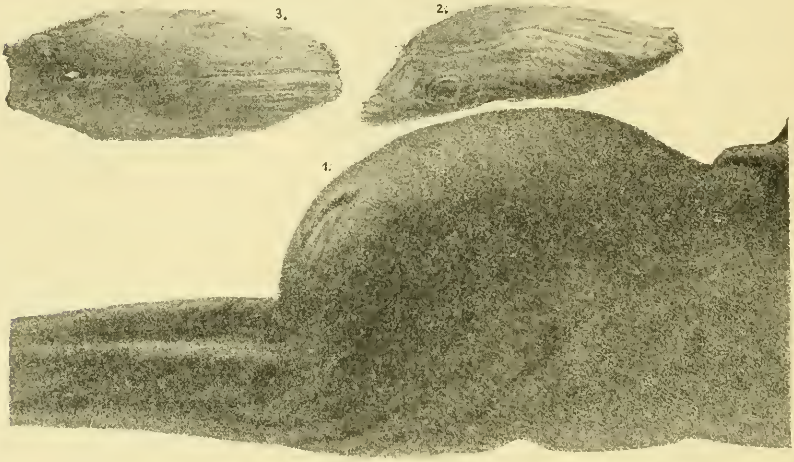

Fig. 51.—Tail of the Devil-fish. After Holmes. (Proceedings Elliott Society of Natural History, I, pl. 3.) About half natural size. 1. Knob and base of tail. 2. Bone with the small spine as extracted from the knob. 3. Upper view of the same with the posterior spinelet (in white).

recorded of a Devil-fish seizing the anchor of a vessel and running away with both anchor and vessel for some distance, to the wonder and fear of the sailors. The spines about the base of the whip-like tail, characteristic of the nearest relations of the Devil-fishes, the Sting-rays and Eagle-rays, are reduced in size and sometimes to a minimum in the Devil-fishes. In the typical species the spine is quite rudimentary and concealed in a subosseous swelling at the base of the tail behind the small dorsal fin.

Further, the Devil-fishes are peculiar in the possession of prebranchial organs, to be noticed later.

III

The Devil-fishes are inhabitants of warm-water seas. They are to some extent pelagic, though, as a rule, they appear not to extend far out into the high seas. They belong to the category of tropicopolitan forms, some one or other species occurring in every tropical and every subtropical sea. Besides, some may venture far beyond the limits of the Tropic of Cancer or of Capricorn, one wandering occasionally as far as New York and another into the Mediterranean Sea.

If we may also believe Turner-Turner, "a characteristic pose is that of lying motionless, or at most with its disk slightly undulating with respiration, in the sand just under the water. Sometimes, indeed, they are found a yard or so above low-water mark, in pits of their own making." This observation needs confirmation for Devil-fishes, although applicable to Sting-rays. But certainly they require to rest on the ground, and sometimes, when harpooned, they descend and (to use a term of the angler) sulk on the bottom. Elliott remarks that at times one "plunges desperately for the bottom, to which he sometimes clings for hours." But they are best known as active—and very active—frequenters of the surface waters.

Another characteristic of a Devil-fish's action is a tendency to turn somersaults. According to Elliott,[1] "It is a very curious exhibition. You first see the feelers thrown out of the water; then the white stomach, marked with five gills, or branchial apertures, on each side (for the fish is on his back); then his tail emerges. After a disappearance for a few seconds, the revolution is repeated, sometimes as often as six times. It happens occasionally that in making these somersets the fish does not rise quite to the surface, but is several feet below; so that his revolutions are detected by the appearance and disappearance of the white or under part of his body, dimly seen through the turbid water in which he delights. Sometimes, indeed, he is unseen; but his presence is shown to the observant sportsman by the boiling of the water from below, as from a great caldron. With no better guide than this, the harpoon has been darted down, and reached him when twelve feet below the surface."

These somersaults (or somersets as Elliott[2] calls them) are often made by the fishes when leaping out of the water. Elliott especially noticed a number in 1846 (July 1st) at four o'clock in the afternoon near Hilton Head (S. C.): "They did not show themselves *somer-*

[1] Op. cit., p. 75.
[2] Op. cit., p. 85.

setting for some time, but after a while began to sport and throw somersets under the water, but so near to the surface as to show their bellies in the evolution. We saw, I do not doubt, as many as twenty fish. We counted eleven that leaped entirely out of the water. They were in the channel, and were further from shore than where we had usually met with them; and, on approaching near to them in our boat, we remarked that those which leaped entirely out of the water did not again show themselves on the surface until they had silently gone a mile or so toward the sea, when they reappeared, gambolled awhile, threw new somersets, and again disappeared for a new seaward movement. The fish which were behind came along sporting until they had reached the spot where the first had thrown their somersets. They, too, then threw their somersets, and disappeared like the first. Usually they leaped twice—leaping from their backs, and falling likewise on their backs; leaping, I should say, at least ten feet above the water."

The appearance and evolutions of the Devil-fish are indeed impressive and startling. Holder[1] thought that "no more diabolical creature could be imagined. They resembled enormous bats, and in following one another around the circle raised the outer tip of the long wing-like fin high out of the water in a graceful curve, the other being deeply submerged." They might be seen, "now gliding down with flying motion of the wings; sweeping, gyrating upward with a twisting vertical motion marvelous in its perfect grace; now they flashed white, again black, so that one would say they were rolling over and over, turning somersaults, were it possible for so large a fish to accomplish the feat." Such evolutions, Holder learned, were "really a common practice of the big rays." But it is the great leaps out of the water that are most striking, especially during the stillness of the night. Holder,[2] on such an occasion on the outer Florida reef, first encountered the fish. "There came out of the darkness, near at hand, a rushing, swishing noise; then a clap as of thunder, which seemed to go roaring and reverberating away over the reef, like the discharge of a cannon. So startling was the sound, so peculiar, that the negroes stopped rowing, and one or two dropped their oars in consternation."

[1] Op. cit., p. 8.
[2] Op. cit., p. 2.

IV

In some warm sea a fortunate observer may find perhaps a Devil-fish or a couple swimming on or near the surface; not rarely a school, or "shoal," of them. (Shoal is the word used by the Hon. William Elliott in his earliest full treatise on them as subjects of sport.[1]) Frequently they project themselves in the air to a considerable height and for some distance. Their progression indeed is rather of the nature of flight than swimming, and has been likened to "the flight of a bird of prey"; it is by flaps of the wing-like pectoral fins and not at all by the tail, as in Sharks and fishes generally.

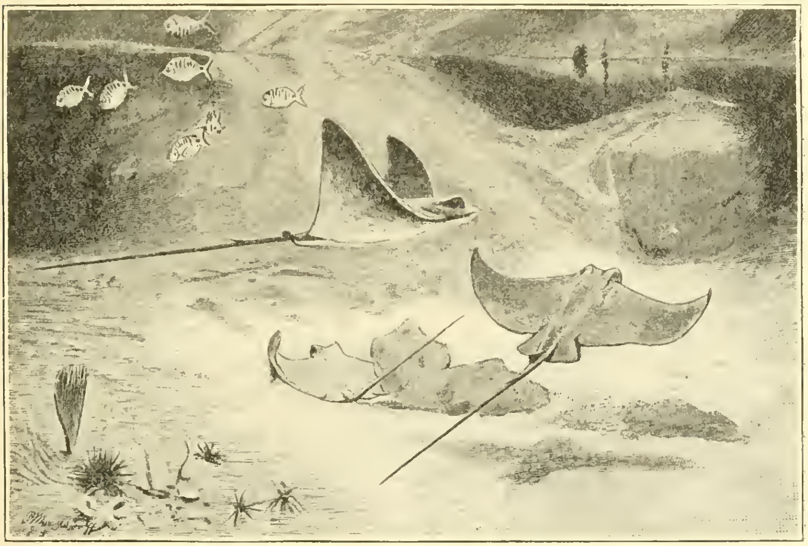

FIG. 52.—Eagle-rays in motion. After Mangelsdorff. (Natur und Haus, 8, 1900, p. 255.)

In fact, the progression of the Devil-fishes is quite similar to that of their near relatives, the Eagle-rays, which have been portrayed from life by Mangelsdorff. Meanwhile, according to Holder, their caropteres, or head-fins, otherwise called arms, feelers, claspers, or horns, are "in constant motion, being whirled about like the tentacles of a squid."

Mr. Hector von Beyer, of the U. S. Bureau of Fisheries, informed Dr. Hugh Smith[2] that he had "observed the animal in the Gulf of

[1] Carolina Sports by land and water, including incidents of Devil-fishing, [etc.]. Charleston, 1846. (2d edition, N. Y., 1850; 3d edition, N. Y., 1859.)

[2] The Fishes of North Carolina, 1907, p. 48.

California" and noticed that "each of these appendages may be curved on itself like an elephant's trunk, and can firmly grasp objects within reach." According to Elliott,[1] "It is the habit of this fish to ply these arms rapidly before its mouth while it swims, and to clasp with the utmost closeness and obstinacy whatever body it has once inclosed. In this way, the boats of fishermen have often been dragged from their moorings and overset by the Devil-fish having laid hold of the grapnel."

That these "arms" are muscular and powerful has been demonstrated on many occasions. The natural movement of the head-fins or caropteres is inward, and when any object strikes between them it is instinctively held, a proceeding which explains the undoubted fact that these fishes can run away with quite large vessels. Many such cases of towing vessels have been recorded.

One of the characteristics for which the Devil-fishes are celebrated is the capture of vessels and carrying them off far from their moorings. In one of the earliest notices of the Devil-fish, by John Lawson in "The History of Carolina" (1714), this peculiarity is described. "The Devil-fish," he says, "has been known to weigh a ship's anchor, and run with the vessel a league or two, and bring her back, against tide, to almost the same place." Later notices do not give the animal credit for the same accommodating treatment! A number of accounts, however, corroborate the tendency indicated. William Elliott noticed several instances, and, in later times, Holder (p. 18) records that "at least instances of this were heard of on the reef occurring from Tampa Bay to Garden Key." He adds: "In every case the vessels, always at anchor, suddenly moved off in a mysterious manner and were towed greater or less distances. The Ray had collided with the chain, and, true to its instincts, threw its two tentacular feelers or claspers around it and rushed ahead, thus lifting the anchor."

In accordance, too, with this proclivity to seize upon objects which bar their progress, Devil-fishes have been charged with damage and destruction to wharves which extend into the water. "It was in obeying this peculiarity of their nature that a shoal of these fish, as they swept by in front of 'Elliott's' grandfather's residence, would sometimes, at floodtide, approach so near to the shore as to come in contact with the water fence, the firm posts of which they would clasp and struggle to uptear, till they lashed the water into a foam with their powerful wings."[2] Any such action, however, would be entirely exceptional and the statement requires authentication.

[1] Op. cit., p. 16.
[2] Op. cit., p. 16.

V

The food of the Devil-fishes, so far from being large animals and occasionally a man or so, as has been alleged, appears to be chiefly the small crustaceans and young or small fishes which swarm in certain places near the surface of the water. Rarely does one prey on large fishes. Once only did the man who had the most experience with the fish (Hon. William Elliott) see evidence of disposition to resort to scaly fish; he gives this testimony:[1] "I have frequently examined the contents of their stomachs, and found little else in them than portions of shell-fish, highly triturated, resembling the shells of shrimps. Once a small crab was found entire; but I sought in vain for the scales of small fish, which I supposed to be their food, partly because the Devil-fish make their appearance in our waters in *May*, before the shrimps are found on our shores, and would thus be anticipating their food—a mistake which fish are not apt to make—and partly because I witnessed a performance on the part of a Devil-fish which could scarcely be referred to anything else but to an occasional indulgence in a fish diet.

"I was watching a Devil-fish, who was playing close to the shore. But in shallow water he is often alarmed by the noise of the oars, and he would not suffer my approach within striking distance. While thus engaged, I observed a shoal of small mullets swimming near the surface, and showing signs of extraordinary agitation, when suddenly the open mouth of the Devil-fish was protruded from below, and the small fry disappeared from view, and were received into it, as into the mouth of an enormous funnel. I do not think it was mere wantonness on the part of the fish, but that he was, on that occasion, indulging a caprice of appetite, and substituting a diet of scále-fish for his ordinary mess of shrimps."

We have, in this observation, a hint as to the function of the "horns" or head fins; these may not only serve by their extension to partly confine the prey, but they may be actively used to drive or scoop them in. The stories of their grasping intentionally may be received with some skepticism, although they do so accidentally.

It is, indeed, largely by means of the head fins, or caropteres, that the Devil-fishes secure their food. That consists at least in part of crustaceans and other organisms which live about the surface of the seas they frequent. In the Gulf of California, where the Devil-fishes are most numerous, such animalcules are said by one observer to so abound that a thick sheet (nappe épaisse) of the organisms is

[1] Op. cit., pp. 84, 85.

formed at the surface of the water. The fishermen in such localities affirm that they never find any large animals in the stomachs of the Devil-fishes.

But, if Richard Hill[1] is to be credited, some Devil-fishes may be also "ground feeders." They are, he thought, "formed for shoving through the fields of turtle grass, *testudinaria,* but, unlike the Rays, which are likewise ground feeders," one of the Devil-fishes "does not seize its prey on the ground, but, pushing on through the marine herbage, it takes into its wide-open mouth the congregated living things that are in the way—it may be the fish that nestle in the vegetation or the naked mollusca that depasture there—at once swallowing them, or rather cramming them in with its cranial arms into its mouth and stomach, without deglutition, having no œsophagus. As the animal in this gathering in of food can not see forward, it must depend on casualties in the course it steers through the marine meadows for prey. The rolled-up head-fins between the crescented head sufficiently direct the food to the mouth."

In the Gulf of Mexico and elsewhere, the Devil-fish has been charged with feeding on shell-fish and complaint has been made that it does considerable damage to oyster beds. This charge is due simply to the fact that the animal has been confounded with the Eagle-rays, whose large molar teeth eminently fit them for crushing shells. The general resemblance as well as real relationship of the Devil-fish to the Eagle-rays is indeed such as to leave no room to wonder that the same name is applied to species of both families, but the singular head-fins of the Devil-fish distinguish it from all its relations of different families.

Probably connected with the food and feeding of the Devil-fishes are peculiar organs within the mouth, called by Panceri[2] and Duméril,[3] who first described them, "prebranchial appendages."

"On examining at the bottom of the mouth the pharyngeal apertures of the branchial chambers, or separating the walls of their external apertures, we see, in front of each of the respiratory surfaces, a very regular series of organs which do not occur in any other fish, whether bony or cartilaginous.

"These organs are elongated lamellæ, the aspect of which somewhat reminds us of that of the stems of ferns, but with the leaflets

[1] The Devil-fish of Jamaica. Intellectual Observer, 2, 1862, p. 167-176.

[2] Panceri (P.) e Leone de Sanctis. Sopra alcuni organi delle Cephaloptera Giorna, M. H. Atti Accad. Pontoniana, Napoli, vol. 9, 1871, pp. 335–370, 2 pls.

[3] Duméril (A.). On the presence of peculiar organs belonging to the Branchial Apparatus in the Rays of the Genus Cephaloptera. Ann. Mag. Nat. Hist. (4), 5, 1870, pp. 385, 386.

turned back toward the branchiæ. Each being formed of a fold of mucous membrane supported by a cartilage, these lamellæ are attached to the anterior surface of the branchial arches, in front of the membranous and vascular folds of the respiratory organs; and it is their position that has suggested the name of *prebranchial appendages,* by which they are designated by the Italian anatomist.

"They do not serve for respiration. By means of injections, M. Panceri has ascertained that they receive arterial vessels, like the other organs, and not branches of the branchial artery."

These organs are thought by Panceri (and Duméril did not dissent) to be "destined, on account of the remarkable size of the apertures of the branchial chambers, the orifices of which are much

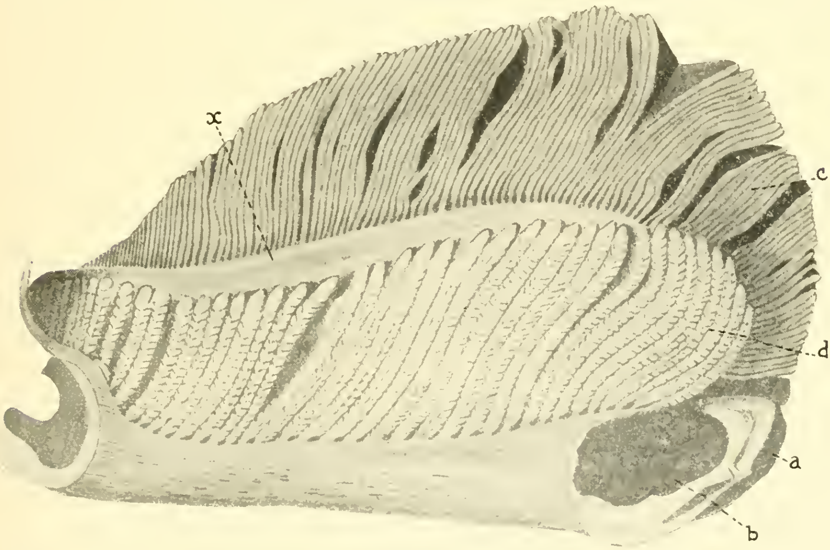

FIG. 53.—Anterior Hemibranch of the Fourth Left Pouch.

a. Fourth branchial arch.
b. Section of the special muscle of the branchial arch or adductor of the two ceratobranchial and epibranchial portions.
c. Branchial lamellæ.
d. Prebranchial appendages.
x. Fold of the mucosa which partly covers the branchial lamellæ.

smaller in the other Rays, to retain the water and prevent it from traversing these cavities with a rapidity which would be injurious to the perfect accomplishment of the act of hæmatosis."

A more probable use for these organs would be as strainers, subserving thus the same function, or rather an analogous one, as that of the gill-rakers of the giant Sharks. They would retain the small organisms contained in the ingesta taken into the mouth, while the water itself would find exit as usual, relieved of a large part of its life.

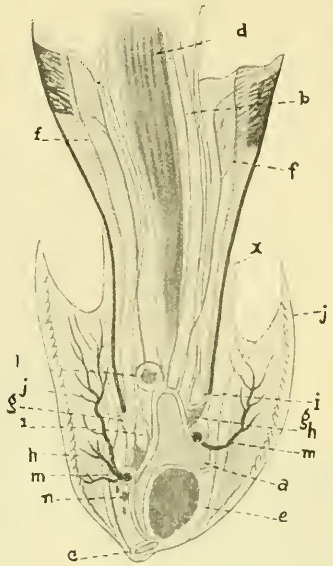

FIG. 54.—A Branchial Arch with Annexed Organs; transverse section next to the articulation of the arch (semischematic).

a. Branchial arch with fossa of adductor muscle.
b. One of the cartilaginous rays of the branchial diaphragm adherent to the anterior branchial lamellæ.
c. Accessory stem which connects with the arch.
d. Muscle of the branchial diaphragm or interbranchial muscle to which posterior branchial lamellæ adhere.
e. Adductor muscle of the ceratobranchial and epibranchial parts of the arch.
ff. Branchial lamellæ whose external surface as usual is folded.
gg. Cartilaginous stems of the bases of the branchial lamellæ.
hh. Muscles which unite the latter to the arch.
ii. Hydrophorous canals.
jj. Prebranchial appendages in profile.
l. Branch of the branchial artery.
mm. Branchial veins with efferent lamellar branches, from which proceed the branches for the prebranchial appendages.
n. Principal nervous trunk.
x. Fold of mucosa covering partly the branchial lamellæ.

VI

The Devil-fishes, of course, like other Selachians, come together in sexual intercourse.[1] The details of their union as well as the

[1]According to Risso (Hist. Nat. Europe Mer., 1826, p. 165) the female of the *M. giorna* is always (toujours) much larger than the males. No observations have been made on the American Devil-fish; it is to be hoped that some may be.

length of gestation are unknown. Even the exact date of the one observation that has been published has not been given, although it appears to have been some time in July. It is, indeed, quite possible that the appearance of the animals close to the coasts of the Southern States may be for the purpose of finding a suitable place for the birth of the young. By Elliott,[1] it was found, in the first years of his experience with them, that they appeared "only in August"; in 1843, "for the first time, in July," and in 1844 they were "taken in June."

Care seems to be extended even to the place of parturition by the Sting-rays, so that the young shall encounter the least danger from the tide as well as from living enemies. Alcock tells that all the small Sting-rays (*Dasybatis walga*) with embryos he observed "were found in shallow little tidal pools lying behind natural breakwaters of sand," and he urges, "it seemed as if this comparatively safe situation had been deliberately chosen by the mother as a nursery for her expected family, as, in the opinion of Professor McIntosh, is the case with the viviparous Blenny (*Zoarces*) of northern seas." Analogous care may therefore be exercised by the Devil-fishes, the relations of the Sting-rays.

A pair of these huge animals, male and female, were seen in union by Mr. Elliott and described by him.[2]

VII

Whatever be the size or other characters of the Devil-fishes, so far as observed, they agree among themselves and differ from most other fishes[3] by having, normally, only a single young one at a birth. The giant mothers noticed by Duhamel, Risso, Mitchill, and Lamont

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[1] Op. cit., p. 67.

[2] Subito, læva—sed longiore spatio, quam, si jaculatus essem, speraverim transfigere ictu—duos pisces cephalopteras aspexi, amplexu conjunctos. Ventribus juxtapositis—capitibus erectis, et supra undam oblatis—antennis lascive intersertis—coitum salacem, ut solet genus squalus, ipso contactu corporis, tunc sine dubio exercuere. Ferire, ob distantiam non licitum, aut duos cephalopteras, solo ictu transfixisse, gloria inopinata mihi contegisset. Cymbam appropinquantem, hastamque minantem, circumspecte evitant—et, in profundo paulisper latentes, iterum, dextra emergunt, ludosque lascivos repetunt. Tunc, quasi deliciis satiati, saltatione in aëre, utrinque facta—apertum mare petivere. Hoc concursu tam raro notato—antennis albis, cum nigris admixis utsi lacertis—imago fœdi et immundi coitus, nudi Africani cum Caucasiana, plane præfigurabatur. (Elliott, Carolina Sports, 3d edition, pp. 93, 94).

[3] The Stingrays (Dasybatids) of some species at least have only a single young.

each had only one (one or two, according to Risso[1]). In case of the small species named *Ceratobatis robertsii* or *massenoidea*, the mother likewise had a single fœtus (a fœtus sixteen inches wide).

Although only one young is formed, that one is worthy of the giant mother and larger than any of the full-grown common Rays of ordinary size. It is practically immune from danger from the customary enemies of fishes and well able to take care of itself.

Nature is economical in her methods and there is some adjustment of ways and means. In the case of egg-laying fishes of inferior size and when no care is taken of the eggs, many thousands—even millions—may be laid by a single fish, and yet the number of adults remains practically the same, generation after generation. In the case of viviparous fishes like the Devil-fishes, a single young one at a birth is enough to keep up the species.

The fishermen of Jamaica, according to Hill, "say that the mother fish makes the violent leaps she is seen to take out of the water to eject the fœtus from the matrix; that the young fish is then observed to fall from her; and that for a time it swims upon the parent's back, and possibly enters the wide mouth-sack when necessary to seek shelter from apprehended danger." All this is improbable. It appears to be certain that the "leaps" are habitual to males and females alike, and it is probable that they are the extension of their peculiar mode of progression or "flight."

A pregnant female, 15 feet wide and which with difficulty forty men with two lines attached to it could drag along the ground, was landed, after a five hours' fight, at Port Royal, Jamaica, in 1824. "On opening it a young, about 20 pounds weight, was taken out, perfectly formed"; it was five feet broad. An account of the capture was given by Lieutenant Lamont in the Edinburgh Philosophical Journal (XI, 113-118).

Two observations respecting the procreation of Devil-fishes require attention.

That the Devil-fishes have only one young each, and consequently are viviparous, is the statement made by all observers. This viviparity is in analogy with the gestation in the relatives of the Devil-fishes, all the Sting-rays and Eagle-rays. Nevertheless a gentleman

[1] Risso, in his "*Remarques*" on the "Céphaloptères" gives the following data: L'époque de leurs amours est l'hiver; les femelles mettent bas en Septembre un à deux petits, qui originairement sont renfermés dans un œuf oblong jaunâtre. Les mâles paraissent quelquefois n'abandonner leur compagne qu'après qu'elle a déposé ses fœtus; et si l'un des deux se jette dans un filet, l'autre ne tarde jamais à le suivre. Risso Hist. Nat. Europe Mer., 3, 1826, p. 165.

with considerable knowledge of ichthyology, Swinburne Ward, once the Civil Commissioner of the Seychelles Islands, after an account of the capture of a Devil-fish which "ten men could not haul" up on the beach, concluded with the affirmation that "she was full of eggs." The idea might be (and has been) derived that this may have been a case of oviparity or multiparity, but the eggs (if they were such) were possibly the reserve stock left perhaps after the birth of a young one. The statement is in great need of confirmation.

Mitchill, in 1823, tells that a "female that was struggling after having been wounded brought forth in her agony a living young one, as Captain Potter related, and Mr. Patchen, while he showed [Mitchill] the orifices through which sucking is probably performed, declared that on dissection mammary organs were found, which discharged as much as a pailful of milk." This at first incomprehensible and incredible statement may be reconciled with facts when we recall the mode of nutrition of the embryo among the Sting-rays, described by Alcock. It was the honest statement of an inexperienced observer who misinterpreted facts.

A remarkable provision among the Sting-rays for the nutrition of the embryo within the body of the mother has been made known by A. Alcock, on whose description, published in 1902, we may draw.[1]

It is by means of a secretion which is regarded as "analogous to milk" that the embryo is for some time fed. The mucous membrane of the oviduct is "shaggy, with vascular filaments [named *trophonemata*] dripping with milk" or rather a milk-like fluid, and on microscopic examination it was found that "each filament was provided with superficial muscles whose contraction must serve to squeeze the milk out. Some such mechanism is undoubtedly necessary, seeing that the young one has no power of extracting the secretion for itself. On examination of the young one, the mother's milk was found inside the modified first pair of gill-clefts or spiracles (the other gill-clefts being tightly closed), and also in large clots within the spiral valve of the intestine, so that there can be no doubt that in these viviparous Rays the unborn young ones may be said to

[1] Alcock (A.). A Naturalist in Indian Seas [etc.], London, 1902, pp. 210, 71, 159. See, also, Observations on the Gestation of some Indian Sharks and Rays. Journ. Asiat. Soc. Bengal, 59, pt. 2, 1890, pp. 51-56, pl. 1; On the Uterine Villiform Papillæ of *Pteroplatea micrura*, [etc.] Proc. Roy. Soc., 49, 1891, pp. 359-367, pls. 7, 8; Further observations on the Gestation of Indian Rays; [etc.]; Proc. Roy. Soc., 50, 1891, pp. 202-209. On Utero-gestation in *Trygon bleekeri*. Ann. Mag. Nat. Hist., (6), 9, pp. 417-427, pl. 19, 1892; Some Observations on the Embryonic History of *Pteroplatæa micrura*. Ann. Mag. Nat. Hist., (6), 10, pp. 1-8, pl. 4, 1892.

'drink its mother's milk' like a mammal, even though the milk-like secretion does not go in at the mouth, but by channels homologous with the ear-drum of air-breathing vertebrates."

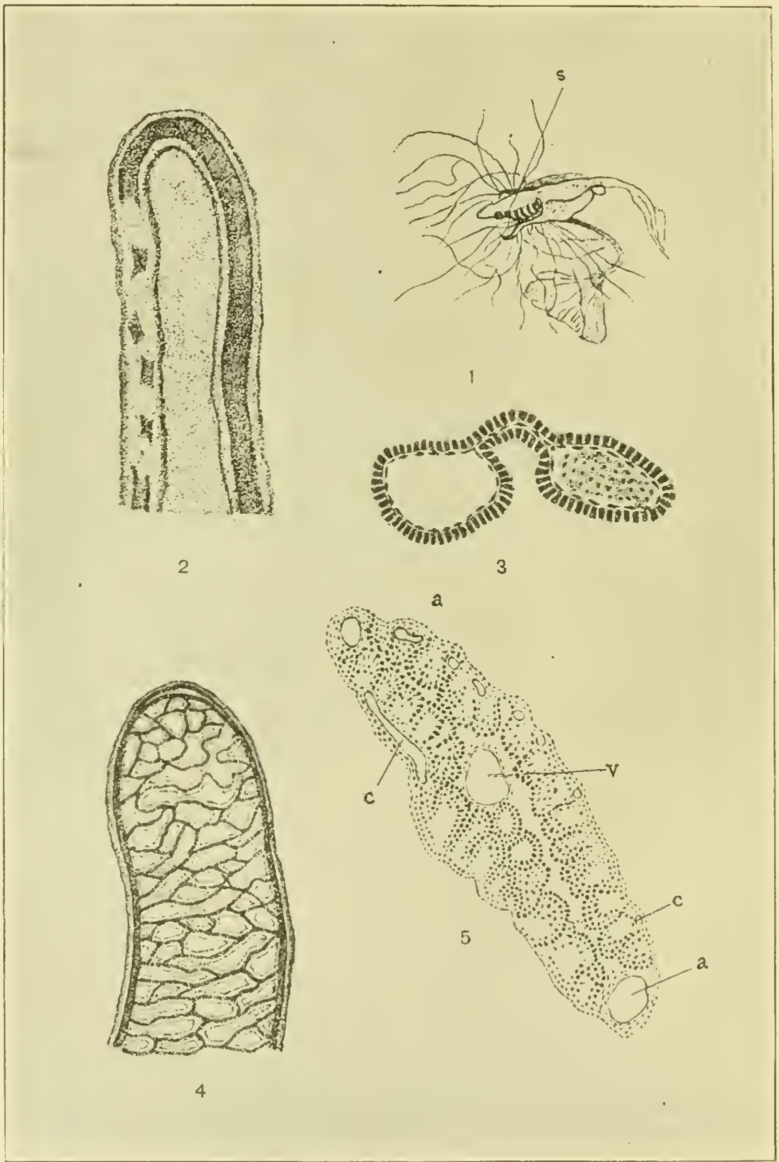

FIG. 55.—*Pteroplatœa micrura.* After Alcock.

EXPLANATION OF FIG. 54.

1. Embryo of *Pteroplatœa micrura,* from dorso-lateral aspect; nat. size, but with only a few of the gill-filaments represented, for the sake of clearness. *s,* spiracle.
2. End of a gill-filament, showing marginal capillary filled in places with blood-clot. × 42.
3. Transverse section of a gill-filament, showing the marginal capillary in section and the single fold of epithelium. × 188. For the sake of clearness the blood-clot is represented in one limb of the capillary only, and the spaces between the nuclei of the surface epithelium are a little exaggerated.
4. End of a trophonema, or nursing-filament, seen as a transparent object in glycerine, showing the marginal artery and the superficial capillary plexus. × 42. The median vein is not seen so near the end.
5. Obliquely transverse section through a nursing-filament, showing the glands still in the form of solid bulbs lying beneath a still unbroken surface of epithelium. × 110. *aa,* arteries; *v,* vein; *cc,* superficial capillaries.

Doubtless an analogous provision for the nutrition of the embryo is developed in the Devil-fishes, and thus we have a satisfactory explanation of the statements of Patchen and Mitchill. Something like milk is secreted by the mother fish and is ingested by the young, but it is chemically different from milk, and instead of being sucked in by the mouth is absorbed through the postocular spiracles. The statements which have been much ridiculed have therefore a sound foundation in fact and are susceptible of a natural explanation.

Nothing is known respecting the development of the embryo of any Devil-fish, but undoubtedly it is similar to that of the Sting-rays.

The very young embryo of the Sting-rays, as of all other Rays, contrasts remarkably with the mother, especially in the case of the very wide forms, such as the Pteroplateines. The embryo at an early stage has a form very like that of a Shark, but with pectorals provided with basilar extensions free from the head, and extending forward parallel with it in advance of the eyes. These extensions later unite with the sides of the head, and the regular Ray has then become developed. Essentially, the form of the mother has been attained by the young when ready for extrusion from the mother's womb. This much at least is known of the new born of Devil-fishes.

VIII

The various species of Devil-fishes are representatives apparently of three different generic types, distinguished by differences of derivation. *Mobula* (also called *Aodon*, *Cephaloptera*, or *Dicerobatis*), has teeth in both jaws; *Manta* (or *Ceratoptera*) has teeth confined to the lower jaw, and *Ceratobatis* has teeth only in the upper jaw. The species also differ in size and the character of the dorsal spine. While a width of twenty feet or more may be attained by some, others become sexually mature when four feet wide. In most of them the tail is short and the dorsal spine characteristic of Sting-rays is obsolete, but it is asserted to be well developed in the *Mobula giorna*.

The number of species of Devil-fishes is uncertain. In 1870 seven species were recognized, five of the genus *Dicerobatis* (*Mobula*)[1] and two of *Ceratoptera* (*Manta*). One representing a new generic type (*Ceratobatis*) was added in 1897. One of gigantic size, generally supposed to be *Manta vampyrus*, has been observed at many places. Whether there are more than one species is uncertain.[2] There is a discrepancy in the length of the tail assigned to some. Most of the giants have a tail nearly as long as the body, but one referred to by Hill, about fifteen feet wide, had a tail only two feet long.[3] The species of *Mobula* differ. The *M. giorna* of the Mediterranean is said to have a tail about three times longer than the width of the disk; the *M. japonica* one "nearly thrice as long as the body," and the *M. olfersii* of Brazil and the Caribbean Sea one about as long as the disk and much less than its width. The *Ceratobatis robertsii* has the tail not much less than twice the length of the disk (620: 350), but considerably less than its width (620: 780).[4]

One species—the true Devil-fish of the United States, *Manta vampyrus*—is not uncommon in the warm American waters and appears on the South Carolina coast in summer in "shoals."

The *Manta vampyrus* has a body or disk nearly twice as wide as long, and a tail about 6/10 as long as the body; the body and tail are rough from the development of small tubercles which extend almost everywhere; the band of teeth (confined to the lower jaw) extends over almost the whole width of the jaw and is composed of about a

[1] Three nominal species were described later—*Dicerobatis draco,* Günther, 1872; *D. monstrum* Klunzinger, 1871, and *Cephaloptera tarapacana,* Philippi, 1894.

[2] This subject will be considered in a future article.

[3] The tail may have been decurtated in youth.

[4] The figure in Day's Fishes of India (1878, p. 745), which he "surmises" may represent *"Ceratoptera ehrenbergii"* is nothing but an illustration of a not uncommon monstrosity of an ordinary Ray (*Raia*) with free anterior extensions of the pectorals, resulting from arrest of development. (See Proc. U. S. Nat. Museum, 1895, pp. 195-198.)

hundred transverse rows; the rows are separated from each other by well-marked interspaces. It is said to attain a width of 30 feet.[1]

This or a very closely related species has been found not only in the West Indian and Carolinian seas, but along the west coast of America, along the African coast, and in the Indian Ocean. A Devil-fish fourteen feet six inches wide, caught near Durban, Natal, also presented the same proportions as the American species. A plate representing it from before and behind was published in the Zoölogist for April, 1899.

Like most other large Selachians, the Devil-fish is beset by Echeneidids, commonly known as Sucking-fish or Suckers and often confounded with the Pilot-fish. Elliott[2] noted that "he is attended by a band of parasites," which "followed him into shoal water" and "adhered so closely after he was aground that several suffered themselves to be taken by the hand."[3]

IX

The Devil-fish from time to time has been the object of sport. He who indulged most in it and captured almost twenty has given animated pictures of some of his adventures. One of the most condensed and entertaining accounts may be welcome here.

One day in late June (24th), sailing toward "Hilton Head" (South Carolina), Mr. Elliott with his crew went after Devil-fish. Soon he saw "a shoal" of them "sweeping along the beach, traveling rapidly downward with the tide" and freely showing themselves at the surface. After an ineffectual cast with a harpoon, "three showed themselves below and one above."

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[1] The records of size are very defective. The largest actually measured by Elliott was 17 feet wide (p. 64), another 16 feet (p. 80), and another 15 feet (p. 43). Another lost after being dragged "into three feet water" was estimated to be larger; "there he lay, extending twenty feet by the wings" (p. 51). One taken in the Gulf of California in 1846 was 19 feet wide, 3 feet 6 inches thick, and had a mouth 3 feet 5 inches wide (Zoöl., 1849, p. 2358). Another noticed by Gosse (The Ocean, p. 193-194, Amer. Edit., p. 189) taken at La Guayra, was 20 feet wide, with a "length from end of tail to end of tusks [caropteres] 18 feet," a "mouth 4 feet wide," and "its weight 3,502 pounds."

[2] Op. cit., p. 44.

[3] Le Vaillant, near the African coast, met three Devil-fishes ("diable"), one of which was accompanied by a sucking-fish ("pilote du diable") attached to each horn ("corne") of the Devil-fish. His account is unreliable. The parasite is the *Remora remora* according to Street (Bull. U. S. Nat. Mus., 7, p. 54), and Pellegrin (Bull. Mus. Hist. Nat., Paris, VII, 327).

Now he shall speak for himself:[1]

"I pushed at one that showed his back fairly above water, as he swam; but he sank just before I reached him, and I drove down the harpoon at a venture. He had a narrow escape, for the staff struck him. At this moment, three showed themselves below and one above. I pushed for the latter, and when I approached the spot, I saw the water boiling up like a caldron—from which sign I knew that the fish was throwing his somersets below the surface (in the way which is so very peculiar to them). Making the oarsmen check the headway with their oars, I looked anxiously for a view, when, unexpectedly, I saw the white of his belly far beneath the water, and quite away toward the stern. He was thus behind me, but wheeling suddenly to the right, I pitched the harpoon at him, across the oars, and felt a sensation of surprise, as well as pleasure, in finding that I had struck him. The fish dashed out violently for the channel, and we payed him out thirty fathoms of rope until, headway being given to the boat, we brought him to a dead pull; and now his motions were very erratic; unlike some that I had before struck, he did not take a direct course for the sea, but sometimes drew the boat against the tide, then suddenly turned and ran directly toward us, so as to give slack line. I inferred from these signs that he was mortally hurt. As often as he approached the Middle Bank and shoaled the water, he drew off in alarm, and would not cross it until he had got to its tail; his course was then for Paris Bank, which, suiting well with our intention to land him, if we could, at Bay Point, we did not interrupt. About this time he came to the surface without being pulled, and showed great distress—and we resolved, then, to draw upon him and get a second harpoon planted. It was after various fruitless efforts, and by shortening the rope as far as we prudently could, that we at length drew him so far up that the dark shadow of his body was indistinctly seen beneath. The second harpoon was now driven, and the gush of blood to the surface showed that it had done its work. We now drew mainly on this second, leaving only a moderate strain upon the first—and after a few convulsive runs, brought him up helplessly to the surface, and with a spear dispatched him outright. With a hatchet we now cut a hole in one of his feelers, and inserting a rope, passed it to the stern, drawing solely on this, so that the resistance of the fish through the water should be as small as practicable. The wind was now due east and moderately fresh; we raised both sails, and, helped at the same time by the oars, made some way in our tedious progress on towing our prize to land. At this time, espied a boat beating down from Beaufort, and on signalizing her, she proved to be that of Col. De Treville, then on his way to Bay Point. His offer of assistance was accepted, and a tow-line being passed to his boat, we landed our fish at the Point exactly at sunset. This fish measured sixteen feet across, which I suppose to be the medium size of those that visit our waters. The first harpoon had struck it near the center of the belly—had pierced

[1] Op. cit., pp. 68-72. The punctuation of the original is preserved.

the liver, and passed nearly through to the back. The second had passed from the back into his lungs or gills—so that the full power of so large a fish was never fairly exerted against us. Had the same fish been struck in the wings, or other parts not vital, his capture would have been uncertain—and would at any rate have cost us the work of many hours.

"I suppose the shoal of Devil-fish was a large one; the third which appeared we struck at—the fourth we harpooned—and as we were rapidly drawing off from the shore, a fifth was seen. How many were still behind, we had not leisure to observe; but conjecture this was but the advance guard of the column."

Later adventurers after sport with the Devil-fish have hunted it along the Florida coast as well as in the Gulf of Mexico and the Caribbean Sea. C. J. Holder has told of his experience in "Trailing the Sea-bat" in "Outing" for 1900, and J. Turner-Turner has devoted two chapters of his book entitled "The Giant Fish of Florida" (1902) to the "Enormous Rays, or Devil-fish," which he pursued. The article by Holder has been republished in that author's work entitled "Big Game at Sea," published in 1908 (pp. 1-35).

The pursuit of such a giant as the Devil-fish is necessarily attended with some danger, but this incident adds to the zest the sportsman feels. Elliott records that he had been "carried twenty-five miles in the course of a few hours by two of these fish (having struck a relay when the first sea-horse escaped, and losing both), with three boats in train."

According to Leon Diguet[1] (1898), in the Gulf of California, where Devil-fishes are numerous, the pearl-fishers, when caught during a calm away from mooring places, always take the precaution of dropping two anchors at night for fear that one should be seized by a Devil-fish and hauled afar by it. Diguet went in pursuit of a specimen for the Musée d'Histoire Naturelle of Paris, and, after one had been harpooned, it turned back on the boat, seized the bow with its headfins, and held it in its clasp till it was lanced a second time. But this clasping is largely automatic, and the Devil-fish only makes for the boat from which it has been attacked when it experiences the stress through the line from that direction. It is not like the attack of some sharks when wounded. The Devil-fish, in fact, has been called a "timid animal" by Diguet.

The Devil-fish, nevertheless, is the object of considerable dread among the fishermen of the Gulf of California; for, although not aggressive, it is frequently encountered, and Diguet tells that numer-

[1] Vaillant (L.) et L. Diguet. Sur le Céphaloptère du Golfe de Californie. Bull. Mus. Hist. Nat., Paris, 1898, pp. 127-128.

ous cases have occurred of death resulting to divers as well as bathers from encounters with the Devil-fish, or Manta, as the men call it.[1] On the other hand, the carcasses of many that are killed are used for bait for other fishes.

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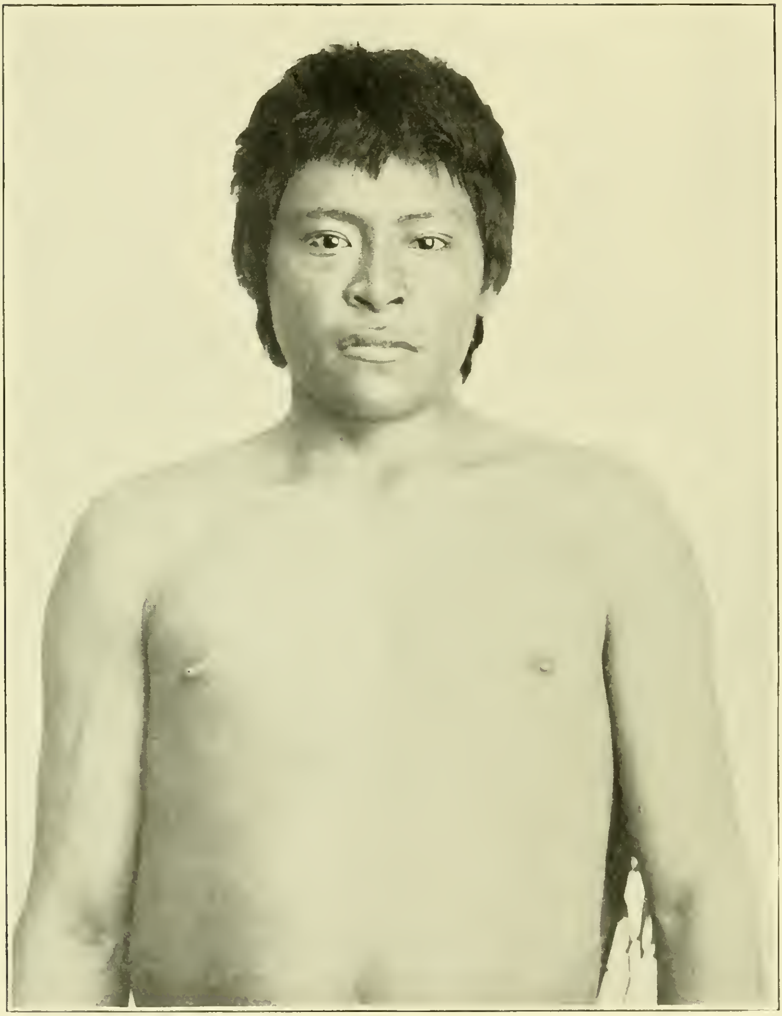
[1] An accomplished naturalist of the second quarter of the last century, Col. Hamilton Smith, "once witnessed the destruction of a soldier by one of these Cephalopteri off Trinidad. It was supposed that the soldier, being a good swimmer, was attempting to desert from the ship, which lay at anchor in the entrance of the Boca del Toro. * * * The Colonel is positive as to this fish being a Cephalopterus." The full account is given in Griffith's edition of Cuvier's Animal Kingdom ("The Class Pisces," p. 654). The evidence is very unsatisfactory.



TYPE OF INDIAN OF THE PERUVIAN REGION

Hipurina man, 22 years old, from Acre District, Brazil

INDIANS OF PERU[1]

By CHARLES C. EBERHARDT

American Consul at Iquitos, Peru

(With Two Plates)

Introduction

The difficulty experienced in obtaining reliable information relative to conditions in general in the region about Iquitos, leads me to believe that the results of certain studies I have made regarding the Indians of Peru may be of some value and interest to others.

I had hoped to make a more thorough study of this interesting subject from actual observation among the different tribes, obtaining specimens of their weapons of warfare, their clothing, utensils, etc., but ill health has prevented any systematic work along these lines. I have been fortunate, however, in having been able to make several trips among different tribes with Mr. George M. von Hassel, thus gaining first hand a limited amount of information on the subject, but the greater part comes from Mr. von Hassel himself, who, it seems to me, is probably one of the best authorities on the subject and one highly qualified to speak regarding these Indians. Mr. von Hassel has had long experience in the interior of Peru. During the last ten or twelve years he has lived for months at a time with various tribes, speaks the Quechua language and many other dialects, and by gaining their confidence has been able to mingle freely with the Indians, gaining an insight into their customs, methods, and manner of living such as few white men have enjoyed.

The accompanying photographs were taken by the French explorer Robushon, who spent a number of years among different tribes. Among his experiences was his romantic marriage with an uncivilized Indian girl, whom he met in the forest one day roaming about entirely nude and alone, her father and mother and others of the tribe of which she was a member having died of some pestilence.

[1] Consular report to the Department of State, transmitted to the Smithsonian Institution by the Department. Dated Iquitos, Peru, November 30, 1907. Slightly abridged and several illustrations omitted.

He took her to France, where she was educated, and she returned to this country a few years later thoroughly conversant with three languages and assumed, with credit to herself, a place in local society among the best families here. Mr. Robushon undertook another trip in a wild part of the Upper Putumayo district about two years ago. He has never returned, and searching parties which have been sent out have been unsuccessful in their efforts to find him. It seems most probable that he was killed and eaten by some of the cannibal tribes of that region.

Owing to the difficulty of obtaining authentic data as to population, due allowance must be made for the estimated number of inhabitants of the Department of Loreto (in which Iquitos is situated), 120,000, and that of trans-Andean Peru, 300,000. Of this latter number one-half, or 150,000, are said to be wild Indians, most of whom, aside from petty tribal wars, are peaceably inclined, obtaining food and such raiment as they require from the supply furnished by a generous and lavish nature.

Enumeration of Tribes

Following is a list of the principal tribes which go to make up this total of 150,000, with the approximate number of inhabitants of such tribes as are said to number more than 2,000, though names of smaller tribes and subtribes almost without number could be added. The total of these numbers is 116,000, and the difference, therefore, 34,000, comprises such tribes as those whose number of inhabitants does not appear on the list and which are composed mostly of from 200 to 1,000 souls each. Some of these tribes are said no longer to exist as such, having become extinct by intermarriage with other tribes, taken prisoners by stronger tribes and the whites, or dying from diseases introduced by the white man, usually smallpox.

In the spelling of these names one will detect at once the Spanish style, which has been given to the words as pronounced by the natives themselves, and as there is always considerable difference in accent, enunciation, etc., of different individuals in the pronunciation of the same word, one often meets with several ways of spelling the name of a certain tribe. Most of the tribes retain the name handed down for generations, though others are known by the names of the rivers or vicinity in which they live, being thus designated by the rubber-gatherers or the whites with whom they come in contact.

Principal Indian Tribes of Peru

Tribe	Number
Huitotos	
Gellas	
Emuirises	
Spunas	
Ucheruas	
Onocaises	20,000
Sebuas	
Nongonis	
Comeyones	
Sigayor	
Miralles	
Bonanisayes	
Casabes	
Caidullas	
Lunas	
Yaramas	
Munjoses	
Conroy	
Ayafas	
Achotes	
Cuyubos	13,000
Canines	
Yanis	
Minicuas	
Miretas	
Chontaberis	
Cheseyes	
Tamas	
Herayes	
Tayajenes	
Guipi	
Angoteros	2,000
Orejones	2,000
Rosainos	
Inji-Inji	
Muratos	7,000
Andoas	
Iquitos	
Itatos	
Huambisas	2,000
Batucos	
Antipas	
Aguarunas	2,000
Jeberos	
Cayapas	
Cahuapanas	

Tribe	Number
Cocamas	
Nautinos	
Ocayos	2,000
Cocamillas	
Lagunas	
Omaguas	
Mayorunas	
Capanahuas	3,000
Nahuas	2,000
Shipibos	
Shetibos	
Conibos	
Remos	
Sacuyas	
Amueshas	
Piros	
Amahuacas	7,000
Yurimaguas (now extinct.)	
Yaros	
Pamaris	3,000
Yamamadis	2,000
Hipurinas	2,000
Pacahuaras	2,000
Mojos or Muzos	6,000
Arahunas	2,000
Capahenis	
Campas	
Machigangas	
Campas (pure)	
Campas Bravos	
Cashibos	15,000
Chonta-Campas	
Pangoas	
Cumaticas	
Cotangos	
Pucapacuris	
Mashcos	
Mashco-Piros	6,000
Sirineiris	
Moenos	
Huachipairis	
Amajes	
Tuyneiris	
Andoques	2,000
Araizaires	
Huarayos	
Yamiacos	
Tiatinaguas	3,000
Atsahuacas	
Pacahuaras	2,000

Tribe	Number
Chacobas	
Amigos or Inaperis	
Huaparis	3,000
Boras	3,000
Cachiboyanos	
Ticunas	3,000
Yuminaguas	
Yahuas	
Pebas	
Zaparos	
	116,000

Brief Descriptions of Tribes

Brief sketches of the manners and customs of a few of the stronger of these tribes may be of interest before a general summary is made.

The Huitotos

The Huitotos, together with their subtribes, are considered the strongest in point of numbers of any of the Indians of Peru. They inhabit the district of the Upper Putumayo River (called Içá in Brazil) and the regions between that river and the Yapurá, or Upper Caquetá, on the north and as far south as the vicinity of the Napo River. The greater part of these are inclined to treat with the whites, and several thousands of them are employed by rubber-gatherers. They speak a distinct language and use the lance and club as weapons, while stone axes are to be found among some of the tribes of the central regions. As is usual with Indian tribes generally, the women do most of the domestic drudgery and hard labor. It is a common sight to see a mother with a babe at her breast bringing in a supply of yucca for the noonday meal in a reed basket hung from her head down her back.

The houses in which they live are not unlike huge circus tents in shape, constructed of poles covered from peak to ground with a thatching of palm leaves. In one of these houses it was estimated that 150 persons were living at the same time. Each family is allotted a triangular space of about 12 feet, and at each point of the triangle poles are erected, from which their hammocks (made of woven reeds) are hung, while in the center of the triangle the cooking for the family is done over a small fire. The rougher work of crushing the yucca, etc., is carried on in the open space in the center of the house, though this space is free to all and is always used for their dances and other celebrations.

The Campas

Though less numerous than the Huitotos, the Campas, with their subtribes, numbering in all some 15,000, are much the more intelligent and in many respects the most interesting of any of the tribes of Peru. They inhabit the vast region from Rosalina, on the Upper Urubamba, to the junction of that river with the Tambo, and from that point the left bank of the Ucayali as far as the Pampas del Sacramento. All of the subtribes speak the Campa dialect and generally wear the traditional *cushma,* a sort of sleeveless shirt, crudely woven from the wild "cotton" which grows in abundance on a large tree in those regions.

The Chonta-Campas and the Cashibos are the least advanced of the subtribes, and still use the light bark of a certain tree for the scant covering they wear when any is used at all. They are generally hostile to the whites and at times have been known to eat human flesh, believing that by so doing they imbibe the strength, physical and intellectual, of their victim. The Cashibos are almost continually at war with the neighboring subtribes. They inhabit the region of the Pachitea and Pampas del Sacramento. They number approximately 3,000, though the continual intertribal wars and frequent excursions of the whites into their territory in quest of workers (when, if resistance is shown, they are often taken by force and practically enslaved) are causing a steady decrease. Men and women alike go naked or use the bark of the tree in the form of a long shirt, as above mentioned. Because of the isolation of their position, the machete and other arms so commonly used by other tribes are almost unknown to them, and they still use, as they have for centuries past, the stone axe and the bow and arrow, and defend the entrance to their homes by concealing sharpened spears in pitfalls.

The Indians of the head tribes of the Campas are generally of rather noble features, friendly to the whites and willing and quick to learn their habits and customs. They are excellent canoeists, learn readily the use of firearms, and are sometimes employed in rubber-gathering. They spin and weave and cultivate quite extensive tracts of corn, yucca, bananas, peppers, and a species of potato.

The Machigangas, another subtribe of the Campas, live in the Upper Urubamba and Pachitea districts, and with few exceptions are friendly toward the whites. They are rather small of stature, with regular features, and men and women alike wear the *cushma.* They are polygamists. Their numbers are also steadily decreasing, as is the case with all the wild tribes, through fevers, smallpox and attacks by neighboring tribes. From their language and customs they show that they must have been in contact with the ancient Incas, though not entirely assimilated. They worship in their manner the sun and moon, believe in witchcraft, and besides their own language speak the Campa dialect.

The Chonta-Campas are distinguished from others of the Campa subtribes by a small piece of wood about an inch long which they wear pierced through the upper lip. Some also wear such a decoration from the lower lip and a metal pendant from the nose and tattoo their faces with blue penciling.

The Aguarunas

The Aguarunas number approximately 2,000, inhabit the Marañon River district below the Cahuapanas River, have their own language and laws, believe in a good and a bad god as well as in witchcraft, and are polygamists. They use the lance and blow-gun with poisoned arrows. They are of medium stature, very muscular, with regular features, and some of the women are quite beautiful. They engage extensively in cultivating the natural products of the country. This tribe, in civilization sometimes designated "Head-hunters," has the gruesome custom of preparing human heads in a manner by which, though reduced to about one-fifth their natural size, they retain the same shape throughout that they possessed during life, and in a seemingly mummified, diminutive head thus prepared, can easily be recognized the features of the individual when alive. This custom originated in preparation of the heads of the enemies of the tribe who fell victims to them during their wars and which were kept as trophies. The head was cut from the body and placed on a pole, where it was allowed to remain several days till decomposition had fairly set in. A vertical cut was then made in the cranium and the bones deftly removed in such a manner that only the thick cuticle remained. The inside of the head was then burned and seared with hot stones and afterwards allowed to smoke in a flame from the burning roots of a certain species of palm. This flame is said to act much the same as salt on the parts exposed, and by the process described the head is made much smaller in size. Specimens of these heads became so much in demand a few years ago for museums, etc., that a premium seemed to be thus placed on the heads of persons venturing in the vicinity of this tribe, and many murders resulted. The Peruvian government has now forbidden the practice, and the specimens becoming more scarce are commanding higher prices. I have known of them selling for $150 to $200 in gold, and rather a poor specimen was recently sold in Iquitos for $80. In the Rio Negro and Orinoco regions there is said to exist a tribe which prepares entire bodies in this manner, and in the Putumayo district they are said to retain in natural size, by a system of smoking, the hands of enemies slain in battle. I have seen teeth, shin bones, and other parts of skeletons thus treasured.

The Aguarunas, in common with several tribes, also make use of certain poisons, both in their wars and in hunting. The poison is extracted from different species of vegetables and plants and prepared by the women and old men of the tribe. It has the peculiarity of killing game without giving any evil effects to one who may eat the flesh. Another poison is scattered over the surface of a pool where fish are known to gather, and great numbers of them are killed in this manner. The small fish, being able to withstand the effects of the poison for only a short time, rise to the surface first, and later the larger ones, though only the latter are taken. There is thus a vast waste, and though this form of fishing is prohibited by law, it is by no means stopped. The Indians of the Putumayo use in their wars a kind of poison which has the peculiarity of producing putrefaction almost as soon as the wound is made.

The Huichipairis

These Indians, united with neighboring tribes, have resisted to this day the invasion of the whites and remain hostile. They live in the Upper Madre de Dios district, are very muscular, both men and women, though not large of stature. The naturally fierce aspect of the men is heightened by the custom of perforating the upper lip, through which a piece of wood, feather or shell is inserted and worn. They have a language of their own, but many of them understand the Quechua and Campa dialects, the latter being introduced by the women of the Campa tribes, whom they are continually stealing.

The Inji-inji

Five hundred souls, the remnant of what was once a powerful tribe, go to make up all that now exists of the Inji-inji Indians, who live along the small streams and branches of the Curaray River. They are the lowest of the Peruvian Indians, both in manner of living and in the progress they have made. They use stone axes for breaking down the trees when small clearings are needed in which to plant corn and yucca. They are not hostile to the whites, but avoid as much as possible any contact with them.

TYPE OF INDIAN OF THE PERUVIAN REGION

Hipurina girl, 18 years old, from Acre District, Brazil

The Nahumedes

This tribe, now almost extinct, is remarkable only for the tradition which clings to it of having been responsible for the naming of the great Amazon. It was they who attacked the Spaniard Arellano on his journey down the great river after he had deserted the Pizarro expedition. The Indians, because of their *cushmas* and the manner of wearing their hair flowing loosely down their backs, were thought to be women warriors or "amazonas," and from that incident, as history also asserts, the river has retained to this day the name of Amazonas.

The Orejones

This name is given to the tribe which inhabits the Napo and its branches, from the fact of their enlarging the lower part of the ear by a process which is begun when they are children, until sometimes the ear hangs down almost to the shoulder. This custom is attributed by some to the Incas, who in this manner indicated the families and descendants of Incas of "royal" blood.

The Tribes as a Whole

The average traveler through the Amazon lowlands would probably notice little difference between the various tribes further than that some wear the *cushma*, others a short covering from waist to knees, and others go entirely nude. Several reasons are apparent by which the Indians have been driven to wear clothing at times: First, the moral; second, climatic conditions, such as cold in the mountainous regions, and third, the abundance of flies, mosquitoes, and other insects which abound in a hot country.

The student would immediately note other differences, probably the first and one of the important ones being that in the regions on the right bank of the Amazon, from Urubamba and Ucayali to the Marañon, all the Indians, with the exception of the Aguarinas, use the bow and arrow, while those on the left bank use the lance and blow-gun with poisoned arrows. These and many other items in detail would probably be interesting, but there has been no opportunity for systematic study of the subject, so general information regarding the Indians of Peru is all that can be furnished.

Form of Government

All of these tribes of Indians seem to be aggregations of numerous families, with one leader or chief, who is recognized as such by all the tribe. Among these families are subtribes, which in turn have their leaders or subchiefs, though the entire group in that vicinity are under the head tribe. For example, the Aguaranas, who, because of their superior culture rule over several smaller tribes, and each of these subtribes has its head man, or *Curaca,* but owe no allegiance whatever to each other; in fact, they often war with each other without interference from the head tribe. They rarely unite to fight a common enemy, which fact has been largely responsible for their condition today, as they have not been strong enough in their scattered condition to repel the invasion of the rubber-gatherers.

Languages

For the most part these tribes speak independent languages, with many dialects. Some of the tribes count as high as five, a very few even to ten, but the most of them use only the fingers in expressing numbers greater than one.

Houses

Excessive rains have made living under some sort of shelter compulsory, and as a result, even during their wanderings in the forests, rude shacks of poles covered with a thatching of palm leaves are hastily constructed, though their permanent abodes are often very cleverly and strongly built of the same materials.

Food

The Indians of Peru subsist almost entirely on the yucca, bananas, corn, fish, and the flesh of birds and game from the forests. Stones and hardwoods are used for grinding and crushing, and earthenware pots, etc., are used for boiling, roasting, and frying. In only a few localities is salt to be found, and even then it is generally used in a mixture with hot wild peppers. Some of the tribes that live on the Amazon and Ucayali eat earth from certain deposits (known by the Inca word *kulpa*) which contains a proportion of salt. Wild animals also seek these deposits. This scarcity of salt and the natural craving of the system for this mineral have been the means of making the eating of this earth a vice similar to the cocaine or opium habit. When taken in such quantities the stomach of the individual becomes much distended and death eventually results from it.

The rather insignificant looking yucca, a shrub which grows ordinarily to a height of from four to six feet, is probably the most practical and useful of all the vegetal products of this region. The root of this plant, which resembles somewhat our sweet potato, is really the "staff of life" for the average Indian household. Baked, it serves as a substitute for bread; fried or boiled, it is as good as our potato; kneaded into a dough and baked with minced meats, fruits, etc., it makes a splendid pastry, while the juice, after treatment by certain processes, is made into *masato,* the beverage common to nearly all the tribes of Peru. To make this drink, baked yucca, crushed and ground till it forms a sort of a meal, is placed in earthen jars, mixed with the raw article likewise crushed (or sometimes chewed by the Indians till, mixed with saliva, a considerable portion is liquid), which serves to ferment the mixture, thus producing a greater or less amount of alcohol. The preparation of this drink is usually the occupation of the older women. Great quantities of it are drunk at the celebrations of marriage ceremonies, births, the beginning of a tribal war or at its successful termination. On journeys a certain amount is always carried, which, mixed with water, furnishes a very refreshing drink. The juice of the banana, prepared in more or less the same manner and mixed with water, is also refreshing.

Physical Characters

In the color of his skin the pure-blooded Indian of Peru is practically the same dark brownish color as the North American Indian. The most of the tribes, however, seem to have become mixed at some time or other with whites or blacks, and many variations in color are therefore to be noted, from the very dark tribes of the Putumayo, in whom may be traced strains of blood of escaped negro slaves from Colombia and Brazil, to the very light Huarayos of the Madre de Dios, of an ancestry of mixed Indian and Spaniard. In stature they may be said to be below the average in height, though usually very stockily built, and strong and muscular.

Mental Traits

When brought from their native haunts into contact with civilization, these Indians are as a rule very quick to adopt the customs of the whites. It is admirable to see the manner in which they learn in a short time to use firearms. As pilots on the smaller boats plying the tributaries of the Upper Amazon many are rendering excellent service, while the crews are often made up entirely of men born and reared in the wilderness. A few of the more aggressive have become shrewd business men and wealthy exporters of rubber.

Polygamy

All of the tribes of this region practice polygamy, a man's standing and wealth being determined by the number of wives he may have, though this number rarely exceeds ten, the wives ranging in age from ten years to fifty years. A man's wives are obtained from among the women of his own tribe, or by barter or theft from neighboring tribes. Thus a number of wives, one the favorite for a longer or shorter period, will live together in one household with very little jealousy or quarreling. They are submissive, attend to all the duties of the household, also work in the small fields of yuçca, corn, etc., and usually accompany the men on their journeys into the forests.

Diseases

In addition to the violent deaths from the many tribal wars and attacks by the whites, certain diseases are proving an alarmingly great factor in reducing the population of the Indians of Peru. Probably chief among these is the viruela, or smallpox, unknown among them till after the coming of the whites, and entire tribes have been known to perish from epidemics of this disease, to which they seem peculiarly susceptible. In the mountainous parts of the country some die of pneumonia, and there is always a considerable number of deaths from malaria and other tropical fevers. Beri-beri, or elephantiasis, a swelling of the legs, is also quite common in certain districts, and among the Aguarunas epilepsy has been known to exist at times.

Medicines

Contrary to the popular belief that Indians in general have a wonderful knowledge of the value of herbs, plants, roots, etc., for medicinal purposes, very little is known or pretended to be known among the Indians of Peru. For fevers of all kinds they commonly use a species of tea made from Peruvian bark, and a mixture of quinine and the leaves of a certain shrub made into a poultice is placed upon wounds. In case of snake bite the blood is immediately sucked from the wound or the wound seared with a burning stick. Those who use firearms place powder on the wound caused by the bite, which is then set afire in the attempt to burn out the poison. When one is attacked by some unknown form of disease he is supposed to have been taken possession of by an evil spirit, and for his relief the Aguarunas, for example, use oaths and prayers by which they hope, through threats or entreaties, to free the victim from the malady.

Cannibalism

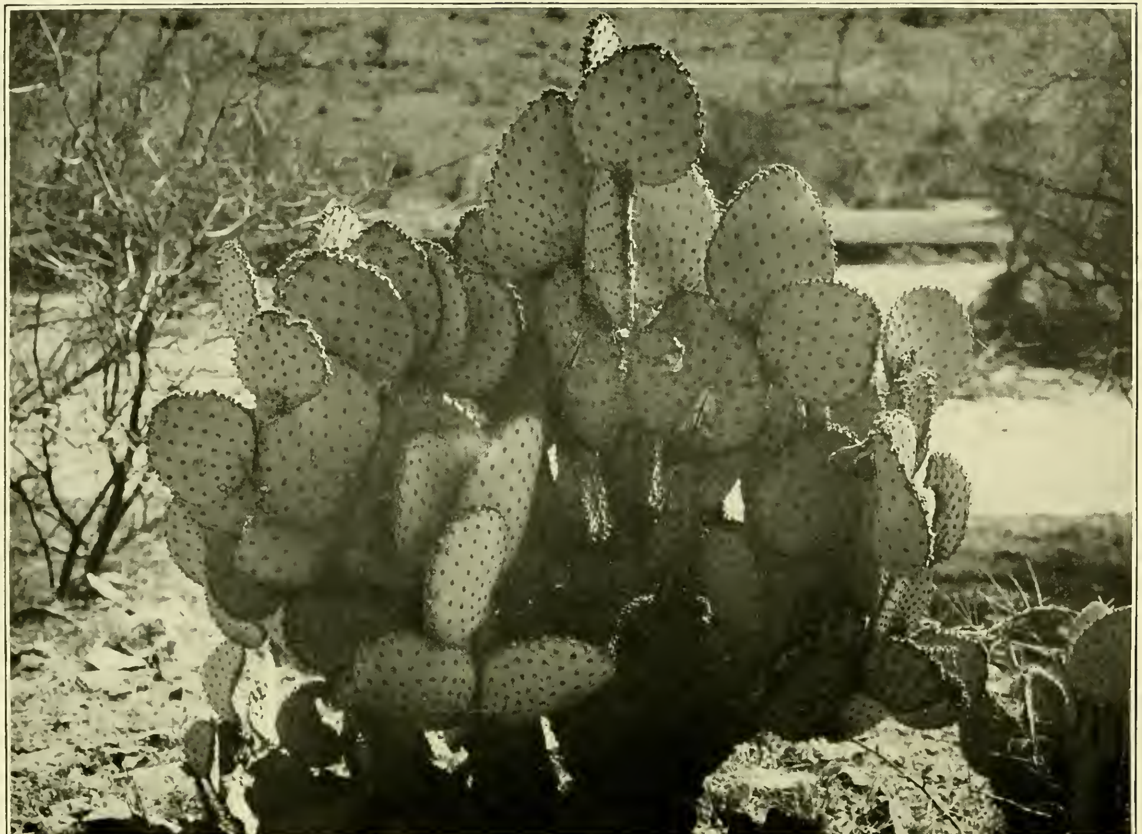
Cannibalism is practised by members of certain tribes of the Putumayo River district, who not only enjoy the flavor of human flesh well prepared, but also believe that they partake of the strength, both physical and intellectual, of their victims. Prisoners of war are most always disposed of in this manner, amid great festivity, the prisoner always having been allowed for days previous all the food and delicacies of the village that he can consume, in order that he may become properly fattened. The indifference which these prisoners display toward the fate that awaits them, even when they know the exact time of their doom, is remarkable. They eat great quantities of all that is given them, that they may make the better feast for their captors, perform duties as slaves, often going unaccompanied for considerable distances from the place of captivity and returning without attempting to escape. When the day for the feast arrives the victim is brought to the center of the village, tied to a beam, and some one of the tribe who may have lost a relative in a war with the tribe of which the victim is a member, or perhaps had a brother eaten by them, is allowed to perform the execution. With a stone axe in his hand he addresses his victim, reminding him that his (the executioner's) brother was sacrificed in a similar manner by the tribe of the victim, that he died without a moan or sign of pain, that he was therefore one of the most valiant of his tribe, that the assembled relatives and friends of the dead warrior would now have the opportunity of seeing if the victim could die as bravely and unflinchingly. After this address the victim's skull is crushed with the axe, sometimes the unfortunate showing marvelous strength and determination in receiving several blows without a groan before he falls. Immediately after the execution the body is cut up and the feast indulged in. Among the Amahuacas the custom of burning the bodies is said to exist, and the charred bones are crushed or ground and afterward used as a flavor for their meals.

Slavery

In various works written on Francisco Pizarro's conquest of Peru we read that in character the Indians at that time were not at all warlike, that their natural tendencies were toward husbandry and agriculture rather than war, which rendered Pizarro's advance much less perilous, and with a few notable exceptions their complete submission was comparatively easily brought about, nothing like such difficulties having been experienced by the Spaniards as was the case with Cortés in Mexico. This same trait of character is discernible in their descendants, who seem to expect no better fate than to become the servants of some *padron,* whom they serve submissively, with but little complaint. Their songs, so characteristic, are indeed well named *tristes* (literally "sadnesses"), and when heard on a dark night about a campfire in the stillness of an Amazonian forest, their pathetic wail or lament seems the climax of all the sadness and pathos of their four centuries of servitude.

The average Peruvian would no doubt show resentment at the statement that slavery exists in Peru, yet such is in reality the case with most of the Indians who come in contact with the whites. For the greater part, however, they are not treated harshly, and in their submissive way, with enough to eat and drink, seem to be contented and probably as well off as when roaming the woods. Their condition might be termed a system of peonage. The Indians enter the employ of some rubber-gatherer, often willingly, though not infrequently by force, and immediately become indebted to him for food, etc. According to Peruvian law a person so indebted to another can be held and obliged to work till that debt is paid, and in these instances the employer sees to it that the employee never receives sufficient wages to extinguish his indebtedness, and he is therefore always practically a slave. By paying off this indebtedness a person may obtain the servant, who in this way becomes similarly the slave of him who pays the debt. However, the scarcity of labor and the ease with which the Indians can usually escape and live on the natural products of the forest oblige the owners to treat them with some consideration. The Indians realize this, and their work is not at all satisfactory, judging from our standards. This was particularly noticeable during a recent visit I made to a mill where *cachassa,* or aguardiente, is extracted from cane. The men seemed to work when and how they chose, requiring a liberal amount of the liquor each day (of which they are all particularly fond), and if this is not forthcoming or they are treated harshly in any way they run away to the forests. The employer has the law on his side, and if he can find the runaway he is at liberty to bring him back, but the time lost and the almost useless task of trying to track the Indian through the dense forests and small streams makes it far the more practical that the servant be treated with consideration in the first place.

Through intermarriage with the whites, disease, and wars, the Indians of Peru are rapidly disappearing, and I am told that statistics compiled for a given period during recent years show that their numbers are diminishing at the rate of five per cent per annum; that in twenty years the wild Indians of the Upper Amazon will have disappeared almost entirely, and it seems only a question of time when the dying tribes of South American Indians must meet the fate of their brothers of North America, and the two in common, once the rulers of two continents, become only scattered remnants of their former greatness, if not entirely engulfed by the wave which seems sweeping over them.



OPUNTIA SANTA-RITA ROSE

ON OPUNTIA SANTA-RITA, A SPECIES OF CACTUS OF ORNAMENTAL VALUE

By J. N. ROSE

Associate Curator, Division of Plants, U. S. National Museum

For several years there has been growing in the New York Botanical Garden a strange Opuntia which somewhat suggests *O. macrocentra,* but which is more highly colored and more weakly armed, or not infrequently entirely unarmed. Upon my visit to Tucson, Arizona, in 1908, I found plants of this species in cultivation at the Desert Laboratory of the Carnegie Institution of Washington, and growing spontaneously in waste places in the town itself and in the mountain ranges to the southeast of Tucson. An illustration of this new species recently appeared in the *Plant World* (vol. XI, p. 224, fig. 6) in connection with which Dr. D. T. MacDougal speaks of this cactus as follows: "The highly colored reddish joints and the delicately tinged flowers make this a very attractive plant, and it may be found in some of the gardens at Tucson." It is, indeed, one of the most attractive of all the Opuntias, and is to be especially recommended for planting in the Southwest. If planted in mass, where it could occasionally be irrigated, I know of no other cactus which would be so striking or effective.

It is to be regretted that persons in charge of public parks and large private or university grounds in that part of the country have not taken advantage of the various Opuntias to obtain unique and pleasing landscape effects. An attempt to show what can be done in this line is to be seen at Mesilla Park, New Mexico, where Prof. E. O. Wooton has very effective groups of these plants.

The description of the species is as follows:

OPUNTIA SANTA-RITA (Griffiths and Hare) Rose

Opuntia chlorotica santa-rita Griffiths and Hare, Bull. N. Mex. Coll. Agr. 60: 64, 1906.

Plate XV

Plant 60 to 140 cm. high, nearly as broad as high, with a short and somewhat definite trunk; joints orbicular or broader than long, blue-green, with the space about the areoles and the margins deep purple, or sometimes, especially when young, pinkish or purplish throughout; areoles 1.5 cm. apart, bearing chestnut-brown bristles; spines usually wanting, when present single or sometimes two, 2 to 4 cm. long, needle-like, chestnut-brown; ovary purplish, shortly oblong; flowers very handsome, of deep yellow color, 6 to 7 cm. broad.

Collected by J. N. Rose in waste ground in Tucson, Arizona, April 26, 1908 (no. 11922). This species is common on the foothills about Tucson and extends south nearly or quite to the Mexican border.

This plant was described in 1906 by Griffiths and Hare as a subspecies of *Opuntia chlorotica,* but it seems to me to be a distinct species.

Explanation of Plate xv.—Made from a photograph taken by Dr. D. T. MacDougal at Surritas, Arizona, February, 1907, and here used through the courtesy of the Carnegie Institution of Washington.

TWO NEW SPECIES OF ABRONIA

By ANTON HEIMERL

University of Vienna, Austria

ABRONIA BIGELOVII Heimerl, sp. nov.

Planta perennis, eodem modo ut in *A. nana* Wats. et in speciebus affinibus caule lignoso, abbreviato, in apice foliorum fasciculum densum et capitulum longipedunculatum gerente spectabilis. Folia omnia basilaria, in forma distinctissima, lineari-oblonga ad linearia, apice obtusata ad obtusissima, in petiolum cuneatim longe angustata, cum petiolo usque ad 34 mm. lg., 3.5-4 mm. lt., petiolo laminam aequante ad evidenter superante, saepius in laminam sensim abeunte, latiusculo, albido, paulum hirtulo, lamina concolore, crassiuscula, griseo-viridia, integra, primum brevissime puberula, eglandulosa, denique glabra, nervo mediano imprimis basin versus distincto, nervis lateralibus indistinctis. Capitulorum pedunculus 5-7 cm. lg., gracilis, erectiusculus, in statu exsiccato angulatus, pilis eglandulosis, valde brevibus, modice dense, superne densius pulverulento-puberulus. Capitula (deflorata solum suppetunt) submultiflora, bracteis illis *A. fragrantis* Nutt. similia, membranacea, late ovata ad ovato-elliptica, breviter acuminata, acutiuscula, ad 8 mm. lg. et 5 mm. lt., tenuiter pulverulento-puberula. Perianthia dense puberula. Anthocarpia, ut videtur, illis *A. turbinatae* Wats. similia.

Legit Dr. J. M. Bigelow "near Galisteo" in expeditione anno 1853 facta (Lieut. A. W. Whipple's Exploration for a Railway Route from the Mississippi River to the Pacific Ocean, near the 35th parallel of latitude in 1853-54).

ABRONIA COVILLEI Heimerl, sp. nov.

Planta perennis, pluriceps, caespites densos, multifoliatos, ad 10-15 cm. lt. formans. Radix valida, basi ad 1 cm. crassa. Caules complures e collo orientes, lignosi, f. intricati, procumbentes, valde abbreviati, ramosi, ad 3-4 cm. lg., eodem modo ut in *A. nana* Wats. foliorum fascicula et in apice capitula floralia pedunculata gerentes. Folia (spurie) radicalia, parva, lamina breviter ovata, in basi subtruncata v. obtusata v. levissime cordata, 7-13 mm. lg., 5-9 mm. lt., in petiolum 10-30 mm. lg. cito contracta, antice obtusissima ad rotundata, crassiuscula, concoloria, lutescenti-viridia, subintegra v. paulum undulata, minutissime pulverulento-puberula, pilis brevissimis, patulis, eglandulosis, modice densis, nervis lateralibus gracillimis, paucis (2-3). Capitulorum pedunculi 17-24 mm. lg., subtenues, eodem modo ut folia minute superne solum distinctius, pilis ± inaequilongis hirtuli, erecti, ± rufescentes. Capitula minora usque 2 cm. lt., 6-12-flora, floribus erectiusculis, bracteis paucis (non raro solum 4-6), herbaceo-membranaceis, lanceolatis, ad 6 mm. lg. et 2 mm. lt., acutiusculis ad leviter acuminatis, viridi-albidis, dense brevissimeque puberulis suffulta. Flores parvi, ad 11 mm. lg.; perianthii pars ovarialis subturbinata, 2.5 mm. lg. et 2 mm. lt., angulis 5 prominentibus, pilis eglandulosis, basi glabriuscula excepta, brevius supra autem longius et patenter hirta; tubus perianthii inferne 1 mm. lt., sursum paulum sensimque ad 1.5 mm. dilatatus, viridulus, superne brevissime et parce, inferne paulo densius (eodem modo ut in parte ovariali) pilosulus; limbus ad 8 mm. lt. (albus ?), profunde partitus, lobis f. obcordatis, ad dimidium emarginatis. Stamina 5-7, antheris paulo ultra 1 mm. lg. Germen 6 mm. lg., stylo superne ad 1.5 mm. stigmatoso. Anthocarpia desunt.

Habitat in California ad Inyo Mountains in Inyo County ubi planta pulchra a clar. Coville et Funston lecta est. (Death Valley Expedition, no. 1782. "*A. nana.*")

Differt ab *A. nana* Watson indumento minutissimo, eglanduloso, foliis ovatis, bracteis capitulorum non scariosis, lanceolatis, minoribus, ad triplo longioribus quam latis, floribus minoribus.

PRELIMINARY NOTICE OF A COLLECTION OF RECENT CRINOIDS FROM THE PHILIPPINE ISLANDS

By AUSTIN HOBART CLARK

Collaborator, Department of Marine Invertebrates, U. S. National Museum

The first consignment of crinoids received from the United States Fisheries steamer *Albatross,* now engaged in work among the Philippine Islands, proves to be a collection of more than usual interest. Not only does it contain a remarkably large number of new and interesting forms, but many species, heretofore known only from single more or less imperfect specimens, are represented.

The littoral comatulids of the Indo-Pacific region have already received more attention than any other group of recent crinoids; Seba, Linck, and Petiver described and figured species, upon which species Linnæus bestowed binomial names; Lamarck diagnosed a number of additional species in 1816, and Müller several more in 1841 and 1846. Since then Carpenter and Bell have made great additions to our knowledge, the former, especially, in his magnificent *Challenger* monograph; in 1893 Hartlaub made the East Indian littoral forms the subject of a most excellent memoir; and in 1895 and 1898 Kœhler and Döderlein published important papers dealing with them. In view of all this previous work, it is with no little surprise that I find in the present, mainly littoral, collection the new forms outnumbering those already known, if we except only the family Comasteridæ.

Some time ago, while discussing the distribution of the recent crinoids, I mentioned that the entire Australian coast, southern as well as northern, was inhabited by purely tropical species, and belonged in my "Indo-Pacific—Japanese" region. I did this with considerable hesitation; for the genus *Ptilometra,* characteristic of southern Australia, had never been taken elsewhere, though all the other genera range at least to Singapore, and most of them as far as Japan. It is, therefore, with peculiar satisfaction that I am now enabled to announce the discovery of *Ptilometra* north of the equator, and to reaffirm, without the possibility of contradiction, the identity of the southern Australian crinoid fauna with that of the tropical East Indies.

Family PENTACRINITIDÆ

Genus METACRINUS P. H. Carpenter

METACRINUS ZONATUS, new species

Stem rather slender, rounded-pentagonal, the lateral grooves slightly marked; internodals 7 to 9 (usually 8), the edges scarcely crenulated, encircled by very prominent ridges, more strongly marked on alternate joints, high and thin, their bases not occupying more than the median third of the joints, and of uniform height all around the stem, passing unchanged over the broadly rounded angles; nodal joints moderately hollowed by the cirrus sockets, and with uniform high thin ridges connecting the bases of the cirri; cirrus sockets scarcely affecting the supra- and infra-nodal joints. Cirri in length about ten times the diameter of the stem, rather stout basally, composed of 55 to 57 joints, the first five short, then about half again as long as broad, gradually becoming broader than long in the distal half; cirrus joints with rather prominent and finely serrate distal ends, giving them a characteristic feeling and appearance.

Basals broad and of nearly uniform height, slightly convex exteriorly, forming a very even basal ring, abruptly cut off distally and not produced into a point; "radials"[1] in all instances 8 (2 + 3; 5 + 6) (*i. e.*, "six, the second and fourth syzygies"); arms dividing three times both exteriorly and interiorly; distal edges of the arm joints prominent, making the dorsal surface of the skeleton very rough, especially proximal to the last axillary; pinnules resembling those of *Metacrinus moseleyi*.

Measurements.—Stem 195 mm. long, with thirty-six internodes; cirri 45 mm. long; arms (from the "primary" radials) 80 mm. long, the terminal 15 mm., with only rudimentary pinnules.

Another specimen has a stem 190 mm. long, with thirty internodes, and cirri 35 mm. long; the stems of both are freshly broken below.

Color (in spirits).—Purple; stem, calyx, and arms to the second axillary greenish yellow; two other specimens are entirely light yellow.

Type.—Cat. No. 25435, U. S. N. M., from *Albatross* Station No. 5167; off Simonor, Tawi Tawi group; 110 fathoms.

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[1] I use Dr. Carpenter's terminology to facilitate comparison with the species described in the *Challenger* report, in the Linnæan Society's Transactions, and by Dr. Döderlein in the *Siboga* report.

Also found at Station No. 5168; off Simonor, Tawi Tawi group; 80 fathoms.

The large number and regularity of the "radials" place this species with *Metacrinus wyvillii, M. costatus, M. nodosus,* and *M. interruptus,* from all of which, however, it is readily distinguishable by the prominent girdle on the internodals and the very broadly rounded angles of the stem. Its closest affinities appear to be with *M. moseleyi,* in which, however, the "radials" are irregular, the girdle on the internodals low and broad, arising from their whole surface, the angles of the stem more marked, and the cirri with fewer joints.

Family COMASTERIDÆ

Genus COMASTER L. Agassiz

COMASTER SENTOSA (P. H. Carpenter)

Station No. 5139; between Jolo (Sulu) and Pangasinan Island; 20 fathoms.

Station No. 5141; between Bubyan and Pangasinan Islands; 29 fathoms.

Station No. 5146; west of Tapul Island (south of Jolo); 24 fathoms.

Station No. 5147; off Balinpongpong Island (south of Jolo); 21 fathoms.

COMASTER FIMBRIATA (Lamarck)

Station No. 5136; off the town of Jolo; 22 fathoms.

Station No. 5137; off the town of Jolo; 20 fathoms.

Station No. 5138; between Jolo and Pangasinan Island; 19 fathoms.

Station No. 5139; between Jolo and Pangasinan Island; 20 fathoms.

Station No. 5141; between Bubyan and Pangasinan Islands; 29 fathoms.

Station No. 5142; north of Jolo (town); 21 fathoms.

Station No. 5147; off Balinpongpong Island (south of Jolo); 21 fathoms.

Station No. 5163; south of San Gasanga Island (Tataan group); 28 fathoms.

Station No. 5165; south of San Gasanga Island (Tataan group); 9 fathoms.

Station No. 5205; Janabatas Channel, between Leyte and Samar; 6 fathoms.

There are also some specimens with no definite locality given.

COMASTER COPPINGERI (Bell)

Station No. 5153; east of Port Dos Amigos, Tawi Tawi; 49 fathoms.

Two of the specimens have only ten arms.

Genus COMATULA Lamarck

COMATULA PECTINATA (Linnæus)

Station No. 5139; between Jolo and Pangasinan Island; 20 fathoms.

Station No. 5142; north of the town of Jolo; 21 fathoms.

There are some additional specimens without data as to exact locality.

This species is at first sight very much like the ten-armed *Comanthus cumingii,* first described by Professor Müller from Malacca—so much so, indeed, that I was at first forced to dissect apart the costals of each specimen to be sure of the identification, though I later learned to recognize the species from external characters. In *Comanthus cumingii* the cirri are proximally rounded with elongate joints, and distally flattened with short joints; this gives the cirri when viewed laterally the appearance of expanding distally; in *Comatula pectinata* the cirri are uniform throughout, the joints all subequal, usually not quite so long as broad. As a comparison, it may be said that while the cirri of *C. cumingii* resemble those of *C. rotalaria,* those of *C. pectinata* resemble those of *C. solaris.* In *C. cumingii* the lower pinnules are much elongated, and decrease gradually in length from the first outward; in *C. pectinata* only the first pinnule is elongated, the second and following being subequal and short; in the latter, moreover, the first two pinnules, and sometimes the third also, are very strongly carinate basally, a feature never found in *C. cumingii.* In *C. pectinata* the costals have a shallow and rounded, though distinct, median furrow, which is quite lacking in *C. cumingii,* while in the latter the proximal third or half of the arms is disproportionately large and swollen, this region not being enlarged in *C. pectinata.*

I have compared the Philippine specimens with one from Java, identified by Dr. Carpenter, and find them identical. Indeed, Carpenter himself mentions the similarity between this specimen and some from Bohol collected by Professor Semper.

Genus PHANOGENIA Lovén

PHANOGENIA TYPICA Lovén

Station No. 5138; between Jolo and Pangasinan Island; 19 fathoms.

Station No. 5139; between Jolo and Pangasinan Island; 20 fathoms.

Dissection shows that the costals in this species, in *P. multibrachiata,* in *P. novæ-guineæ,* and in *P. gracilis* of Hartlaub are united by synarthry and not by syzygy, the dorso-ventral ridge across the joint face being always plainly visible, at least near the central canal. The distichals are ordinarily 4 (3 + 4); but all the succeeding division-series are 2 (1 + 2); the distichals are rarely 2. In *Comatula pectinata* the division series, when present, are 2 (1 + 2), as in *C. paucicirra,* and the costals are also united by syzygy. In *Phanogenia typica* the syzygies in the division series sometimes have traces of the synarthrial ridge which would seem to show that the syzygies were in the process of encroaching upon the synarthries of the division series, but had not yet succeeded in replacing the two first.

Phanogenia typica, P. multibrachiata, P. novæ-guineæ, and *P. gracilis,*[1] therefore, occupy an intermediate position between *Comatula* and the group of species of "*Actinometra*" typified by the *Alecto parvicirra* of Müller, having the costals and distichals of the latter, but the remaining division series of the former; they further differ from both in the great differentiation of the comb on the lower pinnules; this comb, moreover, is not confined to the proximal pinnules, as in other forms, but reappears at intervals all along the arm. There is a sixth, undescribed, species from the East Indies allied to *P. typica* and *P. gracilis,* and presenting the same peculiarities; in view of the sharp differentiation between these and the other species of the Comasteridæ, it would give a more correct idea of the systematic value of their characters to restrict the genus *Phanogenia* to them, and to consider the species with distichals 4 (3 + 4) or 2, subsequent division series 4 (3 + 4) or 2 as constituting the genus *Comanthus,* typified by the *Alecto parvicirra* of Johannes Müller (= *Comatula rotalaria* Lamarck).

These two genera may be differentiated as follows:

a^1.—First articulation of the free arm a syzygy; all division series except the first 2 (1+2); terminal comb short, with long curved teeth, and set at an angle to the axis of the pinnules, not confined to the proximal pinnules, but occurring at intervals throughout the arm.......*Phanogenia*

[1] To which must be added *P. distincta.*

a^2.—First articulation of the free arm a synarthry; all division series 4 (3+4) or 2; terminal comb long, with short teeth, continuing in the same direction as the basal portion of the pinnule, and confined to the pinnules in the proximal part of the arm............................*Comanthus*

Comatula is readily distinguished from both of these genera by the syzygy between the costals, and *Comaster* by the presence of a pinnule on the first brachial of all arms not arising from costal axillaries.

PHANOGENIA NOVÆ-GUINEÆ (J. Muller)

Station No. 5136; off the town of Jolo; 22 fathoms.

Station No. 5137; off the town of Jolo; 20 fathoms.

Station No. 5138; between Jolo and Pangasinan Island; 19 fathoms.

Station No. 5142; north of Jolo town; 21 fathoms.

Station No. 5147; off Balinpongpong Island (south of Jolo); 21 fathoms.

Station No. 5153; east of Port Dos Amigos, Tawi Tawi; 49 fathoms.

Station No. 5174; off Jolo town; 20 fathoms.

Station No. 5179; between Tablas and Romblon; 37 fathoms.

The cirri are usually less than ten in number, with 12 or 13 joints, the proximal much elongated, the distal short. The arms are 75 mm. to 90 mm. long, composed of joints with overlapping and spinous distal ends; the pinnule joints are more or less spinous.

PHANOGENIA MULTIBRACHIATA (P. H. Carpenter)

Station No. 5141; between Bubyan and Pangasinan Islands; 29 fathoms.

Station No. 5142; north of Jolo town; 21 fathoms.

Station No. 5146; west of Tapul Island (south of Jolo); 24 fathoms.

Genus COMANTHUS A. H. Clark

COMANTHUS NOBILIS (P. H. Carpenter)

Santa Cruz, Marinduque.

Station No. 5138; between Jolo and Pangasinan Island; 19 fathoms.

Station No. 5146; west of Tapul Island (south of Jolo); 24 fathoms.

Station No. 5147; off Balinpongpong Island (south of Jolo); 21 fathoms.

Station No. 5163; south of San Gasanga (Tataan group); 28 fathoms.

Station No. 5165; south of San Gasanga (Tataan group); 9 fathoms.

COMANTHUS DUPLEX (P. H. Carpenter)

Station No. 5145; off the town of Jolo; 23 fathoms.

COMANTHUS DIVARICATA (P. H. Carpenter)

Station No. 5138; between Jolo and Pangasinan Island; 19 fathoms.

Station No. 5147; off Balinpongpong Island; 21 fathoms.

There are also other specimens with no definite data.

COMANTHUS ROTALARIA (Lamarck)

Alecto parvicirra 1841. J. Müller, Archiv für Naturgesch., 1841, 1, p. 145.[1]

Station No. 5142; north of Jolo town; 21 fathoms.

Station No. 5147; off Balinpongpong Island (south of Jolo); 21 fathoms.

Station No. 5159; west of Sunalac Island (Tataan group); 18 fathoms.

Station No. 5163; south of San Gasanga (Tataan group); 28 fathoms.

Station No. 5205; Janabatas Channel, between Leyte and Samar; 6 fathoms.

Pangasinan Island; shore.

Tataan Islands; shore.

There are also other specimens with no definite data in regard to locality.

There can be no doubt that the species commonly known as *parvicirra* is in reality the same as the previously described *rotalaria*. The only recognized difference between the two is the possession by the latter of distichal series of 2 followed by palmar series of 4 (3 + 4), while in the former all the division series are 4 (3 + 4); but both Carpenter and Hartlaub, who have each treated of the species "*parvicirra*" at considerable length, admits the more or less common occurrence of distichal series of 2 in specimens they unhesitatingly refer to it. Dr. Hartlaub, under his "Type B" of *parvicirra*, says that this type has distichal series of 2, and 4 (3 + 4),

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[1] For additional synonyms see Carpenter, *Challenger* Reports, xxvi, Zoölogy, p. 338.

with a strong tendency toward the former condition; three of his specimens had five of each type, two six of 2, and the remainder (not more than four) 4 (3 + 4) one eight of 2, and two all of 2. Carpenter in his description of *rotalaria* says "two distichals, the second axillary without a syzygy;" later he says "tridistichate series occur abnormally in both examples [he had only two];" his figure shows nine distichal series, three of 4 (3 + 4), and six of 2. Overlooking the difference in the number of the distichals, Carpenter's description of *rotalaria* is included in every character in his more exhaustive one of *parvicirra;* since Hartlaub has shown the number of distichals to be valueless, we are forced to the conclusion that *rotalaria* and *parvicirra* are identical.

Carpenter records from the same station in the Philippines (Samboangan, 10 fathoms) seven specimens of *parvicirra*[1] and two of *rotalaria,* the latter, however, both with one or more distichal series of 4 (3 + 4). The present Philippine collection may safely be considered to include specimens identical with Carpenter's Philippine examples. I find in it all variations; the majority of the specimens have the distichals mainly 4 (3 + 4); many have them all 4 (3 + 4); but one (Tataan) has them all 2, thus being even more typical than Carpenter's specimens, which he refers without question to *rotalaria.* But there is not the slightest doubt that all the specimens before me are specifically identical; and therefore, assuming my "tridistichate" specimens to be comparable to Carpenter's Philippine *parvicirra* (they are certainly identical with the two *Challenger* specimens in the National Museum), and my "bidistichate" specimens to be the same as his *rotalaria,* from the unquestionable specific identity of mine I am led to infer the specific identity of his.

Some question might, of course, arise in regard to the correctness of Carpenter's conception of *rotalaria;* but he personally examined minutely the collection at Paris, and so careful was he in regard to specific discrimination that I believe we are safe in assuming the identity of the Paris specimens and those dredged by the *Challenger* at Zamboanga.

COMANTHUS ALTERNANS (P. H. Carpenter)

Station No. 5142; north of Jolo town; 21 fathoms.

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[1] I have at hand two of these.

COMANTHUS CUMINGII (J. Muller)

Station No. 5137; off Jolo town; 20 fathoms.

Station No. 5142; north of Jolo town; 21 fathoms.

This very distinct species has about ten cirri with thirteen joints. It is hardly necessary to call attention to the fact that none of Professor Bell's records of "*Actinometra cumingii*" refer to this form.

COMATELLA new genus

The type of arm structure found in "*Actinometra*" *pulchella* (*i. e.*, *alata*), *maculata, stelligera,* and *nigra* differs from that found in any other group. The division series are all 2, but the first two brachials of the free arm are united by syzygy. In ten-armed specimens belonging to one of these species, or in arms springing direct from the costal in others, the first syzygy is between the third and fourth brachials. Assuming the type of arm division to be extraneous, and Z_1 and Z_2 to be the distichals, this would be at once explained; for a splitting of the arm just before the first syzygial pair would, of course, result in a doubling of the syzygial pair, these two resultants resting upon Z_2 as an axillary; thus we would get distichals 2, and a syzygy between the first two brachials. This is the condition found in *maculata* and in the majority of specimens of *alata;* but in some specimens of the latter, and in *stelligera* and *nigra,* from one to five additional axillaries occur. Now the manner of occurrence of these additional division series is unique; in *nigra*, starting from the distichal axillary, they are only found exteriorly, so that from each distichal axillary there spring two main trunks giving off interiorly at every two joints an undivided arm, after the last axillary ending in undivided arms themselves. In *stelligera* and in *alata,* when palmars are developed, the costal axillary instead of the distichal is the starting point. The first two joints of the undivided arms and of the terminal arms at the end of the branching trunks always have a syzygy between the first two brachials; but in *alata* and in *stelligera,* in arms springing from the costal axillary the first syzygy is between the third and fourth brachials. The natural inference is an extraneous division, as in *Comaster*, but just before, instead of just after, the first syzygial pair. When exterior palmar series are developed in *alata* and in *stelligera*, we get a peculiar state of affairs; for internally the distichals represent the first two brachials of a free arm followed by the third and fourth (a syzygial pair) as usual; but externally they represent an interpolated division series, the two palmars representing Z_1 and Z_2, or the first two brachials of the two exterior arms. In *nigra* the costals and distichals appear both to be interpolated, instead of only the costals, as in the other species; the proof of this would be found in an arm arising undivided from a distichal axillary (a condition I have not been able to observe, as all the specimens before me have the full complement of palmar series), where, if this interpretation were correct, the first syzygy would be between the third and fourth brachials. This condition, in which a single division series represents internally Z_1 and Z_2, and externally an interpolated series, I propose to distinguish as *compound* arm division; and it seems worth while to recognize the species possessing this compound type of arm division as constituting a distinct genus, which may be designated *Comatella*, the genotype to be *Actinometra nigra* P. H. Carpenter. The presence of a syzygy between the first two brachials of the free arm (this being the first syzygy), combined with the exclusive occurrence of division series of 2, distinguishes the species at sight from those of the remaining genera.

COMATELLA NIGRA (P. H. Carpenter)

Station No. 5136; off the town of Jolo; 22 fathoms.

Station No. 5139; between Jolo and Pangasinan Island; 20 fathoms.

Station No. 5142; north of Jolo town; 21 fathoms.

Station No. 5145; off Jolo town; 23 fathoms.

Station No. 5146; west of Tapul Island (south of Jolo); 24 fathoms.

Station No. 5147; off Balinpongpong Island (south of Jolo); 21 fathoms.

The cirri are about xx, 30, the distal joints with small dorsal tubercles; there are three to five post costal axillaries; the first costals are entirely, and the radials partially, visible; the rays and division series are widely separated. The arms are 150 mm. in length, and the cirri, which are rather stout, 30 mm.

Family ZYGOMETRIDÆ

Genus CATOPTOMETRA A. H. Clark

CATOPTOMETRA MAGNIFICA, new species

Centro-dorsal large, discoidal, with a moderately concave, broad polar area 5 mm. to 10 mm. in diameter, having a deep rounded pit in the center.

Cirri marginal, arranged in two closely crowded, irregular, but more or less alternating rows XXX-XL, 18-25[1] (usually 20-24), 30 mm. to 35 mm. long; first joint about twice as broad as long, second not quite so long as broad, third squarish or very slightly longer than broad, fourth slightly longer, fifth slightly longer still, about half as long again as its median diameter; next three joints similar, the following then gradually decreasing in length, the terminal six or seven being squarish; opposing spine, though prominent, small, terminally situated, rarely reaching in height more than one-third the diameter of the penultimate joint; terminal claw large; longer than the penultimate joint (usually half as long again, sometimes even longer), stout, and moderately curved.

The cirrus joints are deeply concave dorsally and laterally, though nearly straight ventrally; this makes the articulations stand out prominently and gives the cirri a characteristic knobby appearance like those of *C. rubroflava;* this character becomes less and less marked as the joints decrease in length distally.

Disk more or less plated along the ambulacra.

Radials, and usually the first costals also, concealed by the centrodorsal; first costals, when visible, very short, united in their anterior half, but widely separated distally; costals united by syzygy; costal axillaries short, triangular, in the smaller specimens about three times as broad as long, in the larger four or five times as broad as long; distichals, palmars, and post-palmars 2; first joints of each division series inwardly united for their proximal half, but their inner edges diverging in their distal half almost in a straight line from the point of union, so that the arms and division series are well separated. Arms 40 to 80 in number; first brachial usually rather large, sometimes nearly as long exteriorly as broad, inwardly united in the proximal half, diverging in almost a straight line in the distal; there is considerable diversity in the size of the first brachials, some being very short, while most of them are about twice as broad as long exteriorly; second brachial nearly oblong, about twice as broad as long; third and fourth (syzygial pair) oblong, somewhat less than twice as broad as long; following six or seven brachials oblong, about twice as broad as long, then becoming wedge-shaped, then almost triangular, about twice as broad as long, gradually becoming less and less obliquely wedge-shaped, and very gradually increasing in length, so that the terminal joints are wedge-shaped, about as long as broad, or rather longer, with rather prominent articulations.

[1] The number of the cirri are given in Roman numerals, and the number of their component joints in Arabic.

Syzygies occur between the third and fourth brachials, again between the thirteenth and fourteenth to seventeenth and eighteenth (rarely an additional one between the ninth and tenth), and distally at intervals of three to thirteen (usually six or eight) oblique muscular articulations. The second and following brachials have projecting and finely spinous distal edges, making the arm characteristically rough.

Proximal pinnules very slender and flagellate; first pinnule 15 mm. to 20 mm. long, very delicate, with about 60 joints, the first five of which are broad and are provided with a dorsal carinate process, the remainder squarish; second pinnule longer, about 22 mm. in length, with the same number of joints, but slightly stouter; first five joints modified as in the first pinnule, the remainder squarish; third pinnule similar to the second and about the same length; following pinnules decreasing gradually in length, in basal stoutness, and in the number of component joints, the sixth being 12 mm. long with 30 joints, of which those in the proximal third are similar to the corresponding joints of the second and third pinnules, those in the distal portion being longer than broad, becoming terminally about twice as long as broad; twelfth pinnule 8 mm. long, with about 20 joints, the first two not quite so long as broad, the third and fourth squarish, the remainder becoming progressively elongated, and about twice as long and broad distally; distal pinnules very slender, 9 mm. long, with about 30 joints, the first wedge-shaped, not so long as broad, the second trapezoidal, about as long as its greater diameter, the third longer than broad, the remainder about twice as long as broad. The pinnule joints have slightly projecting and very finely spinous distal ends.

Measurements.—Arms 140 mm., cirri 30 mm. to 35 mm. in length.

Color (in spirits).—Red brown, the cirri yellow brown; in life apparently bright yellow with regular bands of bright red on the arms, like *C. rubroflava.*

Type.—Cat. No. 25436, U. S. N. M., from *Albatross* Station No. 5137; off the town of Jolo; 20 fathoms.

This species was also found at Station No. 5139; between Jolo and Pangasinan Island; 20 fathoms.

This fine species resembles *C. rubroflava* in the knobby character of the cirri and the roughness of the arms; but the cirri are very much longer than in that species, while the arms are from forty to eighty in number as compared with a maximum of thirteen in *C. rubroflava;* moreover, the distichal series in *C. rubroflava,* as in all of the recent Zygometridæ previously known, are 4 $(3 + 4)$, while in the present species they are 2.

Genus EUDIOCRINUS P. H. Carpenter

EUDIOCRINUS SERRIPINNA, new species

Centro-dorsal discoidal, the rather broad dorsal area flat.

Cirri XIX, 12-14, 5 mm. to 7 mm. long, arranged in a partially double marginal row; first joint short, second squarish, third, fourth, and fifth about half as long again as broad basally, the terminal five or six squarish; second and following with expanded distal ends, this character dying away distally; cirri rounded basally, but becoming compressed distally, the distal portion consequently appearing broader in lateral view; opposing spine prominent, central in position, not reaching half the diameter of the penultimate joint in height; terminal claw longer than the penultimate joint, abruptly curved basally.

The arms are as in the other species of the genus, except that the brachials are rather more strongly overlapping, the carination, which is very slight, is single instead of double, and the syzygies occur at intervals of three oblique muscular articulations; the surface of the joints is finely granulated, as in *E. granulatus*.

The proportions of the pinnules are as in the other species, but the lower pinnules, and especially those which are enlarged, have the distal ends on the dorsal side very strongly produced, giving them a strongly serrate profile.

The strongly serrate condition of the lower pinnules distinguish this species at once from the other three species of the genus; the single carination of the dorsal surface of the arms is also unique, while the small number of the cirrus joints differentiate it sharply from *E. indivisus* and *E. granulatus*.

In Professor Bell's description of *E. granulatus*, he uses "first" and "second" pinnule in the sense of the two first pinnules on the same side of the arm, while Professor Semper uses the same terms strictly, taking the pinnules alternately in order of sequence; hence Professor Bell finds a great difference between the "first" and "second" pinnules of his *E. granulatus*, and those of *E. indivisus*, which, in reality, is non-existent.

Measurements.—Arms about 40 mm., cirri 5 mm. to 7 mm. long.

Color (in spirits).—Yellowish brown, the cirri lighter, the perisome darker.

Type.—Cat. No. 25437, U. S. N. M., from *Albatross* Station No. 5136; off Jolo town; 22 fathoms.

Genus ZYGOMETRA A. H. Clark

ZYGOMETRA ELEGANS (Bell)

This species was found at Station No. 5137; off Jolo town; 20 fathoms; and at Station No. 5138; between Jolo and Pangasinan Island; 19 fathoms.

Family HIMEROMETRIDÆ

Genus PONTIOMETRA A. H. Clark

PONTIOMETRA ANDERSONI (P. H. Carpenter)

One magnificent specimen was secured at Station No. 5146; west of Tapul Island (south of Jolo); 24 fathoms.

Genus HIMEROMETRA A. H. Clark

HIMEROMETRA BARTSCHI, new species

Centro-dorsal thick, discoidal, with a rather strongly concave polar area; cirri arranged in two and a partial third crowded, more or less alternating, rows.

Cirri XXX, 41-43, long, rather more than one-third the length of the arms, moderately stout; first five joints about twice as broad as long, the following gradually increasing in length to the ninth or tenth, which is squarish; after about the sixteenth they gradually decrease in length, the terminal joints being about twice as broad as long; after the seventeenth joint small but prominent dorsal spines are developed; opposing spine centrally situated, rather slender, reaching about half the diameter of the penultimate joint in height; terminal claw considerably longer than the penultimate joint, slender, moderately curved.

Radials approximately even with the edge of the centro-dorsal; first costals short, united for their entire length; division series and brachials as in *H. crassipinna*.

Distichal and palmar pinnules 25 mm. long, very stout basally, but tapering gradually to a slender and delicate tip, with about 40 squarish joints; first brachial pinnule 15 mm. to 17 mm. long, proportionately more slender than those preceding, with about 32 joints, slightly longer than broad, the first two of which are slightly carinate; second brachial pinnule smaller and more slender, 13 mm. long, with 30 joints, the first short, the next three or four squarish, the remainder slightly longer than broad; the second, third, and fourth joints are somewhat carinate; third brachial pinnule 8 mm. long, small and weak, with about 20 joints, those in the proximal half squarish, those in the distal slightly longer than broad, the second to the sixth rather strongly carinate; succeeding pinnules decreasing rapidly in length, the fifth and following being 5 mm. long, then slowly increasing again and reaching a length of 9 mm. distally.

Measurements.—Arms, 120 mm., cirri 45 mm. in length.

Color (in spirits).—Brown.

Type.—Cat. No. 25438, U. S. N. M., from *Albatross* Station No. 5146; west of Tapul Island (south of Jolo); 24 fathoms.

Another similar specimen was obtained at Station No. 5147; off Balinpongpong Island (south of Jolo); 21 fathoms.

This species agrees with *H. crassipinna* in the general scheme of its arm division and in the shortness and strong overlapping of the projecting distal ends of the brachials; the distichals are 4 (3 + 4), the palmars 4 (3 + 4) externally, 2 internally; the post-palmars, which are developed on the inner side of the inner palmar series of each distichium only are 4 (3 + 4); each distichium divides once externally and twice internally, which would make fifty arms in all; the type specimen has fifty-one. The comparatively slender lower pinnules, which become delicate and flagellate distally preclude any possibility of confusion with *H. crassipinna*.

HIMEROMETRA ROBUSTIPINNA, new species

This new form agrees in its general appearance and in its arm structure with *H. crassipinna*, but the cirri, while containing the same number of joints, are without dorsal spines, though the last three joints may have small central tubercles (in *H. crassipinna* strong dorsal spines are developed in the outer third or even half of the cirri), and the lower pinnules, though with the same number of component joints, are much stouter, with most of the joints broader than long, and smooth, without the prominent projecting spinous distal ends characteristic of the joints of the proximal pinnules of *H. crassipinna*.

The type has 37 arms 100 mm. long, and 18 cirri 35 mm. long; the distichal pinnule is 15 mm. long.

Color (in spirits).—Dull violet.

Type.—Cat. No. 25439, U. S. N. M., from *Albatross* Station No. 5165; south of San Gasanga (Tataan group); 9 fathoms.

HIMEROMETRA MAGNIPINNA, new species

The absence of prominent dorsal spines on the cirri of this species separate it at once from *H. crassipinna* and *H. bartschi,* and give the cirri a certain resemblance to those of *H. robustipinna;* but they are smaller than those of that species measuring only one-quarter of the arm length instead of rather over one-third, and are correspondingly delicate.

The proximal pinnules, however, are different from those of any other form; they are very stout, but also very long, and taper evenly from the base to the tip; the distal ends of their component joints are slightly swollen, but are not spinous and overlapping as in *H. crassipinna;* the taper is much more gradual than in that species, while the pinnules have 28 or 29 joints instead of 20.

The arm structure and arrangement is as in *H. crassipinna, H. bartschi,* and *H. robustipinna.*

The type specimen has 62 arms 120 mm. long, and 25 cirri 30 mm. long, with 28 to 32 (usually 28 to 30) joints.

Color (in spirits).—Dull violet.

Type.—Cat. No. 25440, U. S. N. M., from *Albatross* Station No. 5139; between Jolo and Pangasinan Island; 20 fathoms.

This species was also found at Station No. 5147; off Balinpongpong Island (south of Jolo); 21 fathoms.

HIMEROMETRA PERSICA A. H. Clark

Station No. 5163; south of San Gasanga (Tataan group); 28 fathoms.

Another specimen has no definite data as to locality.

HIMEROMETRA BENGALENSIS (Hartlaub)

Station No. 5146; west of Tapul Island (south of Jolo); 24 fathoms.

HIMEROMETRA QUINDUPLICAVA (P. H. Carpenter)

Station No. 5139; between Jolo and Pangasinan Island; 20 fathoms.

Another specimen has no definite data in regard to locality.

HIMEROMETRA ANCEPS (P. H. Carpenter)

Station No. 5147; off Balinpongpong Island (south of Jolo); 21 fathoms.

Other specimens have no definite locality given.

HIMEROMETRA MILBERTI (J. Müller)

Station No. 5100; off Corregidor Island (entrance to Manila Bay); 35 fathoms.

HIMEROMETRA DISCOIDEA, new species

Centro-dorsal large, hemispherical or somewhat columnar, with a large convex polar area; cirrus sockets marginal, in two crowded alternating rows.

Cirri XVII, 37-45 (usually about 40), 30 mm. long; the cirri decrease very gradually in diameter for the first eight or ten joints, then remain uniform; first cirrus joint short, about twice as broad as long, or rather shorter, the following gradually increasing in length, becoming squarish after about the twelfth or sixteenth, and becoming about one-third broader than long in the terminal portion; from about the eighteenth onward prominent, though small, dorsal spines are developed, subterminal in position, becoming terminal in the last two or three joints; opposing spine small, median in position, not rising to more than one-third the diameter of the penultimate joint; terminal claw somewhat longer than the penultimate joint, moderately curved.

Radials projecting slightly beyond the centro-dorsal, their dorsal surface parallel to the dorso-ventral axis of the animal; first costals short, oblong, about three times as broad as long; costal axillaries rhombic, about twice as broad as long, rising to a low conical tubercle with the first costals. Ten arms about 130 mm. long; first brachial wedge-shaped, about twice and one-half as broad as its exterior length, almost entirely united interiorly; second brachial irregularly quadrate, rather larger than the first; third and fourth brachials (syzygial pair) oblong, twice and one-half as broad as long; following brachials to the tenth slightly wedge-shaped, about three times as broad as long; the following brachials become more obliquely wedge-shaped, somewhat over twice as broad as their greatest length, then gradually become shorter and less and less obliquely wedge-shaped and very short and discoidal after about the proximal third of the arm.

First pinnule small and comparatively slender, 7 mm. long, with fifteen joints, all somewhat longer than broad, the first two and the terminal three or four being not quite so long as the others; second pinnule 11 mm. long, with seventeen joints, stouter than the first; first two joints squarish, the remainder slightly longer than broad;

third pinnule 10 mm. long, with fifteen joints, resembling the second; fourth and following pinnules 7 mm. long, with fourteen joints, the fifth and following being about as stout as the first; distal pinnules 10 mm. long.

In the specimen from the Philippine Islands, all the lower pinnules have squarish joints; the first is 9 mm. long with 19 joints, the second 10 mm. with 17, the third 8 mm. with 15, and the fourth and following 6 mm. with 14; the distal pinnules are 10 mm. long.

Color (in spirits).—Flesh color, the perisome brown.

Type.—Cat. No. 25453, U. S. N. M., from Port Denison, near Bowen, Queensland.

A specimen was dredged at *Albatross* Station No. 5138, between Jolo and Pangasinan Islands; 19 fathoms.

This is probably the species which has been recorded from Port Denison as "*Antedon milberti*," but the relatively slender cirri with comparatively long joints contrast sharply with the very stout cirri of *milberti*, which have exceedingly short joints.

HIMEROMETRA VARIIPINNA (P. H. Carpenter)

Station No. 5157; west of Sunalac Island (Tataan group); 18 fathoms.

HIMEROMETRA UNICORNIS, new species

Centro-dorsal thick-discoidal, the small polar area deeply concave.

Cirri XX, 30-32, stout, arranged in two closely crowded, more or less alternating rows; cirrus joints remarkably uniform, all about twice as broad as long, with very prominent dorsal distal ends, giving the cirri a strongly serrate profile dorsally; after the tenth the joints bear paired dorsal tubercles.

Radials barely visible, separated somewhat distally; first costals oblong, short, about three times as broad as long, rounded, widely separated, with a strong rounded-triangular ventro-lateral process supporting the disk; costal axillaries broadly pentagonal, rather over twice as broad as long, with a somewhat larger ventro-lateral projection than the first costals; distichals and palmars 2, the latter developed only on the outer side of the rays; joints of the division series and first brachials with stout ventro-lateral processes; about 30 arms; first eight brachials oblong, about twice as broad as long, then becoming slightly wedge-shaped about twice as broad as long, gradually becoming less and less wedge-shaped and practically oblong again, about twice as broad as long in the outer half of the arm. The brachials, except the discoidal proximal series, have everted and finely spinous distal ends, giving the arm a characteristic rough feeling, much as in *Catoptometra*. Syzygies occur between the third and fourth brachials, again between the fourteenth and fifteenth to forty-second and forty-third (usually in the vicinity of the thirtieth) and distally at intervals of six to twelve (usually seven to nine) oblique muscular articulations.

First pinnule very slender, 12 mm. long, with 28 joints, the first two about twice as broad as long, then increasing in length to the fifth, which is squarish, the remainder being slightly longer than wide, increasing to about half again as long as broad distally; second pinnule 15 mm. long, very stout and stiff, with 20 to 23 joints, the first two nearly twice as broad as long, the third squarish, the remainder slightly longer than broad; the fourth or fifth and following joints have prominently everted and spinous distal edges dorsally and laterally, though ventrally the joint ends are unmodified; third pinnule smooth, 6 mm. long (or one-half the length of the first), small, but rather stiff, tapering evenly from the base to a slender tip, with 13 joints, of which the distal are about half again as long as broad; fourth pinnule similar, but only 5 mm. long; following pinnules similar, but very gradually increasing in length; distal pinnules 10 mm. long, with 20 or 21 joints, the first nearly twice as broad as long, the second trapezoidal, nearly as long as its greater diameter, the remainder about half again as long as broad. All the pinnules are somewhat stiffened.

Measurements.—Arms 140 mm., cirri 20 mm. to 25 mm. long.

Color (in spirits).—Reddish brown, the large second pinnule lighter, or yellow, the remaining pinnules nearly black in their proximal, white in their distal half; or, light blue-gray, with numerous small red-brown spots; cirri red-brown.

Type.—Cat. No. 25441, U. S. N. M., from *Albatross* Station No. 5160; off Nusa Takbu Channel (Tataan group); 12 fathoms.

Other specimens were obtained at Station No. 5141; between Bubyan and Pangasinan Islands; 29 fathoms.

Station No. 5147; off Balinpongpong Island (south of Jolo); 21 fathoms; and Station No. 5163; south of San Gasanga (Tataan group); 28 fathoms.

The short, stout cirri of this species, combined with the greatly enlarged second pinnule, distinguish it at a glance from all the "bidistichate" species of *Himerometra*. It is most nearly related to *H. bella* and *H. abbotti*.

HIMEROMETRA ECHINUS, new species

Centro-dorsal discoidal, the moderately large polar area slightly concave; cirri arranged in two closely crowded, more or less alternating rows.

Cirri XXIV, 26-30; first four joints about twice as broad as long, sixth squarish, seventh to tenth or eleventh about one-third longer than broad, then becoming squarish again, and, in the terminal twelve or fourteen, broader than long; tenth and following joints with large dorsal spines; opposing spine terminally situated, erect, about half as long as the diameter of the penultimate joint; terminal claw rather longer than the penultimate joint, slender, and moderately curved.

Radials projecting slightly beyond the centro-dorsal; first costals trapezoidal, proximally about four times, distally about three times as broad as long, united in their basal third, but diverging very rapidly from their point of union, so that the free lateral border of two adjacent first costals forms a moderately curved even line; costal axillaries broadly pentagonal, nearly twice as broad as long, with large and broad ventro-lateral projections; distichals, palmars, and post-palmars 2, bearing on the outer side of the rays, in common with the first brachials, large and broad ventro-lateral processes. Forty arms in the type (one interior palmar series being absent, but its loss compensated by the development of an external post-palmar series on the same distichium); first nine or ten brachials discoidal, or very slightly-wedge-shaped, about twice as broad as long, then becoming short-triangular, rather more than twice as broad as long, and short-wedge-shaped in the distal portion of the arms. Syzygies occur between the twenty-second and twenty-third to thirty-second and thirty-third (most commonly in the vicinity of the twenty-third) brachials, and distally at intervals of 9 to 24 (usually 9 to 13) oblique muscular articulating.

First pinnule 15 mm. long, large, stiff, and spine-like, resembling the second, with 15 joints, the first two nearly twice as broad as long, the third squarish, then increasing in length, the seventh and following being from once and one-half times to nearly twice as long as wide; second pinnule 16 mm. long, with 12 or 13 joints, of which the distal are rather longer than those of the first; third pinnule 15 mm. long, resembling the second; fourth, 12 mm. long, with 11 joints, resembling the third; following pinnules decreasing in length and also slightly in stoutness, the seventh being 7 mm. long, with 10 joints, then gradually losing their peculiar stiffness, and later gradually increasing in length; distal pinnules 10 mm. long, with about 20 joints, the first two not so long as broad, the third squarish, the remainder about one-third longer than broad, becoming half again as long as broad distally.

Measurements.—Arms 110 mm., cirri 25 mm. in length.

Color (in spirits).—Dull yellowish, the division-series and arms thickly covered with small dull red spots and blotches; perisome brown.

Type.—Cat. No. 25442, U. S. N. M., from *Albatross* Station No. 5147; off Balinpongpong Island (south of Jolo); 21 fathoms.

The length of the second pinnule, which has comparatively few joints, and the similarity of the first to the second, place this species near *H. tenuipinna;* but the greater number of joints in the lower pinnules, and the fact that the first eight or nine instead of only the first three are similar in character, distinguish it at once.

HIMEROMETRA GRACILIPES, new species

Centro-dorsal a thick disk with a small flat polar area, the cirri arranged in two, and a partial third, more or less alternating crowded irregular rows.

Cirri XIX, 41-52 (usually about 50); first joint about twice as broad as long, following increasing in length to the fifth or sixth, which is squarish, then remaining the same (or becoming slightly longer than broad) to about the twenty-sixth, then gradually becoming shorter, about half again as broad as long; after the twentieth to the twenty-second dorsal spines gradually begin to develop, which, however, never become very large; opposing spine terminal, erect, about half as long as the diameter of the penultimate joint; terminal claw longer than the penultimate joint, slender, moderately curved.

Radials very prominent, their external dorsal surface parallel with the dorso-ventral axis of the animal, about twice as broad as long; each radial bears a low rounded postero-lateral tubercle on each side; first costals trapezoidal, about three times as broad as long proximally and twice as broad as long distally; they are basally united, but diverge very rapidly distally; costal axillaries pentagonal, about one and one-half times as broad as long; distichals, palmars, and post-palmars 2, widely separated, the last developed only on the outer side of the distichal series. Forty-four arms in the type; first ten brachials oblong, not quite twice as broad as long, then wedge-shaped, almost triangular, about twice as broad as long, becoming proportionately longer in the distal part of the arms.

Syzygies occur between the third and fourth brachials, again between the forty-fourth and forty-fifth to the fifty-sixth and fifty-seventh (usually nearer the latter), and distally at intervals of 6-11 (usually 7-9) oblique muscular articulations.

First pinnule 10 mm. long, slender but somewhat stiffened, tapering evenly from the base to the delicate tip, with 22 joints, the first about twice as broad as long, the fourth squarish, then gradually increasing in length, the seventh and following being about half again as long as broad; second pinnule usually slightly longer, with 17 joints, those in the distal part being more elongated than the corresponding joints in the first; third pinnule 5.5 mm. long, of the same character as the two preceding, with 12 joints; following pinnules small, short, and delicate, 4 mm. long, with 12 joints, the first three squarish, the remainder longer than broad, becoming about twice as long as broad distally; distal pinnules 7 mm. long, with 20 joints, the first short, the second squarish, the third about half again as long as broad, the remainder about twice as long as broad, or rather longer.

Measurements.—Arms 90 mm., cirri 35 mm. to 40 mm. in length.

Color (in spirits).—Brownish gray.

Type.—Cat. No. 25455, U. S. N. M., from *Albatross* Station No. 5163; south of San Gasanga (Tataan group); 28 fathoms.

HIMEROMETRA PROTECTUS (Lutken)

Simonor, Tataan Islands.

Pangasinan Island; also a specimen with no definite locality given.

HIMEROMETRA MONACANTHA (Hartlaub)

Station No. 5109; Simo Banks, southwest of Manila Bay, Luzon; 6 fathoms.

Station No. 5147; off Balinpongpong Island (south of Jolo); 21 fathoms.

Genus CYLLOMETRA A. H. Clark

CYLLOMETRA SUAVIS, new species

This species is allied to *C. perspinosa,* with which it agrees in its general structure; but it entirely lacks the prominent spinous overlapping of the pinnule and cirrus joints characteristic of that species, and the lower pinnules, while stiffened as in *C. perspinosa,* are subequal in length and not elongated, and are much more slender than in that species. The cirri, while containing 35-40 joints, as in *C. perspinosa*, differ strikingly from those of that species in having the dorsal spines in the distal portion single and median in position instead of paired. The general appearance of the whole animal is much more delicate than in *C. perspinosa;* the costals are more elongated, the arms, cirri, and lower pinnules more slender.

Measurements.—Arms about 100 mm., cirri 25 mm. to 30 mm. in length.

Color (in spirits).—Purple, the costals and discoidal lower brachials with a median line of white; arms, pinnules, and cirri purple, with very numerous narrow bands of white.

Type.—Cat. No. 25443, U. S. N. M., from *Albatross* Station No. 5137; off Jolo town; 20 fathoms.

Fragments of another specimen were dredged at Station No. 5145; off Jolo town; 23 fathoms.

CYLLOMETRA MANCA (P. H. Carpenter)

Station No. 5213; east of central Masbate; 80 fathoms.

Genus OLIGOMETRA A. H. Clark

OLIGOMETRA GRACILICIRRA, new species

Centro-dorsal thick-discoidal, the rather large polar area thickly covered with small blunt spines.

Cirri in a single marginal row, xv, 28-30; first joint very short, the following gradually increasing in length to the fourth, which is squarish, then becoming very slightly broader than long after the tenth; from the seventh joint onward long and sharp dorsal spines are developed; opposing spine as long as the diameter of the penultimate joint, arising from the entire surface of that joint; terminal claw rather stout, about as long as the penultimate joint, moderately curved.

Radials visible, but short, bearing a small median tubercle on the distal border; first costals oblong, nearly three times as broad as long, with straight lateral edges which are just in apposition; costal axillaries broadly pentagonal, about once and one-half times as broad as long. Ten arms; first two brachials wedge-shaped, the shorter side in, the first interiorly united for one-half or two-thirds of their length, and both slightly flattened exteriorly; third and fourth brachials (syzygial pair) nearly twice as broad as long, rather longer interiorly than exteriorly; following brachials to the ninth oblong, about twice as broad as long, after which they become obliquely wedge-shaped, about as long as broad, and gradually less and less obliquely wedge-shaped distally; costals and lower brachials with a faintly indicated rounded median keel; brachials after about the eleventh developing slightly overlapping and spinous distal edges. Syzygies occur ordinarily between the third and fourth, ninth and tenth, and fourteenth and fifteen brachials, and distally at intervals of seven to eleven (usually nine) oblique muscular articulations.

First pinnule moderately stout, with 7 or 8 squarish joints, about 2 mm. long; second pinnule about 3 mm. long, considerably stouter than the first, with 9 or 10 joints, the first two not quite so long as broad, the third squarish, the remainder slightly longer than broad; third and following joints with strongly overlapping and spinous distal edges; third pinnule similar, but smaller; fourth pinnule, while similar to the third, is about the size of the first; after the twelfth or thirteenth the pinnules increase in length, reaching about 4.5 mm. distally.

Measurements.—Arms 55 mm., cirri 12 mm. in length.

Color (in spirits).—Costals while, with a broad median line of purple; arms purple, with a median line of white in their proximal third; cirri white, with a narrow band of purple about the middle of each joint.

Type.—Cat. No. 25444, U. S. N. M., from *Albatross* Station No. 5153; east of Port Dos Amigos, Tawi Tawi; 49 fathoms.

The slender and spiny cirri with comparatively numerous joints, as well as the delicate build of the whole animal and the shortness and stoutness of the lower pinnules, distinguish this species at once from all the others of the genus.

OLIGOMETRA PULCHELLA A. H. Clark

One specimen from Station No. 5139; between Jolo and Pangasinan Island; 20 fathoms.

This species was previously only known from Singapore.

Family TROPIOMETRIDÆ

Genus CALOMETRA A. H. Clark

CALOMETRA CARDUUM, new species

This species is a member of that division of the genus *Calometra* in which the rays, through lateral processes, are more or less in contact, and comes nearest to *C. flavopurpurea,* of Japan.

Centro-dorsal hemispherical or thick discoidal, a large convex polar area bare, the cirri marginal, arranged in two closely crowded rows.

Cirri x-xv, 26-40 (usually 34-36); first joint short, the following becoming progressively longer to the fourth or fifth, which is squarish, then remaining similar to about the end of the proximal third of the cirrus, after which the length gradually decreases; from the twelfth or fourteenth onward prominent blunt dorsal spines are developed; opposing spine rather small, the apex opposite the end of the penultimate joint, the spine arising from the entire dorsal surface of that joint.

Radials usually concealed by the centro-dorsal, but sometimes partially visible in the interradial angles; first costals short and band-like, in lateral apposition, the dorsal surface coarsely rugose, the edges crenulate or more or less dentate; costal axillary triangular, about twice as broad as long, the dorsal surface rugose, the edges finely crenulate; distichals 2, resembling the costals, and, like them, in close lateral apposition. Fifteen to twenty arms; first brachial wedge-shaped, longer outwardly than inwardly, in close apposition interiorly, the edges sharply crenulate or dentate; second brachial similar; third and fourth brachials (syzygial pair) roughly oblong, not quite twice as broad as long; next three brachials oblong, rather more than twice as broad as long, then becoming more and more wedge-shaped, after about the twelfth becoming triangular, broader than long, then very gradually becoming wedge-shaped again and increasing in length, though even distally the joints are never quite so long as broad; arm terminating very abruptly with three or four minute joints, beyond which the terminal pinnules extend for about 3 mm. Syzygies occur between the third and fourth brachials, again between the thirteenth and fourteenth to seventeenth and eighteenth (in undivided arms usually also between the ninth and tenth), and distally at intervals of four oblique muscular articulations.

The pinnules are essentially like those of *C. flavopurpurea.*

Measurements.—Arms 60 mm., cirri 20 mm. to 25 mm. in length.

Color (in spirits).—Bright yellow, the calyx, division series, and cirri white. One specimen has a narrow dull purple band crossing the arms at the first syzygy, and another has indistinct dull purplish blotches on the pinnules.

Type.—Cat. No. 25445, U. S. N. M., from *Albatross* Station No. 5167; off Simonor Island (Tawi Tawi group); 110 fathoms.

This species is readily distinguishable from *C. flavopurpurea* by the absence of the sharp median keel on the costals, and the strongly dentate or sharply crenulate edges of those joints.

CALOMETRA ACANTHASTER, new species

This new form comes nearest to *C. multicolor*, of Japan, but it differs from that species in a number of characters which appear to be perfectly constant. The arms are thirty in number instead of twenty or less, palmar series (2) being developed on the outer side of each distichal series in 2, 1, 1, 2 order; the third pinnule is as large as and resembles the second instead of being considerably smaller, as in *C. multicolor;* the cirri, while containing the same number of joints, are very different in appearance from those of *C. multicolor;* in the latter the joints in the distal half of the cirri are rounded ventrally, the distal ventral ends are even with the proximal ventral ends of the succeeding joints, the width is about twice the length in the middle lateral line, and the dorsal spines arise from one-half or rather less of the dorsal surface and are small and pointed; in *C. acanthaster* the distal half of the cirri is sharply carinate ventrally, and the distal ends of the joints are prominent, overlapping the bases of the succeeding joints; the joints themselves are broader, being about three times as broad as long in the lateral line, and the dorsal spines, which arise from the entire dorsal surface of the joints, are high, and terminate in a long ridge parallel to the median line of the joint instead of in a point.

Measurements.—Arms 60 mm., cirri 20 mm. long.

Color (in spirits).—Yellow, the cirri with a few narrow bands of deep purple, and the pinnules with large, indistinct blotches of light purplish; or purple, the centro-dorsal, costals, and blotches on the arms and pinnules white; or white, the arms with about every third brachial deep purple, the pinnules and cirri narrowly banded with purple.

Type.—Cat. No. 25446, U. S. N. M., from *Albatross* Station No. 5153; east of Port Dos Amigos, Tawi Tawi; 49 fathoms.

Genus PTILOMETRA A. H. Clark

PTILOMETRA TRICHOPODA, new species

Centro-dorsal columnar, the polar area a low truncated cone bearing five rather long, rounded tubercles which are radial in position; cirrus sockets in ten columns, two in each radial area, usually two cirrus sockets to a column.

Cirri xx, 80-85 (usually 84 or 85), very long and slender, tapering gradually from a moderately stout base to a slender tip; first joint short, second about twice as broad as long, the following gradually increasing in length to the fifth, which is squarish, and still further increasing to the eighth, which is not quite half again as long as broad; the proportions of the following joints similar until the eighteenth or twentieth, after which the joints gradually decrease in length, the thirty-second to the thirty-fifth being squarish, the following gradually becoming broader than long, the terminal joints being very short; the fourth to about the sixteenth joints with a strong ventral overlap (though smooth dorsally), and the middle of the distal ventral border strongly produced in the form of a sharp and prominent spine, this condition reaching a maximum on the eighth or ninth joint, then gradually decreasing in intensity, disappearing after about the sixteenth; at about the twenty-fifth joint a slight prominence of the distal dorsal edge is noticeable; after the thirty-sixth the median part of the dorsal edge is produced into a small, sharp spine which projects forward in line with the rest of the dorsal surface of the joint; after about the fiftieth joint this spine begins to broaden basally, soon transforming into a high curved spine arising from the entire dorsal surface of the joints, just like the dorsal spines in the distal part of the cirri of *P. macronema;* last four joints decreasing rapidly in size; opposing spine very small (though of normal proportions when compared to the very small penultimate joint which bears it); terminal claw minute.

Ends of basal rays visible as dorso-ventrally elongated tubercles in the angles of the calyx; radials rather prominent, about four times as broad as long, with a rather low, rounded tubercle in the median part of their proximal border, first costals oblong, about three times as broad as long, in close lateral apposition and somewhat flattened laterally; costal axillaries rhombic, about twice as broad as long, with a tendency to rise into a low, rounded tubercle at the articulation with the first costals; distichals and palmars 2, the latter developed exteriorly in 2, 1, 1, 2 order; division-series and first four or five brachials sharply "wall-sided;" but, owing to the thinness of the joints dorso-ventrally, the flattened lateral area is comparatively narrow. Twenty-four to thirty arms; first eight brachials discoidal or oblong, about twice as broad as long, then gradually becoming more and more wedge-shaped, and after the twelfth obliquely wedge-shaped, not quite so long as broad, and in the distal portion of the arms less obliquely wedge-shaped again, but not increasing in length; arm ending abruptly with a few minute incurved joints, as in *P. macronema,* the terminal pinnules exceeding the arm tip by about 4 mm.; arms dorsally rounded and comparatively broad in the proximal half, becoming gradually strongly compressed and carinate distally, the brachials developing prominent overlapping spines, as in *P. macronema*. Syzygies occur between the third and fourth brachials (in one case the first syzygy is between the sixth and seventh), again between the thirteenth and fourteenth to nineteenth and twentieth (most commonly between the seventeenth and eighteenth, with rarely an additional syzygy between the seventh and eighth), and distally at intervals of six to twelve (usually seven or eight) oblique muscular articulations.

First pinnule small and weak, about 6.5 mm. long, with 10 or 12 joints, the first short, the second rather longer than its anterior diameter, decreasing in width distally, the remainder about two and one-half times as long as broad; second pinnule about 9 mm. long, stiff and spine-like, with fifteen joints, the first short, the second rather longer than its anterior diameter, the third not quite so long as broad, the following about twice as long as broad; the pinnule is sharply triangular, and the dorsal ridge on each joint is produced distally over the bases of the succeeding joints in the form of a slender spine; third and following pinnules similar to the second, but about 10 mm. long. The pinnules as a whole are considerably more delicate than are those of *P. macronema;* the plating of the disk and ambulacra is approximately as in *P. macronema.*

Measurements.—Arms 70 mm., cirri 60 mm. in length.

Color (in spirits).—White, the costals with a lateral line, the division-series with narrow transverse lines at the articulations, and the pinnules with a spot in the middle of each joint of very light purple; cirri deep violet in the distal two-thirds, in the proximal third white, with a lateral line of deep violet.

Another specimen is entirely deep purple.

Type.—Cat. No. 25447, U. S. N. M., from *Albatross* Station No. 5153; east of Port Dos Amigos, Tawi Tawi; 49 fathoms.

This species was also found at Station No. 5179; between Tablas and Romblon; 37 fathoms.

The large number of arms, the narrowness of the calyx and arm bases, the extraordinary spinous ventral overlap of the joints in the proximal third of the cirri, the regular arrangement of the cirri, and the greater delicacy of the entire animal distinguish this species at once from *P. macronema*. The number of arms alone is usually a sufficient character, for, although sometimes having as many as thirty, *P. macronema* usually has less than twenty.

Family THALASSOMETRIDÆ

Genus THALASSOMETRA A. H. Clark

THALASSOMETRA COMPRESSA (P. H. Carpenter)

Station No. 5110; off Talin Point, west Luzon (14° N. lat.); 139 fathoms.

Genus CHARITOMETRA A. H. Clark

CHARITOMETRA SMITHI, new species

This is a species of *Charitometra* falling in the division including *C. angusticalyx, C. inæqualis, C. distincta, C. brevipinna,* and *C. imbricata,* species with the second division-series usually 4 (3 + 4) and the third 2 (1 + 2), and with usually about thirty arms. The division-series and lower arm joints are in very close apposition so that the distichal pinnule is not visible exteriorly, as it is in *C. distincta* and *C. imbricata* (= *granulifera* of P. H. Carpenter, not of Pourtalès); the strong carination of the more distal cirrus joints and the presence of an opposing spine, combined with the smooth and evenly rounded division-series and arm bases distinguish it at once from *C. angusticalyx* and *C. brevipinna,* while the length of the proximal and the shortness of the distal cirrus joints, the latter having the distal dorsal edges so prominent as to appear almost spinous, preclude any possibility of confusion with *C. inæqualis.* It may be described as follows:

Centro-dorsal thick discoidal or short-columnar, the cirrus sockets arranged in two rows and roughly in three irregular columns in each radial area, though the middle column is sometimes lacking.

Cirri XXVII-XXX, 19-22 (usually 20); first joint very short, second about twice as broad as long, third nearly squarish, fourth slightly longer than broad, fifth nearly half again as long as broad; following joints decreasing very gradually in length, the tenth and following being about as long as their distal diameter; the joints after the eighth or ninth becoming rounded carinate dorsally, soon developing rather prominent rounded tubercles situated on the distal dorsal edge; opposing spine, though prominent, small, terminally situated, reaching a height equal to about half the diameter of the penultimate joint or rather less, its base occupying only the distal third of the joint; terminal claw about as long as the penultimate joint, rather stout and moderately curved.

Disk completely covered with small plates; side and covering plates of arms and pinnules very well developed.

Ends of basal rays just visible as more or less irregular tubercles in the angles of the calyx; radials quite concealed in the median line of the arm, though sometimes slightly visible over the ends of the basal rays; first costals very short, three or four times as broad as long, triangular, apex downward, laterally in close apposition, the dorsal surface coarsely rugose; costal axillaries triangular, rather more than twice as broad as long, the dorsal surface rugose; distichals 4 (3 + 4), rarely 2; palmars 2 (1 + 2), developed interiorly in 1, 2, 2, 1 order as a rule; first distichal more or less covered with small crowded tubercles, but the remaining joints of the division-series perfectly smooth; division-series and proximal six or eight brachials in close apposition and sharply flattened laterally. Twenty-eight arms (in the type); proximal twelve or fourteen brachials oblong, about twice as broad as long, then becoming triangular and nearly as long as broad, and in the distal part of the arm wedge-shaped and longer than broad. The first syzygy is usually between the first two brachials, but may be between the third and fourth, especially in arms springing direct from a distichal axillary; in arms where the first and second brachials are united by syzygy the third and fourth are often similarly united, the next syzygy is near the nineteenth to the twenty-fifth brachial (usually between the twentieth and twenty-first or one or two joints farther on), and the distal intersyzygial interval is from four to twelve (usually six or seven) oblique muscular articulations.

Distichal pinnule 13 mm. long, slender and evenly tapering, flagellate distally, with about 45 joints, in the proximal half about once and one-half as broad as long, becoming squarish distally; first brachial pinnule similar, but only about 9 mm. long with 35 joints, the first five of which are noticeably carinate; second brachial pinnule about the same length, but with only about 25 joints, the first four or five of which are carinate and slightly broader than those of the first pinnule, the terminal joints being about twice as long as broad. In the following pinnules the joints, except the first two, gradually become longer and fewer in number; the tenth pinnule is 8 mm. long with 17 joints, the first two not so long as broad and bearing a triangular or bluntly triangular process distally, the remainder squarish, gradually becoming slightly longer than broad; third to the seventh or eighth joints very slightly enlarged, protecting the genital glands, but the enlargement is not very noticeable and tapers off evenly in both directions; distal pinnules 9 mm. long with 17 or 18 joints, the first short and wedge-shaped, the second not quite so long as broad, the remainder approximately half again as long as broad.

Measurements.—Arms 60 mm.; cirri 20 mm. to 25 mm.

Color (in spirits).—Arms and cirri yellow, the calyx and division-series, and the first four or five brachials, dark brown.

Type.—Cat. No. 25448, U. S. N. M., from *Albatross* Station No. 5123; between Marinduque and Mindoro; 283 fathoms.

This species was also found at Station No. 5116; north of Maricaban Island (between Luzon and Mindoro); 200 fathoms; and at Station No. 5198; off Panglao (west of Bohol); 220 fathoms.

It gives me great pleasure to associate with this interesting species the name of Dr. Hugh M. Smith, of the United States Bureau of Fisheries.

Family ANTEDONIDÆ

Genus PEROMETRA A. H. Clark

PEROMETRA ELONGATA, new species

A specimen, consisting of the centro-dorsal (with the cirri) calyx, and arm bases, belonging to a species of this genus, while agreeing in the main with Carpenter's description of *P. balanoides,* differs widely from his figure of that species, and probably represents a new form, which may be described as follows:

Centro-dorsal sharply conical and greatly elongated, 4 mm. long by 1.5 mm. broad at the base; cirrus sockets arranged in ten columns of four or five each, two columns in each radial area; sockets in each column closely crowded, but the pair of columns in each radial area separated from their neighbors by a shallow rounded furrow averaging about half as broad as the adjacent cirrus sockets, the two columns of each pair being separated by a line rather less than half as broad as the furrow separating the radial pairs; distal third of the centro-dorsal marked with partially obliterated cirrus sockets which bear no cirri.

Cirri XLV, 27-35 (usually nearer the latter), 20 mm. to 26 mm. long; first joint about twice as broad as long, second slightly longer than broad, third about twice and one-half as long as broad, fourth rather over three times as long as broad, fifth and following about four times as long as broad or rather over; after the tenth or twelfth the joints gradually decreasing in length, the terminal ten being squarish or only slightly longer than broad; after the first ten the distal dorsal edge of the joints begins to be somewhat prominent, this very gradually increasing distally; opposing spine rising from almost the entire dorsal surface of the penultimate joint, the apex terminal in position, rather stout, reaching not quite to the diameter of the penultimate joint in height; terminal claw moderately stout and moderately curved, about as long as the penultimate joint.

Radials rather long being, in the median line, about half as long as broad; first costals short, with concave distal ends and proximal borders, over twice as broad as their lateral length, decreasing slightly in diameter anteriorly, not in contact basally; costal axillaries rhombic, about as long as broad; first brachials small, about three times as long exteriorly as interiorly, not in contact interiorly, the distal border concave; second brachials much larger, irregularly quadrate; third and fourth brachials (syzygial pair) half again as long interiorly as exteriorly, about twice as broad as the exterior length; brachials as far as the second syzygy slightly wedge-shaped, about twice as broad as long; first pinnule on the fifth ("fourth," to use Carpenter's terminology) brachial, as in *P. balanoides*.

Color.—Centro-dorsal purple; arms purple, with a broad median line of white; pinnules and cirri white.

Type.—Cat. No. 25449, U. S. N. M., from *Albatross* Station No. 5178; north of Tablas Island; 78 fathoms.

The greatly elongated centro-dorsal, which does not have prominent interradial furrows, the elongation of the proximal and the shortness of the distal cirrus joints, together with the length of the radials and the absence of synarthrial tubercles, appear to differentiate this species sharply from *P. balanoides;* the absence of the pinnule on the second brachial and the regular arrangement of the cirri in ten columns, separate it at once from *P. diomedeæ*.

EUMETRA, new genus

Centro-dorsal hemispherical, the moderately large polar area finely papillose; cirrus sockets forty to sixty in number, in four or five closely crowded alternating rows.

Cirri long and slender, compressed, deciduous, about one-third the length of the arms, with about twenty-five joints, all but the basal two of which are greatly elongated, three times as long as broad or longer; opposing spine absent; terminal claw not so long as the penultimate joint, slender, sharp, and nearly straight.

Costals and first two brachials in close lateral apposition, though not laterally flattened, the synarthrial tubercles very prominent; brachials essentially as in *Antedon*.

First pinnule small and weak; second pinnule half as long again, stouter and stiffer; third pinnule over one-third longer than the second, stouter, and very stiff; fourth resembling the second, but stiff like the third; following pinnules decreasing gradually in length and stiffness; distal pinnules about as long as the second, very slender, the first two joints very short, the remainder greatly elongated, as usual in the Antedonidæ.

Genotype.—Eumetra chamberlaini.

The numerous and slender cirri with greatly elongated joints, no opposing spine, and an almost straight terminal claw, combined with the very stiff lower pinnules of which the third is much the longest make this genus easily recognizable.

EUMETRA CHAMBERLAINI, new species

Centro-dorsal hemispherical, rather low, bearing forty to sixty cirrus sockets in four or five closely crowded alternating rows.

Cirri long, XL-LX, 25, slender and delicate; first joint very short, second squarish, third about half again as long as broad, fourth nearly four times as long as its proximal diameter, fifth and following about five times as long as their proximal diameter; terminal ten or twelve joints decreasing very slightly in length, so that the last three or four are only about two and one-half times as long as broad; penultimate joint slightly over twice as long as its proximal diameter, decreasing slightly in diameter distally; no opposing spine; terminal claw about three-quarters the length of the penultimate joint, slender, evenly tapering, very slightly curved; the distal half of each cirrus joint is slightly and very gradually expanded, and the distal edges are prominent; cirri rather strongly compressed throughout.

Radials even with the edge of the centro-dorsal; first costals extremely short, divided in the median line by a posterior projection from the costal axillaries, and bearing more or less prominent rounded tubercles in the antero-lateral angles; costal axillaries rhombic, about once and one-half as broad as long, the sides strongly concave, the anterior angle sharp and somewhat produced; costals and first two brachials in close apposition; synarthrial articulations between the costals and the first two brachials rising to a very prominent tubercle. Ten arms; first brachial about twice as long exteriorly as interiorly, deeply incised in the median line, the bases of adjacent first brachials just meeting over the anterior angles of the costal axillaries; second brachial much larger, irregularly quadrate, with a strong posterior prolongation incising the first brachial; third and fourth brachials (syzygial pair) rather more than twice as broad as long in the median line, rather longer inwardly than outwardly; next four brachials and the next syzygial pair (ninth and tenth brachials) slightly wedge-shaped, about twice as broad as long; brachials then becoming triangular, at first not so long as broad, soon becoming as long as broad, and distally wedge-shaped again, and, in the terminal portion of the arms elongate; brachials smooth, not overlapping. Syzygies occur between the third and fourth, ninth and tenth, and fourteenth and fifteenth brachials, and distally at intervals of, in one specimen, three, and in another four, oblique muscular articulations.

First pinnule 6 mm. long, somewhat stiff, slightly compressed, tapering evenly from the base to the tip, composed of 12 joints, the first not so long as broad, the third slightly longer than broad, the fourth about half again as long as broad, the remainder about twice as long as broad; second pinnule half as long again (9 mm.), stouter and stiffer than the first, containing about 16 joints, the first about twice as broad as long, the second squarish, the third rather longer than broad, the remainder about twice as long as broad; third pinnule the longest and stiffest, 13 mm. long, with 20 to 22 joints, the first short, the second squarish, the following increasing in length, the fifth and succeeding being about twice as long as broad, and slightly longer distally; fourth and fifth pinnules resembling the second; distal pinnules 9 mm. long with 18 or 19 joints, the first very short, the second about as long as its proximal diameter, slightly trapezoidal, the third and following greatly elongated and very slender, with slightly expanded articulations.

Measurements.—Arms 80 mm., cirri 25 mm. to 30 mm. in length.

Color (in spirits).—Yellow, the cirri white, the perisome brown.

Type.—Cat. No. 25450, U. S. N. M., from *Albatross* Station No. 5178; north of Tablas Island; 78 fathoms.

Genus IRIDOMETRA A. H. Clark

IRIDOMETRA SCITA, new species

This species comes nearest to *I. psyche* from Japan, in that the second pinnule is much the largest and longest on the arm; but it may be at once distinguished by its cirri which, though containing the same number of joints as those of *I. psyche*, have the proximal joints elongated and "dice-box shaped," and the distal squarish; the first and second pinnules also are proportionately rather larger than those of *I. psyche*, and have more numerous joints.

Measurements.—Arms 60 mm., cirri 10 mm. long.

Color (in spirits).—Purple, with blotches of darker.

Type.—Cat. No. 25451, U. S. N. M., from the Philippine Islands.

Genus TRICHOMETRA A. H. Clark

TRICHOMETRA EXPLICATA, new species

This new species resembles *T. aspera*, of the West Indies, in its general appearance and in the character of its cirri, having fewer joints in the latter than *T. vexator*, of the Hawaiian Islands. All the specimens are, unfortunately, badly broken, and only one has any cirri remaining.

The genus *Trichometra* was previously known only from the coast of the South Atlantic States (*T. aspera*) and from the Hawaiian Islands (*T. vexator*); as the fauna of both the West Indies (including the coasts of the Southern States) and the Hawaiian Islands belongs to what I have called the "Oceanic" area, the genera and species characterizing which are evidently derivatives from Indo-Pacific—Japanese stock, and mostly occur in the Indo-Pacific—Japanese region, though separated from the typical Indo-Pacific—Japanese genera and species by a considerable difference in depth of habitat, it was only to be expected that *Trichometra* would eventually be found in the East Indies. *Zenometra* is another such genus; though now known only from the West Indies (*Z. columnaris* and *Z. pyramidalis*) and the Hawaiian Islands (*Z. triserialis*), it undoubtedly occurs in the East Indian region, and will eventually be discovered there.

Centro-dorsal conical, in lateral view an equilateral triangle, with slightly convex sides; cirri in number, arrangement, and proportions of their joints resembling those of *T. aspera;* the cirrus joints number 25-28.

Radials even with the edge of the centro-dorsal; first costals short, in lateral apposition, much incised in the median line; costal axillaries rhombic, nearly as long as broad; costals and first two brachials in lateral apposition and laterally flattened; the synarthrial tubercles are slightly marked. Ten arms; first brachial about twice as broad as long exteriorly, inwardly united at the base; second brachial much larger, irregularly quadrate; first syzygial pair and following brachials about as long as broad, wedge-shaped, after the tenth becoming very obliquely wedge-shaped and considerably longer than broad, the length gradually increasing distally. The costals and lower brachials have abruptly everted, finely spinous distal edges, but these are somewhat broader than those of *T. aspera,* and do not stand out so high; this eversion of the distal edge of the brachials after the second syzygy gradually becomes more and more recumbent, taking the form of an overlapping of the distal ends of the brachials, which gradually dies away, disappearing after about the twentieth brachial. Syzygies occur between the third and fourth, ninth and tenth, and fourteenth and fifteenth brachials, and distally at intervals of two oblique muscular articulations.

First pinnule 10 mm. long with 20 joints, resembling that of *T. aspera,* but proportionately stouter; second pinnule 7 mm. long with 16 joints, more slender than the first; the first three joints are squarish, the following gradually increasing in length; third pinnule 7 mm. long with about 20 joints, rather stouter than the second; the first three joints are squarish; fourth pinnule 7 mm. long, with a small genital gland; following pinnules similar, but with larger genital glands. The distal part of the arms is lacking in all the specimens.

Color (in spirits).—Brownish yellow, probably yellow in life.

Type.—Cat. No. 25452, U. S. N. M., from *Albatross* Station No. 5123; between Marinduque and Mindoro, Philippine Islands; 283 fathoms.

Family PENTAMETROCRINIDÆ

Genus PENTAMETROCRINUS A. H. Clark

PENTAMETROCRINUS DIOMEDEÆ, new species

This species is most closely allied to *P. atlanticus* of Southern Europe and the West Indies; of the Pacific species it is nearest to *P. tuberculatus.*

Centro-dorsal conical, the sides gently convex, 3 mm. high and 4 mm. broad at the base, the cirrus sockets closely crowded, arranged roughly in two or three, with sometimes a partial fourth row, and four columns in each radial area.

Cirri XL-LX, 14-17 (usually 15-17), 15 mm. to 20 mm. long; first joint short, second squarish, third about twice as long as broad, fourth about three times as long as broad, fifth-seventh about four times as long as broad; following joints gradually decreasing in length, the antepenultimate joint being about twice as long as broad, and the penultimate about as long as broad; cirri not tapering distally, but the penultimate joint less in diameter than the antepenultimate; terminal claw considerably longer than the penultimate joint, stout basally, tapering distally, comparatively straight in the basal half, but curved strongly downward at the tip; cirrus joints practically oblong in lateral view, the distal ventral ends of the more proximal only very slightly prominent; cirri moderately compressed.

Arms and pinnules resembling those of *P. varians,* but the lowest pinnule present in that species is absent in *P. diomedeæ,* the first pinnule being on the fifth (epizygal) brachial and bearing a genital gland; proximal part of the arm moderately tubercular.

Measurements.—Arms about 100 mm. long; cirri 15 mm. to 20 mm. in length.

Color (in life).—Not distinguishable from *P. japonicus.*

Type.—Cat. No. 22699, U. S. N. M., from *Albatross* Station No. 4934; Eastern Sea, off Kagoshima Gulf, Japan; 152-103 fathoms.

A specimen was obtained at *Albatross* Station No. 5173; between Mindoro and Luzon.

RICHARD RUSH

(1780–1859)

From painting by T. W. Wood, 1856

THE RELATION OF RICHARD RUSH TO THE SMITHSONIAN INSTITUTION

By CYRUS ADLER

(With One Plate)

Three names are connected for all time with the establishment of the Smithsonian Institution: James Smithson, the founder; Richard Rush, the agent appointed by the United States to secure the bequest; and Joseph Henry, the first Secretary and organizer of the Institution.

In the publications of the Institution and in public documents there are numerous references to the relation of Richard Rush to the establishment, yet nowhere have these been brought together in any succinct form. Moreover, the Institution has recently come into possession of some unpublished material bearing on the subject, and I therefore propose to give in the following pages a statement concerning the part which Richard Rush had in securing the bequest and in aiding in the organization of this unique establishment.

Richard Rush, himself a famous man, was the son of an equally distinguished father, Dr. Benjamin Rush, and the family name has been honorably connected with Pennsylvania, as colony and State, since 1683. Benjamin Rush was a conspicuous figure of the Revolutionary period and one of the most distinguished inhabitants of Pennsylvania of his time. He was a medical professor in the University of Pennsylvania, a well-known practitioner of medicine, an accomplished scholar, a member of the Continental Congress, a signer of the Declaration of Independence, and the first to hold the position of Surgeon-General of the American Army.

I cannot refrain, before proceeding to the subject of this paper, from quoting two paragraphs out of the "Commonplace Book" of Doctor Rush relating to his son Richard:[1]

November 23, 1811.

This day it was announced in the "National Intelligencer" that my son Richard Rush was appointed Comptroller of the United States, and to my

[1] "A Memorial containing Travels Through Life or Sundry Incidents in the Life of Benjamin Rush, Born Dec. 24, 1745 (Old Style) died April 19, 1813. Written by himself also Extracts from his Commonplace Book as well as A Short History of the Rush Family in Pennsylvania. Published privately for the benefit of his Descendants. By Louis Alexander Biddle. Lanoraie, 1905."

great astonishment and distress on November 25th he set off for Washington to accept of it. I dissuaded him from doing so from the following considerations: First. The degradation to which such an office exposed a man of literary and professional talents. It was an office that could be filled by any clerk of a bank. Second. The vexations and poverty of political life. Third. His comfortable establishment and excellent prospects in Pennsylvania, the State of his ancestors and family. Fourth. The sickliness of Washington and the insufficiency of the salary to support a growing family. Fifth. The dishonor which he would do to his understanding by such an act. Sixth. My age, also my young family, which required his advice now and would still more require it after my death. I offered to implore him not to accept of the appointment upon my knees, but all, all to no purpose. Oh, my son, my son Richard, may you never be made to feel in the unkindness of a son the misery you have inflicted upon me by this rash conduct. He was dissuaded from it by all his friends and was blamed for it by most of the citizens of Philadelphia who knew him.

December 30, 1811.

This day my son and his family set off for Washington to enter upon the labor of the humble office he had preferred to the respectable and professional office he held in Pennsylvania. This day also the awful news of the burning of the theatre in Richmond, Virginia, reached this city, in which above sixty persons, among whom was the Governor of Virginia and many other persons of note, perished. It took place on the 26th of this month.

The foreboding of this otherwise far-sighted man did not, however, come to pass. On the contrary, a most distinguished career awaited Richard Rush. As indicated in his father's diary, he went to Washington to accept the office of Comptroller of the Treasury. From 1814 to 1817 he was Attorney-General of the United States. In 1817 he acted temporarily as Secretary of State, and was then appointed Minister to England, where he remained until 1825, negotiating several important treaties. In that year he was recalled to accept the position of Secretary of the Treasury in the Cabinet of President John Quincy Adams, and in 1828 he was candidate for the Vice-Presidency on the ticket with Mr. Adams. He was Minister to France from 1847 to 1851.

He was an author of prominence of his day and is especially remembered by his "Residence at the Court of London from 1817 to 1825," still one of the important contributions by an American to the history of our diplomacy. He also published a work entitled "Washington in Domestic Life," and is by some considered the real author of the Monroe Doctrine.

However, I do not purpose to give here a biography of Richard Rush, but simply to state his relation to the Smithsonian Institution. This began in 1836, through the appointment by President Jackson of Mr. Rush as the agent on behalf of the United States to assert and prosecute the claim to the legacy bequeathed by James Smithson, which had been previously brought to the attention of the Government. John Forsyth, then Secretary of State, writes to Mr. Rush under date of July 11, 1836, notifying him of his appointment by the President, remitting him power of attorney for the United States, and informing him that he would be required to give bond in the sum of $500,000 for the proper performance of his duties. He was allowed $3,000 per annum for his personal services and $2,000 for all contingencies other than legal expenses, and was given a letter of credit on the banker of the United States at London, M. de Rothschild, for $10,000, the amount appropriated by Congress for the purpose. The modest allowance for salary and expenses, as contrasted with what was for that day an enormous bond, is significant of the customs of the times.

The Secretary of State wrote in the following terms to the Secretary of the Treasury:

LEVI WOODBURY, ESQ.,
Secretary of the Treasury.

DEPARTMENT OF STATE,
WASHINGTON, *July 11th*, 1836.

SIR: I have the honor to inform you that Richard Rush, Esq., of Pennsylvania, has been appointed by the President, in virtue of an act of Congress, passed at their recent session, the agent of the United States to assert and prosecute their claim to the legacy bequeathed to them by James Smithson, late of London, deceased; and likewise to state that Mr. Rush has been apprised that it is necessary for him to execute, and deposit with you, the bond or bonds required by the second section of the said act.

I am, sir, your obedient servant,

JOHN FORSYTH.

A copy of the bond has recently come into the possession of the Institution and is as follows.

Know all men by these presents that we, Richard Rush, Benjamin C. Howard and John Mason, Jr., are held and firmly bound unto the Treasurer of the United States and his successors in office, in the full and just sum of Five hundred thousand dollars, current money of the United States, for the payment of which sum, we bind ourselves, our, and each of our heirs, executors, and administrators, jointly and severally, firmly by these presents.

Sealed with our seals and dated this twelfth day of July in the year Eighteen hundred and thirty-six.

Whereas the President of the United States has appointed the said Richard Rush, the Agent of the United States, required to be appointed under the provisions of the Act of Congress, entitled "An Act to authorize and enable the President to assert and prosecute with effect, the claim of the United States to the legacy bequeathed to them by James Smithson, late of London, deceased, to found at Washington, under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men" Approved 1st of July, 1836.

Now, the condition of the above obligation is such, that, if the above bounden Richard Rush shall faithfully perform the duties of said Agency, and faithfully remit to the Treasurer of the United States, all, and every sum or sums of money or other funds which he may receive for payment, in whole or part of the said legacy, mentioned in said Act of Congress, then the above obligation to be void and of no effect, otherwise to remain in full force and virtue.

RICHARD RUSH [SEAL]
J. MASON, JR. [SEAL]
BENJN. C. HOWARD [SEAL]

Signed, sealed and delivered in the presence of
GEO. P. FORREST
THOS. C. WRIGHT
T. B. WASHINGTON
E. R. FORD.

I am satisfied with the within bond and securities.

LEVI WOODBURY
Secty of Treasury.

Official Bond of Richard Rush to the Treasurer of the U. S. in penalty of five hundred thousand dollars, with B. C. Howard and Jno. Mason, Jr. Sureties. Received July 13, 1836.

P. G. WASHINGTON
Actg. Treas. U. S.

Dated July 12, 1836.

Mr. Rush sailed from New York on the first available ship, and arrived at Liverpool on the 31st of August. He employed as solicitors Messrs. Clarke, Fynmore & Fladgate, with whom our legation at London had had previous transactions on the subject. His first considerable letter to the Secretary of State was from London, under date of September 24, 1836. In it he gives interesting information concerning Smithson and his will. He reports that while there seems to be no doubt that the United States is the final legatee of Smithson, a suit or legal proceedings of some nature, to which the United States must be a party, will have to be instituted in the Court of Chancery in order to make valid their right and enable them to get possession of the fund, now in the hands of the court and subject to its judgment.

After writing this letter Mr. Rush thought that it might possibly be more advisable not to subject the United States to the delays of court proceedings, but to bring the matter indirectly to the attention of the British Government through the American Minister. However, after consulting counsel, Thomas Pemberton and Edward Jacob, the former of whom Rush describes as "at the head of the chancery bar," and Mr. Jacob as being "in the first class of eminence, next to Mr. Pemberton," it was decided that it was absolutely necessary to file a bill, in the name of the President of the United States, against the testator's executors, declaring the United States entitled to the fund. Mr. Rush explains the technical usages of the English bar, which require that his dealings with counsel should be through the solicitors; but, in spite of all this eminent legal counsel, he seems to have taken a hand in the law affairs himself, for he points out to counsel, on its being recommended that the bill be drawn in the name of the President, that there was a possibility of a temporary vacancy occurring in the Executive power under our Constitution. The counsel, however, decided that this did not alter the opinion, and they thought it would not answer to bring a suit in the name of the United States alone, whatever the provisions of our Constitution on this point.

Under date of December 20, 1836, Rush writes to the Secretary of State that, while the Smithson case continues in the proper train with every advantage that he has been able to give it, it has not yet come to its first hearing before the Court of Chancery.

On January 9, 1837, he writes cautiously: "We must hope that the bequest of Mr. Smithson will ultimately be adjudged to the United States;" that there is a complication in the matter, "and we dare not with confidence affirm that the decision will be favorable prior to its taking place."

On February 2, 1837, he writes that the case had its first hearing in the Court of Chancery on the day before, and the results so far are favorable to the establishment of the claim of the United States; that the Attorney-General was not present in court personally, but was represented by Mr. Wray, who in effect abandoned all opposition on the part of the Crown; that the court decreed that the case be referred to one of the masters in chancery. He further states that counsel also appeared for Messrs. Drummond, who were the executors, and made a little show of opposition; but he adds, "as their clients are, in fact, nothing more than stakeholders," they will offer, he believes, no serious opposition. Mr. Rush closes his long report of the first proceedings in court with the statement that had the Attorney-General interposed a claim for the Crown under the law of escheats, he had contemplated drawing up a counter-representation on behalf of the United States, founded on the public objects of Mr. Smithson's will, and have it presented to the British Government, through the American Minister; but that all necessity for such action was now at an end, by the course which the law officers of the Crown had pursued, and that he did not think that any such application appeared at present to be needed, either for the purpose of justice or expedition.

The next extensive report was dated February 10, 1837. Mr. Rush writes that the court desired an amendment to the bill, which stands officially "The President of the United States of America *versus* Drummond," so as to include the Act of Congress authorizing the President to receive the fund and make arrangements therefor. He states that counsel were disposed to view this with satisfaction, the United States having never before appeared as suitor in an English court.

Under date of March 25, 1837, he transmits the advertisements agreed upon to determine whether Smithson or his nephew had any heir or heirs, and calls attention to the form of the advertisement, which he says was by his direction framed with all the brevity compatible with the essential object of the court's decree, as he wished to guard against the risk of raising up spurious claimants or combinations in France, Italy, or England to battle with the right of the United States, whereby, although their ultimate recovery of the fund might not be prevented, great delays might be interposed.

Writing April 28, 1837, Mr. Rush speaks of keeping a constant watch over the legal expenses, which are proverbially heavy in English chancery proceedings. He adds: "It seems that something is to be paid for every step taken, every line written, and almost every word spoken by counsel, senior and junior, solicitors, clerks, and everybody connected with the courts, and officers attached to them."

There then arose, in connection with the affair, several vexatious small claims upon the Smithson fund, which Mr. Rush combated with great dignity and firmness. On July 21, 1837, he seems to have become a little impatient, and writes to the solicitors asking them what the prospects were for a speedy decision. Under date of July 28, 1837, he writes Mr. Forsyth: "Had it not been for the obstructions created by Monsieur de la Batut, this part of the case would have been expedited, and a door the sooner opened by which the United States might have got possession of the fund."

On August 1, 1837, he writes that the arrears of cases in the Court of Chancery were upwards of 800, recounts other discouragements, but adds that he does not despair of having the case of the United States brought to a final and successful close in the course of the ensuing winter or spring. He asks for and receives by January, 1838, a renewal of his power of attorney from the President to prosecute the Smithson claim. He is not sure whether the exhibition of the new power will be eventually demanded, but if not, he trusts the President will believe that he has erred on the safe side.

On February 9, 1838, he writes to the solicitors that he is willing to take the responsibility of having the master's report made without further evidence in the premises, and also that he will make certain concessions in order to avoid the possibility of an appeal to the House of Lords, which would consume a great deal of time.

On March 28, 1838, he states that the report of the master has been made and confirmed. He expects a decree after the Easter term, and under date of May 12, 1838, he writes to the Secretary of State: "I have great satisfaction in announcing to you, for the President's information, that the case came on to be heard again on the 9th instant, when a decree was solemnly pronounced adjudging the Smithson bequest to the United States." He adds that the suit is ended, and that only a few formalities remain to put him in actual possession of the fund. The fund is principally in 3 per cent annuities. Having no special instructions as to what he is to do, it is his present intention to sell the whole at the best time and for the best prices to be commanded, and to bring it over in gold for delivery to the Treasurer of the United States, in fulfillment of the trust with which he is charged.

He points out in this rather long report that, although the best part of two years has been spent in the suit, he yet regards the matter with satisfaction, and that within a fortnight a member had stated in the House of Commons that "a chancery suit was a thing that might begin with a man's life and its termination be his epitaph." He congratulates the President and the Secretary of State on the result, and adds: "A suit of higher interest and dignity has rarely, perhaps, been before the tribunals of a nation. If the trust created by the testator's will be successfully carried into effect by the enlightened legislation of Congress, benefits may flow to the United States and to the human family not easy to be estimated, because operating silently and gradually throughout time, yet operating not the less effectually."

His difficulties were not quite at an end. On May 31, 1838, he writes very urgently to the solicitors for the necessary document from the proper officer of the court, by which the Smithson fund adjudged to the United States may be placed at his disposal. But six days later, on June 5, he writes triumphantly to the Secretary of State that the formalities had been finally completed and the fund placed in his hand. He gives an exact statement of the stocks, and says that the important operation of selling them now remains to be conducted. He will take the best advice for so managing the sales as to promote the best interests of the United States. He still thinks that the best mode of bringing home the money will be in gold.

On June 13, 1838, he reports that the sale of the stock is going on well. He had first intended to sell all the stock for cash immediately, but found that an attempt to sell all at once would probably have depressed the market for this particular form of security and have occasioned a loss of several hundred pounds. In regard to this matter of selling the stock, he reports that he received most beneficial aid from the constant advice of our consul, Colonel Aspinwall.

On June 26, 1838, he reports that the sales of stock are finally closed; that they have all been good—even fortunate. The prices have been high as compared with the state of the stock market for several years past. The entire amount of the sales yielded an aggregate of more than a hundred thousand pounds. The two days on which all the transfers are to be made are the 30th of June and the 6th of July. He will then convert the whole into English gold coin and bring it to the United States. He concludes this dispatch with very high praise of the solicitors, and says that had they desired "to eke out a job," they could easily have made the suit last for years to come.

Under date of July 14, 1838, Mr. Rush writes that he has made arrangements for obtaining, insuring, and shipping the gold; that it would be on the New York packet *Mediator,* by or before the 17th instant, and that he has taken passage on the ship himself. The costs of the suit have been paid, but the other expenses he cannot definitely report upon until he arrives in New York or Washington.

On August 28, 1838, Mr. Rush writes to the Secretary of State, from the harbor of New York, reporting the arrival of the ship *Mediator* with the gold on board; that he has paid the expenses of every kind incurred by closing the business in London and shipping the gold; that the freight, primage, and other small charges are still to be paid; that when all expenses are deducted there will be upward of £104,500. The whole is in sovereigns packed in boxes. He adds that, the money being consigned to no one here, he must continue to hold it in his custody until he has received instructions as to whom to deliver it, as provided for by the Act of Congress of the 1st of July, 1836.

On actually landing in New York he received such instructions from the Secretary of the Treasury, directing him to transfer the Smithson fund to Philadelphia, to be deposited with the treasurer of the mint to the credit of the Treasurer of the United States. Mr. Rush also found a letter from the Secretary of State extending him congratulations on the success of his mission and on his safe return to this country.

On September 4, 1838, he writes from Philadelphia to the Secretary of State that, owing to the delay in getting the ship into the dock, he was not able to leave New York until the first of the month; that he was accompanied by two agents of the Bank of America, that institution having afforded him every facility. He nevertheless did not feel at liberty to withdraw his own personal superintendence from the operation of transferring the gold until he saw it deposited at the mint. He had immediately had it conveyed there on reaching Philadelphia on the 1st instant, the director and treasurer of the mint having been in readiness to receive it, and he writes: "I have now the satisfaction of informing you that official receipts of this amount from my hands have been forwarded to the Treasury Department." There are other details about the transfer of the money given, and at the end of his letter Mr. Rush writes: "Somewhat worn down by fatigue since coming on shore, after an uncomfortable voyage of squalls, gales, and head winds, I venture to ask a little repose at my home, before proceeding to Washington, for the purpose of making out and rendering to you an account of all expenses that have attended the final recovery of this fund, of which the United States, by the information I give you in this letter, are now in possession. In the course of the next week I shall hope to proceed to Washington with the view stated."

On September 11, 1838, he writes to Mr. Forsyth that he has received a letter from the Secretary of the Treasury asking for an early statement of his expenses, but that he cannot then make out a statement, owing to sickness and fatigue. On the 15th of the month, however, in Washington, he writes to Mr. Forsyth, giving him the full statement.

The next step was that of actually creating the establishment required under Smithson's will, and here, too, Mr. Rush rendered important service.

On July 19, 1838, John Forsyth, as Secretary of State, by direction of President Van Buren, invited a number of eminent gentlemen—public men and scholars—to express an opinion as to the best method of applying the proceeds of the bequest in order that the President might have the benefit of their judgment in presenting the matter to Congress.

The view seemed to be generally accepted at the time that the Institution was either to be a university for instruction or an establishment devoted to some one specific subject, such as an astronomical observatory or a national library. Mr. Rush combated these views. He declared that a university or a college, in the ordinary sense, was not the kind of institution contemplated by Mr. Smithson's will; that he judged, from the language and the fact of the United States being trustee, that it ought to be as comprehensive as possible in its objects and means and national in its government. He thought that one of the main objects of the Institution should be the gathering of natural history productions of various places; recommended that our consuls, naval and military officers, and even ministers abroad be employed for this purpose; and that the officers of the army should collect facts bearing upon geology, natural history antiquities, and the character of the aboriginal races of the United States. He recommended that a building be erected in Washington with accommodations for the business of the Institution; that a press be established, or authority to employ one, for printing communications and literature. He provided for a very elaborate system of lectures, to comprehend the leading branches of physical and moral science. In concluding his rather long letter, Mr. Rush, with a modest distrust of his own abilities to advise in the matter, declared that the establishment of this Institution would be like a new power coming into the Republic. I have omitted such parts of his statement as were not adopted, but it is noteworthy that he projected the lines upon which the Institution was finally established more closely than any other person.

As Mr. Goode put it in his account of the founding of the Institution in the Smithsonian History:[1] "Mr. Rush objected to a school of any kind and proposed a project which corresponds more nearly than any other of those early days to that which was finally adopted. In a shadowy yet far-seeing way, he outlined a system of scientific correspondence, of lectureships, of general coöperation with the scientific work of the Government, a liberal system of publication, and collections—geological, zoölogical, botanical, ethnological, and technological."

The first meeting of the Regents of the Institution under the organizing act was held on September 7, 1846, and of this body Mr. Rush was a member as a citizen of Pennsylvania. At the meeting held the next day, September 8, 1846, he was appointed a member of the committee of three on library.

How seriously Mr. Rush took up his work for the Smithsonian Institution when he became a Regent may be gathered from a remark in the introduction to a small volume entitled "Washington in domestic life, from original letters and manuscripts," published by the

[1] The Smithsonian Institution, 1846–1896. History of its first Half Century. Edited by George Brown Goode. Washington, 1897, pp. 33.

Lippincott Company of Philadelphia, in 1857. This little book, by the way, was largely based upon a collection of letters, mostly domestic and personal, addressed to Tobias Lear, the faithful friend and private secretary to Washington when President. Mr. Rush said:

"Mrs. Lear first informed me of these letters ten or twelve years ago, when in Washington. . . . I brought them home as requested, being then too much engaged in the business of the Smithsonian Institution as one of the Regents on its first organization, to examine them while in Washington."

At the meeting of the Board of Regents held on December 17, 1847, a resolution was introduced, reciting that, as Mr. Rush had been appointed Minister to France, a joint resolution be introduced into Congress for the appointment of a Regent to fill this vacancy, and that on the other hand the Board of Regents recommend to the establishment the election of Mr. Rush as an honorary member of the Institution, and furthermore that the then Chancellor, George M. Dallas, be deputed to propose Mr. Rush for this office. There is no record, however, of this action having been carried through.

Mr. Rush early became interested in a building for the Institution, and in a letter from Philadelphia, May 20, 1847, to Mr. Owen, he refers to the work of the building committee generally, and adds:

"On the eve of my departure on the French mission I cannot lose this opportunity of saying with what constant interest I shall continue to follow up the proceedings of the Smithsonian Regents; and of adding, that if it ever be thought I could render the least service to the Institution, while in Paris, it would afford me the greatest pleasure to be called upon."

Mr. Rush returned, however, in time to actually take part in the work of the building committee, and his signature is appended to all its reports. In 1853 he was appointed a member of the special committee on the distribution of the income.

In all the discussions in the year 1855, relative to the division of authority between the Secretary and the Board of Regents, Mr. Rush stood steadily for the authority of the Secretary over all his assistants, and thus again, by his far-sightedness, aided greatly in placing the executive work of the Institution upon a firm foundation. He was a member of the committee to represent the Board of Regents before the joint committee of the House and Senate appointed to investigate the Institution, at the instance of Rufus Choate.

At the meeting of the Board January 28, 1860, Mr. Rush's death was announced and Senator Pearce made the following remarks:

Since the last meeting of the Board of Regents, as announced by the Secretary, one of its earliest and most distinguished members, the Hon. Richard Rush, has departed this life.

The history of his public career is familiar to all the Regents, to whom I need scarcely detail even its more prominent incidents; but I may remark that it is seldom the good fortune of any man to fill so many important offices, and to execute so many responsible public trusts, not only with credit, honor and usefulness, but with ever-increasing reputation. Mr. Rush's life was a long one, and he entered into the service of his country while yet in the spring of manhood. He was Comptroller of the Treasury at a time when the fiscal affairs of the Government were in disorder, when the public accounts were numerous and complicated, and often required difficult legal adjustment. He was next Attorney-General. Soon after the peace of 1815 he was Minister to England, and occupied that important post during eight years, when various national questions of difficulty and delicacy required for their proper settlement diplomatic skill, firmness and caution. He was Secretary of the Treasury when measures of revenue were violently disputed; Minister to France when the monarchy was a second time overthrown and a republic again proclaimed. To these great and varied employments he brought integrity, ability, intelligence, firmness, courtesy, and a directness of purpose which scorned all finesse, and which served his country to the full extent of all that could have been demanded or hoped. He was a good scholar, having graduated at Princeton College, and cultivated literature, as well as the severer studies of his profession, with great zeal and success.

Withal he was remarkable for the kindness of his temper, the amenity of his manners, and the charms of his conversation.

With this establishment he had the earliest connection, having, under the authority of the Government, caused the institution of legal proceedings in England for the recovery of the fund with which it was founded and endowed, and superintended their progress to the close.

The Act of Congress of 1846 having established the Smithsonian Institution, he was appointed one of its first Regents, and was constantly continued by Congress a member of their Board. His zeal for the increase and diffusion of knowledge among men, and his sound judgment, contributed to the adoption of the system of operations which, so far, has borne the happiest fruits; and his interest in and care for its successful management furnished one of the enjoyments of a tranquil old age, "attended by reverence and troops of friends."

I offer the following resolutions:

Resolved, That the Board of Regents have learned with deep regret the death of the Hon. Richard Rush, one of their members, whose long and distinguished career of public usefulness commanded their entire respect, and whose moral and social worth won their highest esteem and regard.

Resolved, That a copy of this resolution be transmitted to the family of the deceased.

This account of the relation of Richard Rush to the Smithsonian Institution is, in the main, based upon letters and papers already published by the Institution, largely in the various historical works edited by William J. Rhees, who for nearly half a century was the depository of the archives and history of the Institution.

By chance the Institution has recently come into the possession of a number of private letters written by Mr. Rush to Colonel Aspinwall, who was our Consul General at London during the period covered by the suit, and who, according to Mr. Rush's official statement, aided him greatly in his labors. Most of the letters refer to the matter of the sale of securities in which Smithson's fortune was invested. While in the main not important, these letters make an interesting addition to the story of Mr. Rush's part in securing the Smithson bequest.

54 Upper Norton St., *June* 6, 1838.

My Dear Colonel:

How would it do to throw overboard entirely the idea of commission on effecting a sale of the stock, and charging one on a moderate or medium scale rather than the high scale, take both these latter operations into your own hands *wholly*, performing them in your own name to go before Congress—where all items of my account are finally to be scrutinized?

I should in that case naturally say in writing to the government that the fund had naturally been saved all expense whatever of an agency for effecting a sale of the stock in addition to brokerage, by the useful advice and assistance I had derived from you.

This might go a good way as a set off to objections that would be made (unreasonably, but that probably would be made,) to your having any hand whatever in the matter.

Would not such a course be likely to come out better in the end, guarding against ultimate recoil either upon you or me directly or collaterally?

Perhaps the peculiar character of the fund which looks exclusively to the interests of Letters and Science among us, would be thought to give it claims to as little diminution as possible in passing on to its final destination. The less taken from it, the better chance shall we have of coming off with flying colours.

I throw out these as things for consideration. Don't be at the trouble of writing about them; I shall certainly be with you on Friday at 12 or a little after when we will talk them over; remaining, as ever yours,

R. R.

(Upon reverse:)

54 Upper Norton St., 6th June, 1838. R. R. Rush.

54 Upper Norton St., *June* 9, 1838.

My Dear Colonel:

Understanding, if I have rightly understood, that you will perform all the agencies necessary to enable me to realize in money the Smithsonian fund I have recovered for the United States, convert it into gold, and ship it to the U. S. for a commission of three quarters of one per cent, I will allow that amount, feeling myself fortunate whilst acting for the U. S. to be able thus to command your services on this interesting occasion; and although you forego all commission or charge on effecting the sales of the stock, I am greatly sensible of the benefit the fund derives in that important matter from your counsel and personal coöperation, not only in being relieved from a commission of one per cent usually charged for this service, but as your knowledge and experience relating to the great stock market of London enable you to get more for the stock than I could probably have done by all my own efforts acting merely through a broker. My understanding is, that the whole amount of what I am to allow you on all the operations from beginning to end, including of course the effecting of insurance, is not to exceed three quarters of one per cent; but please say if I am right, and believe me

Always yours,

RICHARD RUSH.

COL. ASPINWALL.

54 Upper Norton St., 9th June, 1838. R. 11th. A. do. R. Rush.

54 UPPER NORTON ST., *June* 10, 1838.

MY DEAR COLONEL:

I am decidedly against waiting for higher prices than can be commanded now, and should therefore like the whole of the Reduced annuities (£12,000) sold to-morrow for the 6th of June, *to be paid for on that day*, unless indeed something should occur not now known to me to make you think it inexpedient. In which case forbear an order to the broker until we meet.

I am to go with my solicitors to the accountant general to-morrow at a little after one, and if I can get away in time will make a point of calling upon you at the office before five,

Remaining, as always, yours. R. R.

(Upon reverse:)

54 Upper Norton St., 10th June, 1838. R. R. Rush.

54 UPPER NORTON ST., *June* 16, 1838.

MY DEAR COLONEL:

The more I reflect upon the stock sales, the more disposed I am not to delay them. We know things present, but not to come. The little Queen I have always understood is a great eater, and every newspaper tells us she is a great frolicker. Now, if the little thing should chance to be taken sick in these junketing times of the coronation, only think how the stocks would come down. People would have the Duke of Cumberland before their imaginations and what not besides—so, as we are now at the close of the week, I think we had better get to work again on Monday or Tuesday in earnest, not waiting for a rise lest, peradventure, a fall should plump upon us instead, through some unforeseen cause or other; and the stocks are really high *now*. Besides, as I have consented to lengthen out the sales on time (though not later than the 10th of July) to be waiting shortens the interval, and therefore lessens our advantage in time contracts I should think. But I will be with you on Monday morning by or before 11, and until we meet nothing need be done, unless before I come the reduced should happen to touch 94 or the bank stock 205.

Always yours, R. R.

(Upon reverse:)

54 Upper Norton Street, 16 June, 1838. R. 18th do. R. Rush.

54 Upper Norton St., *June* 20, 1838.

My Dear Colonel:

I will beg the favor of you to get me one of the printed papers of the Stock Exchange, giving the prices, on the 18th, the day on which our two last sales were made.

I will call for you tomorrow at about ¼ past 6 in a carriage to go out to our dinner together,

Remaining yours sincerely, R. R.

Col. Aspinwall.

(Upon reverse:)

54 Upper Norton St., 20th June, 1838. R. do.

54 Upper Norton St., *Friday, June* 22, 1838.

My Dear Colonel:

Assuming that you may probably have sold the small remnant of bank stock to-day, I will ask the favor of a line in the course of to-morrow stating the gross amount in pounds sterling of what all the stock will have yielded when the money is paid—brokerage and stamps off.

Always yours, R. R.

(Upon reverse:)

54 Upper Norton St., 22d June, 1838. R. do. A. 23d do. R. Rush.

June 22, 1838.

My Dear Colonel:

With your line of to-morrow, may I beg you also to send the list of commissions, &c., &c., to be copied from the newspaper—if done.

R. R.

(Upon reverse:)

June 22d, 1838. R. 23d do. Richard Rush.

54 Upper Norton St., *June* 26, 1838.

My Dear Colonel:

I do not forget that I am to be with you on Saturday to attend to the business of the transfers, but will fix the time when I have the pleasure of being with you at dinner the evening before.

Be so good as to favor me with a line to-morrow morning barely to say how the matter of exchange stands *now,* for I have not seen the last quotations; that is, just say how much *less* we should gain by the operation in gold than stated in your note of the 15th if the turn has been that way as I suppose.

I have by some chance mislaid the printed slip of prices at the Stock Exchange for the 18th instant; which please send me if still to be had—as I hope.

Always yours, R. R.

54 Upper Norton St., 26 June, 1838. R. do. A. do. R. Rush.

54 Upper Norton St., *June* 30, 1838.

My Dear Sir:

It is high time now that all the stock is sold to be thinking of shipping the gold, as the money will soon be converted into it. Be so good therefore, as to be turning in your mind what you are to do for me. I shall count upon your services towards effecting insurance, paying the premium, agreeing for the freight and in short taking all the steps necessary to the whole operation at the custom house and elsewhere, in the most regular way and on the best terms attainable. I have mentioned to you my personal preference for going with Captain Champlain in the Mediator; but having a public trust in hand, I could not indulge my wish unless he would agree to take the gold on terms fully as favorable in every particular as could be obtained in any other packet ship. I shall trust to you for making the contract and all arrangements with Captain Champlain.

I remain always sincerely yours,

Richard Rush.

Col. Aspinwall.

(Upon reverse:)

54 Upper Norton St., 30th June, 1838. R. 2d July. A. do. Richd. Rush.

54 Upper Norton St., *July* 2, 1838.

My Dear Colonel:

I have arranged it with my solicitors that one of them is to meet us on *Friday* next, at a quarter before *ten*, at No. *31*, Upper Norton Street (close by me) on the business of the trunks. You will perhaps request Mr. McCurley to be there at the same time, and if you will have the goodness to call on me after you have breakfasted, we will go to the house together, and be able I have little doubt to make a short piece of work of it.

Always yours, R. R.

Col. Aspinwall.

P. S.—I do not forget that Friday is the *6th* and of course our day for transferring and *receiving;* but we shall be in ample time for that, after finishing the work in our neighborhood.

(Upon reverse:)

54 Upper Norton St., 2d July, 1838. R. 3rd do. Richard Rush

Address:

To Colonel Aspinwall,
Consul of the United States,
1 Bishopsgate,
Churchyard, London.

By the *Monongahela,*
Captain Miercken,
for Liverpool.

Sydenham, near Philadelphia, *May* 18, 1839.

My Dear Colonel:

A late letter from my son informs us of your recent affliction in the loss of a daughter, on which event there are none who would offer you more heartfelt condolence than Mrs. Rush and myself, which neither you nor Mrs. Aspinwall I am sure will doubt. Believe me my dear Sir I felt sincerely for you. Having so recently been with your amiable and interesting family circle, I can see the more vividly the chasm that was made. But I will say no more, except to be remembered in the most friendly and kind manner, my wife joining, to Mrs. A. and the flock still surrounding you, and capable of affording you so many sources of happiness and content.

I had intended before this to drop you a line on the termination of the little Smithson affair. I assure you we both came well out of it, as I hoped we should. I have reason to know that there were those in Congress eagle-eyed to find fault, but they could not. All that I did, with your good aid, was so fair and square—so above all cavil even—that they had to give up the task as hopeless. I have been fully discharged from the trust; my accounts all settled, all found correct, no extra charges, no disputed items, no suspended ones, (*) no any thing of that sort, and in the end I had a letter from the Secretary of the Treasury in which he was pleased to speak of the fidelity, care, promptness, &c., &c., with which the whole matter had been conducted, and to hear verbally when at Washington of your judicious and commendable assistance to me. But O what a little uproar would have been raised if we had not kept the main fund as undiminished as possible; even our old friend Mr. Adams would not have spared us you may be sure. It is well that we saved it from the usual mercantile pickings. I hope my son showed you the documents published by Congress on the subject. I would have sent you a copy of them also, had I been able to procure one.

With renewed and kindest remembrances to you all,

I am, my dear sir,

Ever sincerely yours,

Richard Rush.

(*) (The accounting officers wanted to suspend one item, a sum I had paid Mr. Brent, consul at Paris, under express directions from the department; but I said no, I will give up the item first—I will have a final and full clearance, and got it—and the item allowed too)

(Upon reverse:)

Sydenham, nr. Philada., 18 May, 1839. R. 19th June. A. 23d Augt. Richd. Rush.

DESCRIPTIONS OF SOME NEW SPECIES AND A NEW GENUS OF AMERICAN MOSQUITOES

By HARRISON G. DYAR and FREDERICK KNAB

Of the U. S. Department of Agriculture

The following new forms are characterized for insertion in the forthcoming monograph of Culicidæ by Dr. L. O. Howard and the present authors. The present paper is in continuation of one recently published by us in Proc. U. S. Nat. Mus., vol. 35, pp. 53-70, 1908:

AEDES PAGETONOTUM, new species

Female.—Proboscis black; head with the occiput clothed with frosty white scales, a black patch well down the side; erect scales pale. Mesonotum clothed with frosty white scales, a few pale brownish ones intermixed on the disk, forming no pattern. Abdomen black-scaled above, with moderate basal white segmental bands, entirely white beneath. Legs dark-scaled without rings. Wings dusky-scaled, the scales broadly linear, the costa black-scaled with a white patch at the base. Claws toothed. Length, 5 mm.

Male.—Similar to the female. Palpi longer than the proboscis, with patches of white scales at the bases of the last two joints. Length, 6 mm.

Ten specimens, Ottawa, Canada, May 15, 16, 1900; May 17, 19, 1901; May 20, 1905 (J. Fletcher); Chelsea [Canada], May 17, 1902 (A. Gibson); Aweme, Manitoba, June 3, 1904 (N. Criddle).

Type no. 12057, U. S. N. M.

AEDES PAZOSI, new species

Female.—Occiput with golden scales. Mesonotum with broad, flat, golden scales. Abdomen dark violet blue above, with lateral triangular apical segmental spots of golden scales, venter golden-scaled. Legs dark violet blue, the scales on the hind tibiæ and tarsi not erect or roughened, last two hind tarsal joints white, the fourth joint marked with black beneath nearly throughout. Wing-scales brown.

One specimen, Vuelta-Abajo, Cuba (J. H. Pazos).

Type no. 12117, U. S. N. M.

Named in honor of the collector, Dr. J. H. Pazos.

BANCROFTIA PERSEPHASSA, new species

Female.—Proboscis black-scaled, a white ring at the middle. Thorax clothed with narrow golden scales, with a subdorsal narrow bare line on either side, the sides of the disk dark except for a patch of golden scales over the root of the wing. Abdomen subcylindrical, truncate at tip, black-scaled above with yellowish white lateral basal segmental spots, venter black, with narrow white basal bands. Wings hyaline, the scales dusky black, the outstanding ones broad, obliquely subtruncate at the tip. Legs black-scaled, the femora with the apices yellowish white and a ring of this color at the apical third; tibiæ similarly marked; tarsi of the hind legs ringed with white at both ends of the joints, the last joint black at the tip; front and mid tarsi with the markings similar, but obsolete on the last three joints. Length, 3.5 mm.

One specimen, San Antonio de los Baños, Cuba (J. H. Pazos).

Type no. 12118, U. S. N. M.

CULEX LACTATOR Dyar and Knab

Variety *lactator* Dyar and Knab

Our *Culex lactator*, described from larvæ, proves to be very variable as adult. We propose to restrict our name to that form of *lactator* in which the legs are entirely black and the proboscis lacks the white ring, being only white-marked beneath, leaving the name *hassardii* Grabham for the normally fully marked form.

Variety *loquaculus*, new variety

In this form the pale markings are all reduced, the tarsal rings smaller than in normal *lactator* and of a brownish shade; the proboscis instead of being ringed is white-marked on the under side.

Type no. 12050, U. S. N. M.

We have selected six specimens as types from the Panama Canal Zone.

Culex lactator is a common tropical mosquito, the adult variable, but the larvæ constant. We have been obliged to recognize named varieties in this case, since the extremes are so different from the normal form as to fall very differently in any synoptic table. These forms would certainly be treated as distinct species by any student studying the adults alone.

CULEX ELOCUTILIS, new species

FEMALE.—Proboscis moderately long and slender, somewhat swollen towards the apex, black-scaled; palpi black-scaled. Occiput clothed with dark scales with bronzy luster, margin of the eyes narrowly white. Mesonotum uniformly dark brown-scaled with a bronzy luster, the scales on the scutellum paler. Abdomen depressed, truncate at tip, dark-scaled above with distinct coppery luster, the anterior angles of the segments laterally silvery white-scaled; beneath with basal segmental silvery bands. Wing-scales dark brownish, long and narrow. Legs bronzy brown, the apices of the hind tibiæ and the bases of the first, second, and third tarsal joints very narrowly pale-marked; claws simple. Length, 3 mm.

MALE.—Palpi longer than the proboscis, entirely black-scaled; coloration as in the female. Length, 2.5 mm.

Two specimens, Coscojar River, Porto Bello Bay, Panama (A. H. Jennings).

Type no. 12051, U. S. N. M.

CULEX IMITATOR Theobald

The typical adult has the thorax adorned with silvery markings, but these may be absent. We would restrict our name *vector,* based upon larvæ, to this form in which the silvery markings are absent.

CULEX VINDICATOR, new species

The name *Culex inquisitor* D. and K. is here restricted to the Trinidad specimens. We propose the new name *Culex vindicator* for part of the specimens from Dominica included under *inquisitor* (Journ. New York Ent. Soc., XIV, 211, 1906). In the Dominican species the proboscis is not ringed, the tarsal joints are narrowly marked with white at both ends, except that the tip of the last hind tarsal joint is black, the abdomen with basal white segmental bands.

Four specimens, Dominica, July (A. Busck).

Type no. 12098, U. S. N. M.

The larvæ are similar to those of *inquisitor,* but the basal tuft of the tube is without the pecten.

CULEX DICTATOR, new species

Another part of the specimens referred to above from Dominica are close to *vindicator,* but the abdomen is differently colored; in the present species it is black above with a coppery luster, the basal white bands of uniform width, while in *vindicator* it is dull black, the basal white bands mesially produced.

Six specimens, Dominica, July (A. Busck).

Type no. 12099, U. S. N. M.

CULEX PECCATOR, new species

Proboscis rather long and slender, very slightly enlarged towards the apex, black-scaled; palpi short, black. Occiput clothed with broad, flat, bronzy black scales. Mesonotum clothed with bronzy black scales. Abdomen subcylindrical, truncate at the tip, clothed above with dull black scales; a row of white lateral triangular basal segmental spots; venter whitish, the last two segments with dark apical bands. Wings with the outstanding scales of the veins dense, spatulate on the forks of the second and fourth veins and on the third vein. Legs dark-scaled, the femora pale beneath. Length, 3 mm.

Eleven specimens, Scott, Lonoke County, Arkansas, September 30 to October 8, 1908 (J. K. Thibault, jr.).

Type no. 12192, U. S. N. M.

CULEX REVOCATOR, new species

Entirely similar to *Culex cubensis* Bigot, except that the labellæ and tip of proboscis are white or whitish-scaled, and other minor differences.

Dr. Grabham sent us the specimens some time ago with the tentative determination "*Culex cubensis?*" We verified this determination at the time, but a later reëxamination revealed the difference specified above.

Twenty-five specimens, Hope Gardens and Newcastle, Jamaica (M. Grabham).

Type no. 12100, U. S. N. M.

CULEX REFLECTOR, new species

In general similar to *C. restuans* Theobald; the head is entirely white-scaled behind and the impressed lines of the mesonotum are distinctly narrower; there is no thoracic ornamentation.

Four specimens, Ancon, Canal Zone, Panama, bred from larvæ found in a tree-hole with *Megarhinus* (A. H. Jennings).

Type no. 12101, U. S. N. M.

CULEX ABOMINATOR, new species

With the general characters of *C. pipiens* Linn., but separable from it by the broader ovate wing-scales and the distinct banding on the under side of the abdomen.

Ten specimens, Tutwiler, Mississippi, August 2, 1904 (H. S. Barber); Rives, Tennessee, July 27 (H. S. Barber); Como, Franklin Parish, Louisiana, August 20 (G. E. Beyer); Victoria, Texas, July 28, 1904 (E. G. Hinds); Plano, Texas, September (E. S. Tucker).

Type no. 12103, U. S. N. M.

CULEX REDUCTOR, new name

We propose this name to replace *Mochlostyrax jamaicensis* Grabham, since when *Mochlostyrax* is placed as a synonym of *Culex,* as we find necessary, Dr. Grabham's name becomes preoccupied by *Culex jamaicensis* Theobald. Theobald's species was later placed by him in the genus *Grabhamia,* and by us in *Aedes,* but the name *Culex jamaicensis* cannot again be used.

CULEX DECEPTOR, new species

Legs dark-scaled. Proboscis swollen at the tip. Occiput dark-scaled, the eyes margined with whitish. Venter of the abdomen black and white-banded, the upper surface dull black without dorsal bands, but with pale lateral spots; forks of the second vein with long ligulate scales.

Three specimens, Fort White, Florida (H. Byrd).

Type no. 12104, U. S. N. M.

CULEX INCRIMINATOR, new species

Entirely similar to *Culex deceptor* Dyar and Knab, except in the scaling of the veins. The scales of the present form are elliptical on the forks of the second vein.

Three specimens, Agricultural College, Mississippi (W. V. Reed); sent to us under the name *Melanoconion atratus* by Prof. Glenn W. Herrick.

Type no. 12105, U. S. N. M.

CULEX FALSIFICATOR, new species

Proboscis black, enlarged towards the apex. Occiput clothed with broad, flat, bronzy black scales, a small area of narrow curved ones behind. Abdomen dull black above with transverse, basal, segmental, dull white bands, beneath yellowish white scaled, the apices of the segments marked with indistinct pale brown bands. Wings with the scales narrowly ovate on the second to fourth veins outwardly. Legs black.

Seven specimens, Havana, Cuba, February 15, 1904 (J. R. Taylor).

Type no. 12108, U. S. N. M.

CULEX INVOCATOR, new species

Proboscis moderate, not swollen at the tip, black-scaled. Occiput with broad flat bronzy brown scales, a few narrow curved ones on the vertex, a patch of dull white scales well down the side. Abdomen deep black-scaled above with rather small lateral whitish spots, venter black-scaled with narrow white basal segmental bands. Legs black. Wing-scales dense, narrow, those on the apical portion of the wing mostly somewhat broader.

Sixteen specimens, San Antonio de los Baños, Cuba (J. H. Pazos).

Type no. 12110, U. S. N. M.

CULEX DUPLICATOR, new species

Proboscis uniform, black-scaled with a broad white ring at the middle. Abdomen black above, with rather narrow white basal segmental bands, some of them slightly produced in the middle. Legs black, femora and tibiæ white-lined on the outer side, the tarsal joints broadly white-ringed at base and apex. Wing-scales narrow, those on the forks of the second vein moderately long, narrowly lanceolate.

Five specimens, San Francisco Mountains, Santo Domingo (A. Busck).

Type no. 12111, U. S. N. M.

CULEX AIKENII Aiken

Theobald described *Gnophodeomyia inornata* from British Guiana (Journal of Economic Biology, I, 20, 1905; Monogr. Culicid., IV, 252, 1907); the description is repeated by Mr. Aiken (The British Guiana Medical Annual for 1906, 60, 1907), but under the name *Gnophodeomyia aikenii,* which name he credits to Theobald, but erroneously. We have received specimens, and find the species referable to *Culex,* of which *Gnophodeomyia* Theobald will become a synonym. Theobald's species on being transferred to *Culex* becomes invalidated through the existence of *Culex inornatus* Williston (U. S. Dept. Agr., Div. Ornith. and Mam., North American Fauna, no. 7, 253, 1893), and will be known as *Culex aikenii* Aiken.

CULEX LACHRIMANS, new name

Culex aikenii Dyar and Knab (not *Gnophodeomyia aikenii* Aiken), Proc. U. S. Nat. Mus., vol. 35, p. 61, 1908.

On account of the above-described facts, we are obliged to change the name of our *Culex aikenii.*

DINANAMESUS, new genus

Metanotum without setæ. Antennæ of the female with the second joint about eight times as long as wide, third and fourth together longer than the second, last joint slender; of the male, the second joint about six times as long as wide, the third nearly as long as the second, the succeeding joints subequal, the terminal joint enlarged into a slight knob, the hair-whorls as in the female.

DINANAMESUS SPANIUS, new species

FEMALE.—Proboscis rather long and stout, black-scaled. Occiput dark-scaled, the margins of the eyes white. Mesonotum brown-scaled, with numerous coarse dark bristles, particularly in the antescutellar region and at the bases of the wings. Abdomen somewhat compressed towards the tip, blunt, the cerci small, vestiture above brown with bronzy luster, beneath paler; tip of the abdomen coarsely hairy. Wings hyaline, the scales of the veins brown, long, narrowly ovate to ligulate; those of the costa with a strong bronzy luster. Legs with the tibiæ rather short and stout, bronzy brown-scaled above, pale-scaled beneath to near the apex. Tibiæ and tarsi uniformly bronzy brown-scaled. Claws simple. Length, 2.5 mm.

MALE.—Antennæ much longer than in the female, the hairs of the whorls slightly longer. Proboscis longer, slightly enlarged towards the apex. Abdomen compressed basally, enlarged towards the tip, the claspers large and stout. Coloration as in the female; claws of the fore and middle legs equal, one claw with a long basal tooth. Length, 2 mm.

Two specimens, bred from larvæ in crab-holes, Corozal, Canal Zone, Panama, and Coscojar River, Porto Bello Bay, Panama (A. H. Jennings).

Type no. 12052, U. S. N. M.

This genus is allied to *Deinocerites,* differing in the reduced length of the second antennal joint. It is a more ancestral form in this respect.

DEINOCERITES PSEUDES, new species

FEMALE.—Antennæ very long, the second joint as long as the next three, the terminal joint not swollen. Proboscis rather long and slender, brown-scaled. Mesonotum dark brown-scaled with numerous coarse black bristles. Metanotum nude. Abdomen compressed apically, blunt, the cerci small, without jointed appendages, vestiture dark above with bronzy luster, yellowish beneath. Legs bronzy brown-scaled, the femora pale beneath nearly to the apex. Claws simple. Length, 4 mm.

MALE.—Antennæ with the third joint slightly shorter than the second, the following joints successively shorter, the last joint with a small knob at the tip, the whorls at the bases of the joints inconspicuous, as small as in the female. Coloration as in the female. Genitalia approximately as in *D. cancer* Theob. Length, 4 mm.

Nine specimens, bred from larvæ in crab-holes, Ancon, Canal Zone. Panama (A. H. Jennings).

Type no. 12053, U. S. N. M.

DEINOCERITES TETRASPATHUS, new species

Similar to *D. cancer* Theobald, but the cerci of the female with four terminal flattened appendages instead of two; the appendages are not inserted together, but are approximated towards the tip of the cercus. Second joint of the antennæ about fourteen times as long as wide, the succeeding joints about six times as long as wide and subequal. Coloration as in *D. cancer*.

Two females, Bluefields, Nicaragua, and Puerto Barrios, Guatemala, without date or collector label.

Type no. 12109, U. S. N. M.

DEINOCERITES TROGLODYTUS, new species

Closely allied to *D. cancer* Theobald and of the same size and coloration, but the cerci of the female are sharply pointed and have a spine on the lower side (fig. 56, 2), and are not elongate conical as in *D. cancer* (fig. 56, 1), or stoutly conical as in *D. melanophylum* D. and K. (fig. 56, 3), while the antennæ of the male are stout at the tip and uniform, the last joint not disproportionately enlarged (fig. 56, 2), not uniformly slender as in *D. melanophylum* (fig. 56, 3), nor with the last joint enlarged like a knob, as in *D. cancer* (fig. 56, 1).

Twenty specimens, Trinidad, British West Indies, June (A. Busck).

Type no. 12128, U. S. N. M.

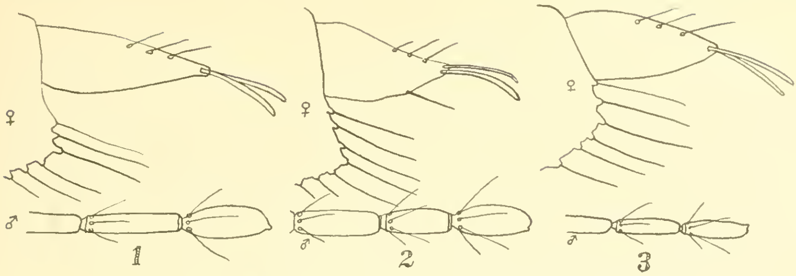


Fig. 56.—*Deinocerites,* female cerci and male antennæ: 1. *D. cancer* Theo.; 2. *D. troglodytus* D. and K.; 3. *D. melanophylum* D. and K.

WYEOMYIA PANDORA, new species

Proboscis moderate, bronzy black. Occiput black with bronzy and blue reflection without white margin to the eyes. Prothoracic lobes dark metallic blue with violet and coppery luster. Abdomen with the colors separated on the sides in a straight line, silvery beneath. Wing-scales broad, ovate, many obliquely subtruncate; legs bronzy black, mid tarsi with the apical two-thirds of the second and all the succeeding joints silvery white on the outer side; hind tarsi with the last two joints white all around. Length, 3.5 mm.

Four specimens, Corozal, Canal Zone, Panama, bred from larvæ in *Calladium* leaf-axils (A. H. Jennings); Gorgona, Canal Zone, Panama, bred from larvæ (A. H. Jennings); Black Swamp, Canal Zone, Panama, from larvæ (A. H. Jennings).

Type no. 12132, U. S. N. M.

WYEOMYIA ONIDUS, new species

Female.—Proboscis moderately long, swollen at the tip. Occiput dark-scaled, the margin of the eyes narrowly white. Prothoracic lobes dark-scaled without white apices. Abdomen dark-scaled above with bronzy luster, white beneath, the colors separated in a straight line. Legs bronzy brown, the femora pale at base beneath, the hind tarsi with the last two joints silvery white beneath, the white interrupted at the apex of the fourth joint; fore and mid tarsi without white. Wing-scales broad.

Male.—Coloration as in the female.

Three specimens, bred from larvæ in the flower cups of *Heliconia,* Tabernilla, Canal Zone, Panama (A. H. Jennings).

Type no. 12054, U. S. N. M.

WYEOMYIA PANTOIA, new species

FEMALE.—Proboscis moderately long, swollen towards the tip, black-scaled. Occiput entirely dark-scaled. Prothoracic lobes dark-scaled, without light scales at the apices. Abdomen dark-scaled above, white beneath, the colors separated on the sides in a straight line. Legs bronzy brown, the femora pale beneath, the hind tarsi with the last two joints silvery white beneath; fore and mid tarsi without white. Wing-scales broad.

MALE.—Coloration as in the female.

Six specimens, bred from larvæ in flower-cups of *Heliconia* and captured, Tabernilla, Canal Zone, Panama, Caldera Island, Porto Bello Bay, Panama (A. H. Jennings).

Type no. 12055, U. S. N. M.

WYEOMYIA SYMMACHUS, new species

FEMALE.—Proboscis moderately long, somewhat swollen at the tip, black-scaled. Occiput dark-scaled, the eyes with a narrow white margin, interrupted towards the vertex. Prothoracic lobes dark-scaled, the tips silvery white, as also the basal portion. Abdomen black-scaled, with bluish iridescence, white beneath, the colors separated on the sides in a straight line. Legs bronzy brown, the femora pale beneath; hind tarsi with the last two joints white-scaled beneath nearly to their apices; mid tarsi with the apical three-fourths of the second, and all of the succeeding joints silvery white-scaled beneath; fore legs dark. Wing-scales broad.

MALE.—Unknown.

Two specimens, bred from larvæ in water in bamboo joints, Tabernilla, Canal Zone, Panama (A. H. Jennings).

Type no. 12056, U. S. N. M.

WYEOMYIA ABRACHYS, new species

FEMALE.—Proboscis rather long, distinctly swollen towards the tip. Occiput dark-scaled, the eyes with a narrow whitish margin. Prothoracic lobes black above, the tips shining but not distinctly white, the lower part white-scaled. Abdomen dark above, white below, the colors separated on the sides in a straight line. Wing-scales narrow, spatulate, broader and denser at the tip. Legs black-scaled, the mid tarsi with the fourth joint distinctly white beneath in the female, the third and fourth joints white in the male, hind tarsi with white bands at the bases of the second and third joints, the fourth and fifth white below except at tip.

Three specimens, Caldera Island, Porto Bello Bay, Panama (A. H. Jennings).

Type no. 12133, U. S. N. M.

WYEOMYIA EUETHES, new species

Female.—Proboscis rather short and stout, distinctly swollen at the tip. Occiput dark-scaled, the eyes with a narrow white margin. Prothoracic lobes dark, white below, without a distinct white tip. Abdomen dark above, white below, the colors separated on the sides in a straight line. Wing-scales large, ovate. Legs black, the mid tarsi with the tip of the second, the third to fifth joints white below, hind tarsi with the fourth and fifth joints white below except at tip.

One specimen, Tabernilla, Canal Zone, Panama (A. Busck).

Type no. 12134, U. S. N. M.

WYEOMYIA CHRESTA, new species

Female.—Proboscis rather long and slender, distinctly swollen at the tip. Occiput dark-scaled, the eyes with a narrow white margin, interrupted subdorsally. Prothoracic lobes dark, white below; abdominal colors separated on the sides in a straight line. Wing-scales large, ovate. Legs black, the mid tarsi with tip of second joint, third and fourth white below, hind tarsi with bases of second and third narrowly white, fourth and fifth white below except at tips.

Two specimens, Tabernilla, Canal Zone, Panama (A. Busck).

Type no. 12135, U. S. N. M.

WYEOMYIA ANTOINETTA, new species

Proboscis moderate, distinctly swollen at the apex. Occiput dark-scaled, obscurely iridescent, the margin of the eyes not white-scaled, a silvery spot on the occiput and on sides below. Prothoracic lobes dark-scaled, with a violaceous luster, the apex and base silvery-scaled. Abdomen dark-scaled above with obscure bronzy and blue luster, white-scaled beneath, the colors separated on the sides in a straight line. Legs dark-scaled with a paler bronzy luster beneath, mid tarsi with the outer half of the second and all of the last three joints silver-white-scaled outwardly, hind tarsi unmarked. Wing-scales narrow. Length, 3 mm.

One specimen, Estero, Florida (J. B. Van Duzee), bred from larvæ in bromeliaceous plants.

Type no. 12179, U. S. N. M.

WYEOMYIA CONCHITA, new species

Proboscis moderate, distinctly swollen towards the apex. Occiput dark-scaled with bronzy and iridescent luster, a patch of silver scales on the vertex. Prothoracic lobes entirely silver-scaled. Abdomen dark-scaled above with faint bronzy and blue luster, the tip silver-scaled, venter white-scaled, the colors separated on the sides in a straight line. Legs dark-scaled, paler with brassy luster beneath, the mid tarsi white beneath on the tip of the second and the last three joints, hind tarsi broadly white-marked at the bases of all the joints beneath. Wing-scales narrow. Length, 2.5 mm.

Fourteen specimens, San Antonio de los Baños, Cuba (J. H. Pazos).

Type no. 12180, U. S. N. M.

WYEOMYIA DRAPETES, new species

Proboscis short, swollen at the tip. Occiput dark-scaled, the eyes with a margin of white scales, widening into a spot on the vertex. Palpi white-tipped. Prothoracic lobes dark-scaled with silvery white tip and base. Abdomen dark-scaled above, white beneath, the colors separated on the sides in a straight line. Legs dark-scaled. Wing-scales short, dense and cuneiform on the forks of the second, third, and fourth veins. Length, 3.5 mm.

Male similar to the female, the palpi entirely white-scaled; mid tarsi with the outer half of the second and the last three joints pale brassy without.

Three specimens, San Juan, Trinidad, British West Indies, larvæ in bamboo stumps, associated with *Sabethes undosus* Coq. (A. Busck).

Type no. 12181, U. S. N. M.

WYEOMYIA CARA, new species

Proboscis rather short, swollen towards the apex. Occiput clothed with dark scales, a white margin along the eyes and a longitudinal stripe on the vertex. Prothoracic lobes blackish with dark brown and violet reflections. Abdomen with the colors separated on the sides in a straight line. Wing-scales broadly ovate, their tips obliquely subtruncate, dense on the second and fourth veins. Legs black with bronzy and blue reflections, the tibiæ and tarsi with pale brassy luster beneath, the last two joints of the hind tarsi with silvery luster beneath. Length, 3.5 mm.

One specimen, Trinidad, British West Indies, June, 1905 (A. Busck).

Type no. 12182, U. S. N. M.

WYEOMYIA CACODELA, new species

Proboscis moderate, swollen towards the apex. Occiput clothed with dark scales, a narrow white margin along the eyes. Prothoracic lobes blackish with dull bronzy and blue reflection. Abdomen with the colors separated on the sides in a straight line. Wing-scales broadly ovate, their tips obliquely subtruncate. Legs black with bronzy and blue reflections, without white markings in the female, the male with the mid legs brassy beneath, the hind tarsi with the last two joints silvery white beneath. Length, 3.3 mm.

Three specimens, selected from a series, Tabernilla, Canal Zone, Panama, bred from larvæ in flower-cups of *Heliconia* (A. Busck); Gorgona, Canal Zone, Panama, from flowers of *Heliconia* (A. H. Jennings).

Type no. 12183, U. S. N. M.

This species is very similar to *W. galoa* D. and K., and was so identified by us for Mr. Busck, and published in his report on the mosquitoes of the Canal Zone. The hind feet of the male, however, are differently colored.

WYEOMYIA AGYRTES, new species

Proboscis rather short, swollen towards the apex. Occiput clothed with dark scales, the eyes with a narrow white margin. Prothoracic lobes blackish, a white patch below. Abdomen with the colors separated on the sides in a straight line. Wing-scales broadly ovate, their tips obliquely subtruncate, dense. Legs black with bronzy and blue reflections, front and mid legs bright bronzy beneath, without white markings in the female. Length, 3.5 mm.

One specimen, Tabernilla, Canal Zone, Panama, bred from larvæ taken May 16, 1905, in water in a bamboo stump (A. Busck).

Type no. 12184, U. S. N. M.

WYEOMYIA HAPLA, new species

FEMALE.—Proboscis very long and slender, the tip slightly enlarged; black. Palpi short, black-scaled. Occiput dark-scaled, with iridescent reflections in some lights. Prothoracic lobes large, prominent, clothed with dark blue scarcely metallic scales and with numerous coarse black bristles along the margin. Mesonotum dark-scaled with slightly metallic luster, predominatingly of a dull green color; scutellum clothed with similar scales. Abdomen black-scaled above, with faint greenish and bluish luster, white-scaled beneath, the colors separated on the sides in a straight line. Legs black-scaled with greenish luster, the mid tarsi white-scaled on the fourth joint below, the hind tarsi at base of second and third, the fourth and fifth joints white below except at the tips.

One specimen, Caldera Island, Porto Bello Bay, Panama, bred from a larva in water between the leaves of a bromeliaceous plant (A. H. Jennings).

Type no. 12102, U. S. N. M.

Described from one of the types of *W. dymodora* D. and K., which was wrongly included and does not fit the description. The Fort San Felipe specimen remains as the type.

LIMATUS CACOPHRADES, new species

FEMALE.—Occiput black with blue and green iridescence, a patch of golden yellow scales at the vertex. Prothoracic lobes golden. Mesonotum dark metallic violet-scaled with golden markings, a median wedge-shaped one anteriorly and a semicircular one before the root of the wing. Scutellum dark violet-scaled. Postscutellum bronzy brown-scaled, with blue, coppery, or golden reflections. Pleura clothed with golden scales above, silvery ones below. Abdomen with the dorsal vestiture black with coppery and blue reflections, the venter yellowish silvery, the colors indented on the sides. Legs bronzy black, with a brighter luster beneath.

MALE.—Proboscis with a tuft beyond the middle, the tip curved and slightly thickened by scales. Coloration as in the female, except that the mid and hind legs are white-marked beneath.

Twelve specimens, selected from a series, Tabernilla, Canal Zone, Panama (A. H. Jennings).

Type no. 12130, U. S. N. M.

This species was formerly identified as *L. durhami* Theobald, but differs therefrom most obviously in the color of the postscutellum.

LIMATUS METHYSTICUS, new species

Similar to *L. cacophrades* D. and K. Thorax with five irregular golden patches. Abdomen silvery beneath, the colors separated on the sides in a straight line. Middle legs with the last three tarsals silver white beneath in the female, white all around in the male; hind legs with the last joint silvery white beneath in both sexes. Proboscis of the male straight, slender, swollen at tip.

Four specimens, Port Limon, Costa Rica, September 28, 1905 (F. Knab).

Type no. 12131, U. S. N. M.

NOTES

Some Noteworthy Accessions to the Division of Invertebrate Paleontology in the National Museum

(With Two Plates)

Mr. Frank Springer, of Burlington, Iowa, has deposited in the U. S. National Museum a second slab of the unique crinoid *Uintacrinus socialis,* which, like the first (see Smithsonian Miscellaneous Collections, Quarterly Issue, Vol. 1, 1904, p. 450), deserves mention. Both of these slabs are now on exhibition, having been mounted on the wall facing the corridors of the southeast balcony. The one specimen so supplements the other that the Museum now has undoubtedly the finest exhibit of this crinoid extant. The first slab was one of several pieces making up a mass originally less than one-half an inch thick, and fifty feet long by twenty feet wide, collected in the upper part of the Niobrara chalk near Elkader, Logan County, Kansas. The bodies of about 140 of these crinoids can be counted upon the surface of the first slab, but the position of the crinoid crowns is such in most cases that, although exceptionally well placed to show their plate structure, they seldom exhibit the complete body and full length of arm. In this latter respect, the second slab is particularly fine, as a glance at the accompanying plates will show.

The slab lately sent by Mr. Springer is nearly six feet square and shows upon its surface over one hundred more or less perfect individuals. It comprises a colony of the *Uintacrinus* found twenty miles west of Elkader, Kansas, in the Hesperornis bed of the upper Niobrara chalk, about the top of the blue chalk where the change in color to yellow has commenced. This horizon has furnished practically all of the Kansas specimens of *Uintacrinus,* and this recent discovery has extended the geographical range in this state to an area about 60 miles in diameter.

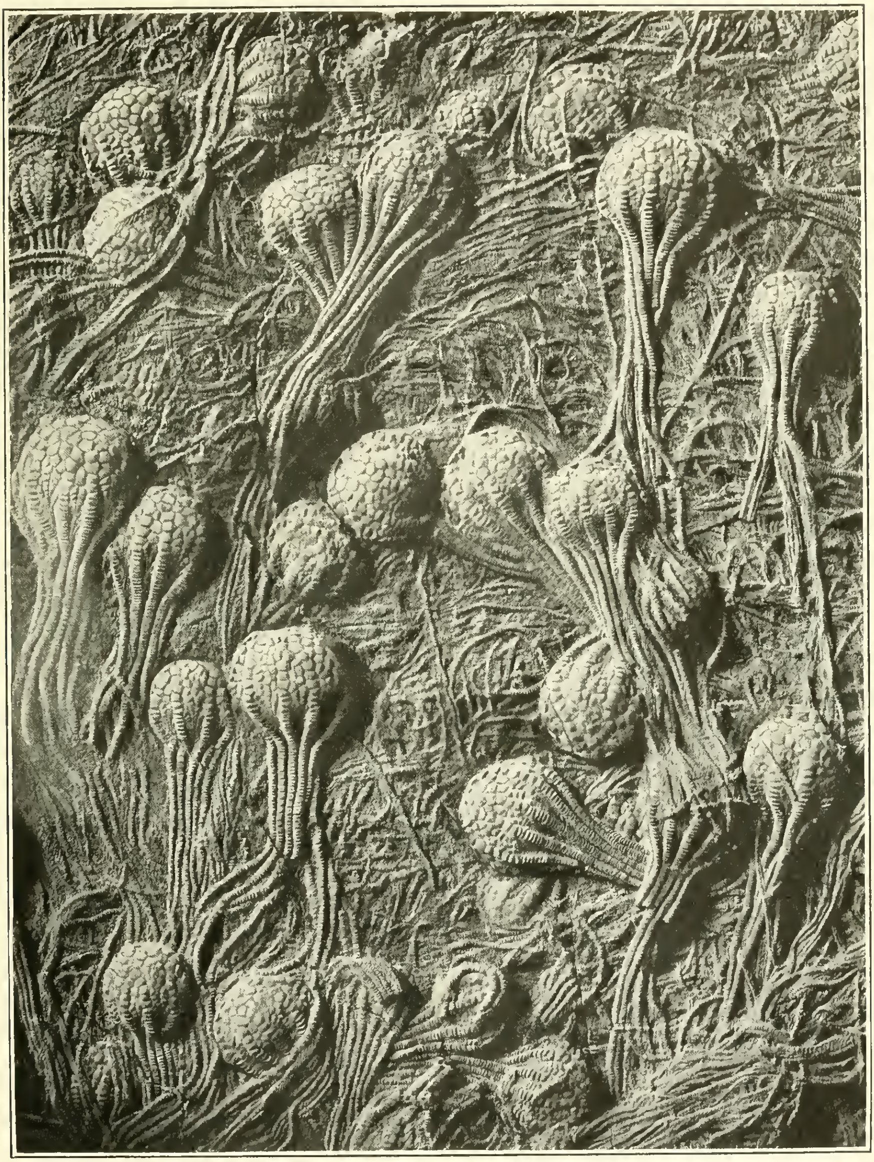
Mr. Springer's studies of *Uintacrinus* have been so thorough that nothing new of scientific interest was brought out in this latest find, but as a Museum exhibition specimen, the slab is unique. The reason for this lies in the exceptionally regular arrangement and position of the bodies and their corresponding arms. In many of the specimens hitherto found, the bodies have been crushed and the arms so flattened out or matted together and entwined that the full length could seldom be traced. In the present specimen, the bodies are resting upon their sides with their arms closely folded together like bundles of parallel rods. The arms seem to be pointing uniformly toward the center of the slab, but whether this arrangement is accidental or due to eddies in the water at the time of the death of this colony, can only be conjectured. However, the former surmise is probably nearer the truth, since the bundle-like arrangement of the arms in practically all of the specimens undoubtedly indicates a less distorted condition of the crinoids at the time of death. Clearer or purer water may likewise possibly account for this regular arrangement, since, in specimens showing the arms widely extended or otherwise disturbed, the enclosing chalk gives an indication of muddy water in its darker color.

Mr. Springer's interest in the National Museum has not been confined to fossil crinoids, on which he is the leading authority, but has extended to other branches of paleontology. From time to time, collections of fossils have been presented by him, but in 1907, the Museum was so fortunate as to secure, through its purchase and subsequent donation by Mr. Springer, the collection of Prof. W. F. Pate, of Lebanon, Kentucky, who had spent many years in accumulating this valuable lot of material. The size and value of the collection is evident when it is stated that about 12,000 specimens, mostly belonging to species hitherto unrepresented in the National collections, have been catalogued in the Museum register under nearly 2,000 entries, and are retained in the permanent stratigraphic and biologic series of the division. The number of specimens set aside as duplicates for exchanges and like purposes was large enough to increase the sum total in the original cabinet to not less than 50,000. This collection, as a whole, came from the Paleozoic rocks of the Mississippi Valley, but specimens from numerous foreign localities, secured by exchange, are likewise present. Altogether about six hundred localities are represented by specimens. The faunas from certain localities and horizons are so complete that it seems in order to note a few of these.

The various Ordovician and Silurian formations, especially of Kentucky, are abundantly represented, but probably the most complete fauna in the collection comes from the celebrated Niagaran Waldron shales. In Indiana a few localities are known where fossils from these shales can be had, but at present the finest exposures are along the west flank of the Cincinnati axis in Tennessee. Mr. Pate discovered the best of these localities, and the collection has benefited accordingly. In the Devonian, the most interesting faunas represented in detail were from the Onondaga and Hamilton lime-

UINTACRINUS SOCIALIS FROM KANSAS

Size, nearly six feet square



A CLUSTER OF THE FOSSIL CRINOID, UINTACRINUS SOCIALIS

stone of Kentucky. In the number of localities and exquisite preservation of the material, the Mississippian or Subcarboniferous strata of Kentucky have the best representation. The lowest strata of this larger group, the Kinderhook Knobstone shales, are well exposed near Lebanon, Kentucky, so that naturally the number of species from this horizon is particularly large.

From a biologic standpoint, the brachiopods of the collection are especially noteworthy. Several years ago a biologic series of this class of organisms was started in the division of invertebrate paleontology; today, by selecting series of specimens from the Ulrich and Rominger collections, and now from the Pate collection presented by Mr. Springer, the number of species of post-Cambrian Paleozoic forms has increased to such an extent that 80 standard drawers are required to contain them. This, combined with the collection of Cambrian brachiopods, makes the National collection unrivaled.—R. S. Bassler.

Sound Signaling by Indians of Tropical South America

For a long time early travelers through tropical South America were at a loss to know how the Indians at the villages along the streams (all travel being by river, of course) were always prepared for them, seeming to know the number of their party, number of canoes, their destination, etc., and it was finally learned that these savages had solved the problem of immediate communication to their own satisfaction and for their own daily use and comfort. It is a well-known fact that the North American Indians of the Great Plains communicated with each other over long distances. Theirs, however, was a sight system of signaling, usually by smoke in daytime and fire by night. Such a system was impossible for the Indians of tropical South America because of miles of dense forests in a country of no mountains or eminences of any great height. By exercising their ingenuity, however, a system of signaling by sound, crude in a way, and yet very effective, has been perfected among them by which they communicate with each other, though many miles apart. A rough sketch of one of the most successful of these signaling devices, which I saw in operation, is reproduced herewith.

The apparatus consists usually of two logs of about six and seven feet in length and twelve and fifteen inches in diameter, of a wood similar to the corkwood, of which the *balsas,* or huge rafts, commonly used on the river, are made. By means of hot stones, two holes, connected by a long narrow canal, are burned into the logs, and through these holes the logs are later hollowed out by the same process and by scraping. By leaving different thicknesses of the wood and by pasting or pegging with rubber different articles inside the log, the sound is regulated, much on the same principle as in the body of a violin. Usually four sounds or notes are produced by hammering, one from each side of the vertical canal on each log, the logs being suspended by rope-like vines from a tree or from a frame built especially for the purpose, as seen in accompanying sketch. The larger log, from which emanate the deeper tones, is called

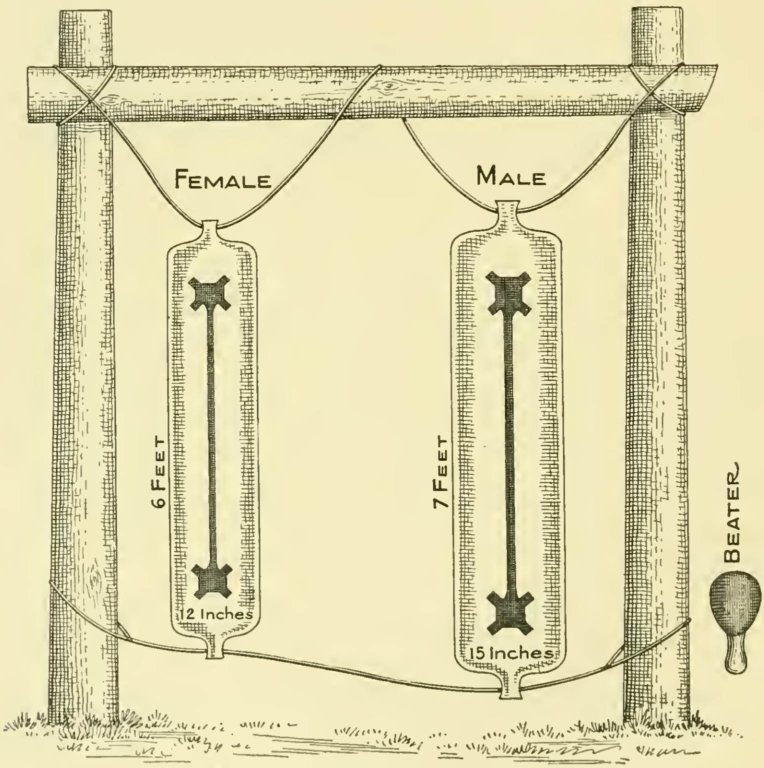


Fig. 57.—The *Manguaré*, for sound signaling.

the "male," and the smaller one the "female." The person who signals stands between the logs, holding in each hand a "beater" made of a piece of wood covered at one end with a ball of crude rubber and not unlike a large drum-stick. The strokes are usually given very rapidly, producing deep, booming notes, which are heard for miles around. Stories vary as to the distances to which the sound penetrates, but in my own experience I have known of a message being received at a distance of approximately 15 miles. The contrivance, among the greater part of the Huitotos of the Peruvian region, is called *manguaré,* though others know it by the name of *huára,* while among many tribes of the region of the northern Amazon it is called *tundóy.*—CHARLES C. EBERHARDT, American Consul.

NATURAL HISTORY EXPEDITION TO AFRICA

In March, 1909, Mr. Theodore Roosevelt, accompanied by his son Kermit and three representatives of the Smithsonian Institution—Lieut.-Col. Edgar A. Mearns, Medical Corps, United States Army, retired; Mr. Edmund Heller, and Mr. J. Alden Loring—will start on a hunting expedition in Africa. The natural history collections made by the party will be deposited in the United States National Museum. It is planned to reach Mombasa in April, 1909, whence the general route will be up the Uganda Railway to Nairobi and Lake Victoria Nyanza, a distance of 650 miles by rail, crossing into Uganda, and passing down the Nile to Cairo. Much of the hunting will be done in British East Africa, where the Uganda Railway can be used as a base of supplies and means of ready transportation. It is expected to reach Khartoum in April, 1910. The expenses of Mr. Roosevelt and his son will be borne by Mr. Roosevelt; the expenses of the three representatives of the Smithsonian Institution will be defrayed from private funds contributed for the purpose.

ANTHROPOLOGICAL RESEARCHES IN EGYPT

Through an arrangement with the Metropolitan Museum of Art in New York, Dr. Aleš Hrdlička, in charge of physical anthropology in the U. S. National Museum, has gone to Egypt for the purpose of studying certain ancient human remains being unearthed near Cairo. Before returning Doctor Hrdlička will visit a number of the more prominent museums and anthropological laboratories of Europe.

CONGRESSES

INTERNATIONAL CONGRESS ON TUBERCULOSIS.—In connection with the Sixth International Congress on Tuberculosis, held in the new building of the U. S. National Museum in Washington, September 21 to October 12, 1908, the Smithsonian Institution offered from the Hodgkins fund a prize of $1,500 for the best paper "On the relation of atmospheric air to tuberculosis." The following committee was selected to award this prize: Dr. William H. Welch, of Johns Hopkins University, chairman; Dr. John S. Fulton, Secretary-General of the International Congress on Tuberculosis; Dr. Simon Flexner, Director, Rockefeller Institute for Medical Research; Dr. George M. Sternberg, Surgeon-General, U. S. A., retired; Dr. Hermann M. Biggs, of the Department of Health, New York city; Dr. George Dock, of the University of Michigan, and Prof. William M. Davis, of Harvard University. The Secretary of the Institution was a member of the head committee on International Congress on Tuberculosis.

Fishery Congress.—In connection with the Fourth International Fishery Congress in Washington, September 22-26, 1908, the Institution made an allotment of $200 from the Smithsonian fund for the best essay or treatise on "International regulations of the fisheries on the high seas; their history, objects, and results." This prize was awarded by the International Jury to Mr. Charles H. Stevenson, of the U. S. Bureau of Fisheries. The Institution was officially represented by Dr. Theodore Gill and Dr. Frederick W. True, and the National Museum by Dr. Leonhard Stejneger and Mr. W. deC. Ravenel.

Congress of Orientalists.—At the fifteenth session of the International Congress of Orientalists, held in Copenhagen, Denmark, August 14-20, 1908, Dr. Paul Haupt, of the United States National Museum and Johns Hopkins University, represented the Institution. Upon recommendation of the Institution the following gentlemen were designated by the Department of State as delegates on the part of the United States Government: Dr. Paul Haupt; Dr. C. R. Lanman, of Harvard University; Prof. Morris Jastrow, Jr., of the University of Pennsylvania, and Prof. A. V. W. Jackson, of Columbia University.

Congress of Americanists.—The Sixteenth International Congress of Americanists was held in Vienna, Austria, September 9-14, 1908. Dr. Franz Boas, of Columbia University, represented the Institution; and the Department of State, at the suggestion of the Institution, designated, besides Doctor Boas, the following-named gentlemen delegates on the part of the United States Government: Prof. Marshall H. Saville, of Columbia; Dr. George Grant MacCurdy, of Yale; Dr. Charles Peabody, of Harvard, and Dr. Paul Haupt, of Johns Hopkins.

Pan-American Scientific Congress.—At the First Pan-American Scientific Congress held in Santiago, Chile, December 25, 1908, to January 5, 1909, Mr. W. H. Holmes, Chief of the Bureau of

American Ethnology of the Smithsonian Institution, represented the United States in the section of anthropology and ethnology.

ARCHEOLOGICAL CONGRESS.—At the Second International Archeological Congress to be held in Cairo, Egypt, at the Latin Easter, 1909, upon suggestion of the Institution, Dr. Albert M. Lythgoe, of the Metropolitan Museum of Art, New York, and Prof. Paul Baur, of Yale University, will represent the United States.

CONGRESS FOR HISTORY OF RELIGIONS.—Prof. Paul Haupt, of the National Museum and Johns Hopkins University, and Prof. Morris Jastrow, Jr., of the University of Pennsylvania, were official delegates on the part of the United States to the Third International Congress for the History of Religions, held in Oxford, September 15-18, 1908.

OTHER CONGRESSES.—The Smithsonian Institution subscribed to membership in the Ninth International Geographical Congress in Geneva, July 27 to August 6, 1908, and in the First International Congress on Refrigerating Industries, held in Paris, October, 5–10, 1908.

NAPLES ZOOLOGICAL STATION

In addition to the assignments of the Smithsonian seat at the Naples Zoological Station for the first months of 1909, announced in the last edition of the *Quarterly Issue,* the application of Mr. H. D. Senior, of the College of Medicine, Syracuse, N. Y., has been approved for the month of July.

PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

Continued from List in Quarterly Issue, Vol. V, Part 1

No.	*Title.*	*Series.*	*Price.*
1808	Atwood, Alice Cary. Catalogue of the Botanical Library of John Donnell Smith, presented in 1905 to the Smithsonian Institution. 1908	Sp.	
1809	Langley, S. P. Researches and Experiments in Aerial Navigation. (Reprints from Smithsonian Reports for 1897, 1900, 1901, and 1904). 1908		
1810	Charles D. Walcott. Cambrian Geology and Paleontology. No. 3.—Cambrian Brachiopoda: Descriptions of New Genera and Species. 1908	M.C. 53	.25
1811	Charles D. Walcott. Cambrian Geology and Paleontology. No. 4.—Classification and Terminology of the Cambrian Brachiopoda. 1908	M.C. 53	.10
1812	Charles D. Walcott. Cambrian Geology and Paleontology. No. 5.—Cambrian Sections of the Cordilleran Area. 1908	M.C. 53	.25
1813	Smithsonian Miscellaneous Collections. *Quarterly Issue*, Vol. 5, Part 2 (containing Nos. 1814–1823). 1909	M.C. 52	.50
1814	Bassler, R. S. The Nettelroth Collection of Invertebrate Fossils. (*Quarterly Issue*). 1908	M.C. 52	
1815	Rose, J. N. A New Opuntia from Arizona. (*Quarterly Issue*). 1908	M.C. 52	
1816	Gill, Theodore. The Story of the Devil-fish. (*Quarterly Issue*). 1908	M.C. 52	
1817	Eberhardt, Charles C. Indians of Peru. (*Quarterly Issue*). 1908	M.C. 52	
1818	Rose, J. N. On Opuntia Santa-Rita, a species of Cactus of Ornamental Value. (*Quarterly Issue*). 1908	M.C. 52	
1819	Heimerl, Anton. Two New Species of Abronia. (*Quarterly Issue*). 1908	M.C. 52	
1820	Clark, Austin Hobart. Preliminary Notice of a Collection of Recent Crinoids from the Philippine Islands. (*Quarterly Issue*). 1908	M.C. 52	
1821	Adler, Cyrus. The Relation of Richard Rush to the Smithsonian Institution. (*Quarterly Issue*). 1909	M.C. 52	
1822	Dyar, Harrison G., and Knab, Frederick. Descriptions of Some New Species and a New Genus of American Mosquitoes. (*Quarterly Issue*). 1909	M.C. 52	
1823	Notes to *Quarterly Issue*, Vol. 5, Part 2. 1909	M.C. 52	
1824	Annual Report of the Smithsonian Institution for the year ending June 30, 1907 (containing Nos. 1737, 1825–1854). 1908	R. 1907	
1825	Proceedings of the Board of Regents, Report of Executive Committee, Acts of Congress, for the year ending June 30, 1907	R. 1907	
1826	Parsons, Charles A. The Steam Turbine on Land and at Sea	R. 1907	

No.	*Title.*	*Series.*	*Price.*
1827	Turpain, A. The Development of Mechanical Composition in Printing	R. 1907	
1828	Sprague, Frank J. Some Facts and Problems Bearing on Electric Trunk-Line Operation	R. 1907	
1829	Fleming, J. A. Recent Contributions to Electric Wave Telegraphy	R. 1907	
1830	Bragg, W. H. On the Properties and Natures of Various Electric Radiations	R. 1907	
1831	Kershaw, John B. C. Progress in Electro-Metallurgy	R. 1907	
1832	Smillie, Thomas W. Recent Progress in Color Photography	R. 1907	
1833	Cajal, S. R. The Structure of Lippmann Heliochromes	R. 1907	
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1855	Report of Executive Committee and Proceedings of the Board of Regents of the Smithsonian Institution for the year ending June 30, 1908	R. 1908	
1856	Report of the Secretary of the Smithsonian Institution for the year ending June 30, 1908	R. 1908	
1857	Twenty-sixth Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution. 1904–05. 1908		

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VOL. V QUARTERLY ISSUE PART 3

THE ARCHER-FISH AND ITS FEATS

By THEODORE GILL

A group of fishes of great interest on account of a most remarkable feat of which some at least are capable is that of the family called *Archer-fishes* or *Toxotids*. These have a characteristic form; the contour is mostly of the rhomb-oval type, but from the middle of the back and front of the dorsal fin there is a downward slope, which is sometimes in so straight a line that the front half of the fish looks as if it may have been planed off. The head is conical, the mouth deeply cleft, so that its front is in the same line as the decline of the snout; the upper jawbones (*maxillaries*) are unusually narrow, and the lower jaw projects. The eyes are very large, lateral, convex, variously mobile and in the type species at least the irises are golden-yellow. The dorsal fin is set far backward and has only 4 or 5 stout spines and a short soft portion. Other characteristics will be noticed in the account of the habits of the best known species. All the known species belong to a single genus—*Toxotes*.

The osteological characters are so significant that a few points may be noticed. The skeleton in its essential characteristics is of the percoidean type, but the vertebral column is almost quite straight, the neural spines have low set bases of insertion and the ribs are inserted directly and rather high up on the centra of the vertebræ behind parapophyses on the third and succeeding vertebræ; the recession of the dorsal fin backwards is coördinated with extremely receding interneurals and with three free styliform interneurals in front; the suborbital chain is narrow and without a subocular shelf.

I

The Toxotids are mostly inhabitants of the littoral waters and mouths of rivers of southern and southeastern Asia and numerous outlying islands from India to Polynesia. In brackish waters some seem to be quite at home, and Zolotnitsky, who had living specimens sent from Singapore to Russia, thought that water with about one per cent of salt was most congenial to the fishes he was cultivating. Nevertheless, they seem, from the testimony of many others, to be equally well accommodated in ordinary salt water. There may be a

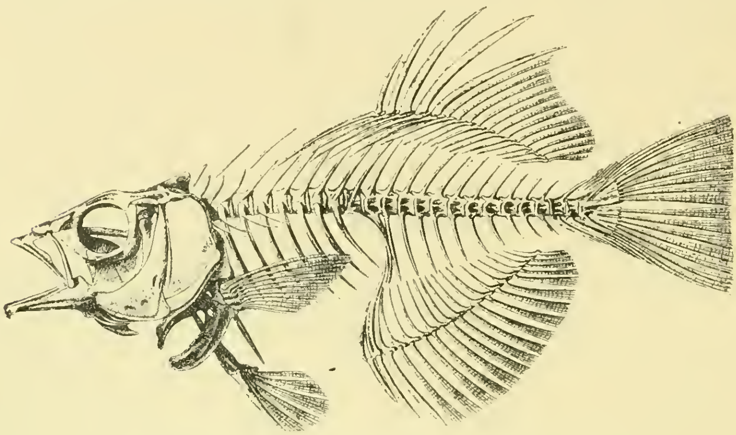


FIG. 58.—Skeleton of Archer-fish. (After Agassiz.)

specific difference, however, in preference manifested for certain conditions. Day, for instance, asserted that the *Toxotes jaculator* affected the sea waters of the coast while the *Toxotes chatareus* was mostly to be found in estuàries and brackish or freshened water. All such characteristics, however, require further evidence.

II

Vague accounts of fishes which secured food by shooting drops of water at insects had reached Europe before, but not till 1764 was there published any notice of such sufficiently precise to give an idea of the character of the shooter. In that year and in 1766, Governor Hommel, of Batavia, sent descriptions and illustrations of two species which were published in different volumes of the Philosophical Transactions of the Royal Society of London.[1] One of these was

[1] The observations of Governor Hommel were published in two communications to the Royal Society by Dr. John Albert Schlosser, viz:

(1) An Account of a Fish from Batavia called Jaculator: In a letter to Mr. Peter Collinson, F. R. S., from John Albert Schlosser, M. D., F. R. S., *in* Phil. Trans., LIV, 1764, pp. 89-91, pl. 9, 1765. (*Chelmo* only noticed.)

(2) Some further Intelligence relating to the Jaculator Fish [etc.], *in* Phil. Trans., LVI, 1766, pp. 186-188, pl. 8, fig. 6, 1767. (*Toxotes* noticed.)

Schlosser was only the intermediary for publication.

a Chætodontid subsequently named *Chelmo rostratus,* and the other a species called "the Jaculator fish," now universally known as the *Toxotes jaculator.* In the second article the author jumped at once into a notice of the characteristic habits.

"When the Jaculator fish intends to catch a fly or any other insect, which is seen at a distance, it approaches very slowly and cautiously, and comes as much as possible perpendicularly under the object; then the body being put in an oblique situation, more or less in this manner  and the mouth and eyes being near the surface of the water, the Jaculator stays a moment quite immovable, having its eyes directly fixed on the insect, and then begins to shoot, without ever shoving its mouth above the surface of the water, out of which the single drop, shot at the object, seems to rise. With the closest attention," continues Hommel, "I never could see any part of the mouth out of the water, though I have very often seen the Jaculator fish shoot a great many drops one after another, without leaving its place and fixed situation."

The after history of the fish is a remarkable one. Hommel's notice was the basis of all the accounts of the Archer-fish subsequently published, but not of the illustrations. In spite of Hommel's repeated statement that the fish never projected "its mouth above the surface of the water," later artists (as in Brehm's Tierleben) represented the entire head and more thrust out of the water and drop after drop ejected vertically at an insect. The illustration, like many other artistic effects, reflected the imagination of the artist rather than either the narrative or Nature.

Year after year passed along—one century and much of a second—and no later observers corroborated Hommel's account. Instead of doing so, inhabitants of countries in which the fish in question was common denied that such a habit as had been attributed to it was practiced or known. The most active ichthyologist that ever lived, long a resident of the same city (Batavia) as Hommel, Dr. von Bleeker, in vain sought corroboration of the ancient account, and in 1875 declared that then the species was only fished for in the bay and he had never been able to obtain living individuals. It was no longer raised as appears to have been the case in the past century, either by Europeans or Chinese, and neither the Chinese nor natives, either at Batavia or elsewhere, practiced or knew about the pretended industry. Consequently he believed that the celebrity of the fish was undeserved and arose from some mistake; "la célébrité n'est pas méritée et ne repose que sur une erreur" were his exact words.

This conclusion was quite generally accepted afterwards. It was apparently justified by the absence of any special physiological aptitude in the mechanism of the mouth and throat of the fish itself for shooting drops. Nevertheless, at last, in 1902,[1] a Russian ichthyologist, N. Zolotnitsky, who had secured a number of living specimens from Singapore, fully corroborated the discredited account and gave many new and interesting details.[2] So remarkable—almost incredible—are some of the statements that they should perhaps be given in the observer's own words; they are here paraphrased so as to give his meaning, but with considerable alteration in the sequence of the paragraphs to accord with that adopted for other species.

III

The Archers are gregarious fishes, not consorting indeed in very large compact shoals like herrings, but in small and loose companies. Considerable activity is often displayed and they may jump entirely out of water; leaps, it has been claimed, sometimes extend to as high as 13 or 14 feet ("4 mètres de hauteur"), but this is incredible. This activity is generally guarded against by would-be captors of the fish who surround the effective net with another or perhaps still more nets.

They frequently swim backwards as well as forwards. This habit of swimming backwards, remarks Zolotnitsky, is very curious and quite customary; indeed, they often swim in this manner for several minutes at a time. They reconnoiter a possible prey and back from it until they secure a good position for observation or attack. The eyes work in harmony.

IV

The action of the eyes deserves special notice. They can be moved in almost every direction—to the left, to the right, upwards and backwards—backwards so that the fish can see everything that goes on behind. Their vision is also very penetrating; they can see small insects at a great distance and drench them with astonishing correctness of aim. But the eyes can not be turned downwards and consequently, when the fish would see what is below, it plunges

[1] The habit was recognized by some able men. H. Milne-Edwards, for instance, in his admirable Leçons sur la Physiologie (XIII, p. 502, 1879), accepted the old statement without any expression of doubt.

[2] Zolotnitsky (N.). Le Poisson Archer (*Toxotes jaculator*) en Aquarium. *in* Archives Zool. Expér. et Gén. (3), x, 1902, pp. lxxiv-lxxxiv.

downward head foremost; it rarely, indeed, sees what is at the bottom, and although worms may be there in abundance, it finds them only when hunger impels it to search for them there. And it is not alone the mobility of the eyes which engages attention; instead of the expressionless stare which is characteristic of fishes generally, the Archer's eyes sparkle with intelligence. Especially when the fish becomes sick or is dying is expression manifested; then it looks at you as if it would implore your attention and would like to speak. The gaze of one of Zolotnitsky's fishes, which was dying, produced on him such a painful impression that he could never forget it! Still another noteworthy feature exists. The eyes may be operated jointly or severally; if the eye of one side is pushed outwards, the opposite one may sink inwards.

V

Another characteristic feature is the susceptibility to external conditions and its manifestation by change of color. The faculty of changing the color of the body as well as the fins is, indeed, developed to a high degree. Every change to which Zolotnitsky's fishes were subjected was accompanied by a change in their colors. The want of oxygen, the temperature of the water, clearness or cloudiness, abundance or deficiency of food, good or bad health, fright, joy. The color is in truth a barometer of their life. They avail themselves of this susceptibility or capability, too, in assuming protective and dissembling hues. When for example they had a nocturnal feast, they discarded their bands and became greenish, accommodating themselves to the color of the water. Zolotnitsky, noticing this, experimented. He covered the aquarium with a paper,—the fishes soon settled to rest and assumed their normal banded condition; then the paper was removed and they immediately became greenish again. He was with good reason astonished at the disappearance of the bands and spots, and naturally puzzled to account for it.

Not only is the coloration a barometer, it is also a thermometer; the fishes are very sensitive to the weather and show its graduations by coloration of the body. At 70° Fahr. and upwards the colors are clear and lively; at 66° Fahr. they begin to fade, and at 60° Fahr. or 61° Fahr., they are quite dull; a little further fall of temperature entails loss of appetite and sluggishness. Zolotnitsky did not venture to experiment with a temperature less than 55° Fahr. (10° R.), for he was convinced that such would be fatal. (Zolotnitsky, 78, 80.)[1]

[1] The pages of the original are numbered in Roman figures.

VI

The Archers subsist largely on insects and their larvæ, and the common species (*Toxotes jaculator*), under some conditions at least, practices what has been called "a singular industry" in pursuit of insects. Numerous kinds of these hover over the water and alight on the vegetation in or close by the water. When the approach of one is sufficiently near, an Archer-fish may take advantage of it to secure a tit-bit or meal. The fish will advance towards the insect, turn its head in a proper direction, direct its eyes forward, and take

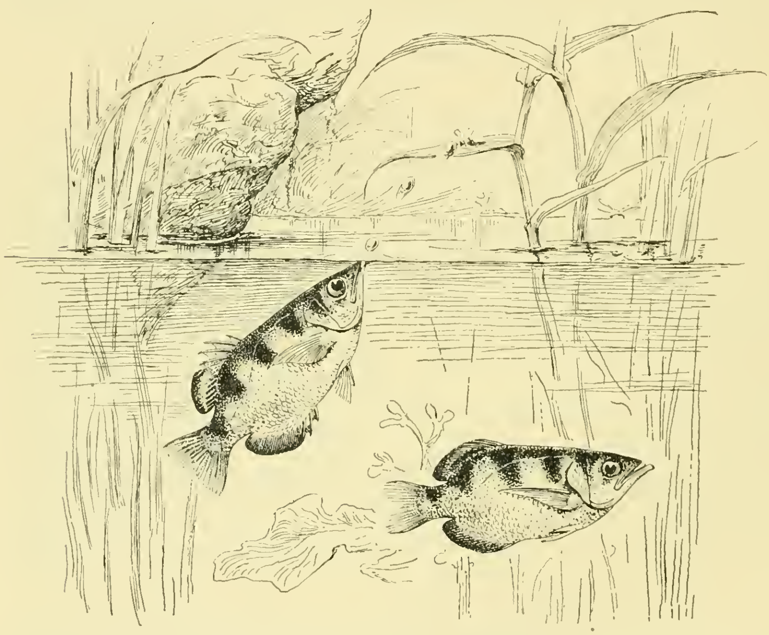


Fig. 59.—Archer-fish Shooting at Insect. (Modified after Zolotnitsky.)

a good look. (Zolotnitsky, 76.) If the insect is badly placed, the fish will back away or change position for a more favorable base for attack. Having found this, it will apply the front of its mouth to the surface of the water, nearly close its jaws, leaving a narrow opening, and shoot a drop of water or perhaps drop after drop at the fly. Ordinarily the drops are projected to distances of from 12 to 20 inches (76), but sometimes they may be sent even 40 inches or more ("1 mètre et davantage") away. The aim is almost always true ("Il vise toujours juste"). The insect, drenched by a shower of such drops, falls into the water, but the true archer may not be the captor. Its companions, like it, dart towards the victim and this naturally becomes the prize of the most adroit or lucky one.

Discrimination and selection were exercised in the choice of insects. The common house-fly was distasteful and only taken, it was thought, when the demands of hunger could not be otherwise appeased. Ants were the chosen food, and small black ants were preferred to the red ones, presumably because the former were less penetrated by formic acid than the latter. (Zolotnitsky, 76.)

Considerable ingenuity is sometimes manifested in the attempt to secure food. On one occasion a larva (bloodworm) of a midge (*Chironomus*) was thrown by Zolotnitsky into the aquarium, but it lodged by the side and an Archer tried several times in vain to secure it, merely pushing it closer against the glass with its projecting lower jaw; at length, it backed a little and blew on the larva, so that the latter was sent toward the middle, and then the Archer readily captured it. The experiment was twice repeated and the fish applied the same strategy to the capture of both larvæ.

Zolotnitsky was very much impressed with the apparent reason which the fish applied. He thought, too, that the old archers could and did measure and proportion the distance and the force used in projecting the drops. The old fishes directed their efforts so successfully that the insects aimed at always fell within reach, but the young ones sometimes used such force as to shoot the flies so that they fell outside of the aquarium.

Although chiefly day-feeders, the Archers are also active and may feed during a bright moon-light night. One hot summer day Zolotnitsky (78) left the aquarium in the open air, and near it a lamp with a great moon-like globe, which attracted a number of insects—mosquitoes, moths and others; many of these came within reach of the archers' shots and the fishes became greatly excited and very active, feeding to repletion. The next day, however, they were in excellent condition and exhibited renewed brilliancy of colors.

VII

Nothing is known respecting the reproductive habits. Zolotnitsky (80) believed that the temperature suitable for spawning was about 73° F. to 75° F. (18° R. à + 19° R.). At such a temperature he found that they were very lively and playful and would be attracted by their own images reflected from the mirror-like sides of the aquarium. Their play was so persistent that they even ceased to eat and ascended continuously to the surface to inhale atmospheric air.

VIII

Zolotnitsky found that they did not require great care and that they soon accommodated themselves to new conditions. He used the water of the Black Sea freshened with a little fresh water. At first they were very wild and timorous, and whirled round and round in the aquarium "like autumn leaves driven by the wind;" several were killed by dashing against the glass sides in attempts to escape. They soon became accustomed to their owner's presence, however, and in a fortnight were so tame that they would approach the hand containing flies and shoot them off into the water.

The chief difficulty experienced was in supplying them with the requisite food. They will never eat dead insects and it is no easy matter to secure a liberal supply of living ones, especially during winter. Zolotnitsky (87) discovered a method of securing a supply of ants by wetting a stem or blade of grass with sea-water and inserting it into an ant's nest. The ants were so much attracted by it that they would not leave it and could be carried thereon as desired. In winter the active larvæ of mosquitoes were obtained and these were eaten by each fish; each larva, it must be remembered, should be alive and they should be fed one at a time.

IX

Five well-defined species of the genus *Toxotes* are known and these are most readily distinguishable by the number of fin rays, size of scales, and coloration. The most generally distributed and best known is the *Toxotes jaculator*. The specific characteristics of that form here given contrast with those of the others.

The dorsal fin has only four spines, the scales are of medium size (28 to 30 in a longitudinal row). The color is distinctive of the species; the ground-color is silvery, and on it are six transverse velvety black bands alternating with citron-yellow areas; the fins are mostly clear yellow, but the dorsal has a black spot and the anal is more or less black. The popular Siamese name, Pla-kat, or Tiger-fish, alludes to a certain analogy between its color and that of a tiger.

All the species are of rather small or medium size, about 5 or 6 inches long, but some individuals of the common Archer, *Toxotes* *jaculator*, reach a maximum of nearly ten inches, and Day obtained specimens of *Toxotes chatareus* over a foot long.

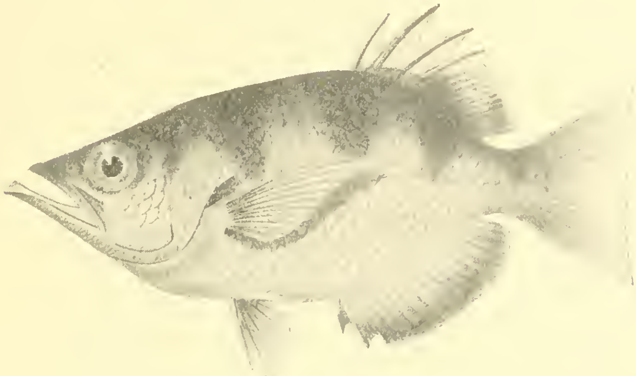


FIG. 60.—Archer-fish. (After Bleeker.)

X

This summary is a true version of the article by Zolotnitsky and will doubtless excite skepticism among physiologists at large as well as psychologists. It contravenes certain assumptions respecting the power and range of vision among fishes, as well as of the intelligence and reasoning powers of such lowly animals. The extent of expression assigned to eyes destitute of mobile surroundings and accommodative adjustments may also be deemed to be exaggerated. Distinction therefore must be exercised between the facts observed (or alleged to have been observed) and the inferences respecting such facts. It must be conceded, however, that fishes which manifest such peculiar action as the Archers should be subjects for still more elaborate observations and experiments, and it appears that they are neither very difficult to procure nor hard to keep.

While Zolotnitsky's account of the Archer-fish is more complete and graphic than any other, it is not the only one, nor the first. As long ago as 1899, two articles appeared in the popular periodical named Natur und Haus,[1] published in Berlin, and it is probable that other observations have been made known later. As, however, the

[1] The following articles are known to the writer:

NITSCHE (PAUL). Der Schützenfische (*Toxotes jaculator*), *in* Nat. und Haus, VIII, 1899, pp. 22-25.

LAMPERT (K.). Der Schützenfische. Nat. und Haus. VIII, 1899, pp. 43, 44.

sets of this periodical in the Library of Congress and the National Museum are incomplete, the idea can not here be verified or disproved. A supplementary account may be given later. As Zolotnitsky, who must have been acquainted with the two articles, made no comments on them, none are called for here. It is to be hoped that some American institution (the New York Aquarium, for instance) may be sufficiently enterprising to import some fishes and enable us to confirm or correct the published observations.

THE PEOPLES OF FORMOSA[1]

By JULEAN H. ARNOLD
American Consul to Formosa

With Four Plates

The Island of Formosa was discovered by the Chinese about one thousand years ago. Since then it has been occupied by Japanese, Dutch, and Spanish respectively; then it passed into the control of the Koxinga family, and susequently back to the Chinese, in whose possession it remained for about 200 years. It has now been more than ten years in the possession of Japan. During these periods the savage tribes have been continuously pressed by foreign peoples. In accordance with their varying contacts with foreigners, there has been more or less difference in the character of the civilizing influences upon the various tribes. With some tribes, the original customs have remained intact during the whole time.

Area and Population

The total area of the Island of Formosa is 2,333 square ri (13,893 square miles), of which the savage district occupies 1,248 square ri (7,407 square miles). In the savage territory live nine groups of tribes, mutually hostile and differing from one another in customs and languages. These groups comprise in all 723 tribes, whose villages number from three to upwards of three hundred houses each. According to investigations made up to the present time the savage population is as follows: Atayal group, 25,932; Vonuum group, 13,889; Tsou group, 2,267; Tsarisen group, 13,760; Paiwan group, 20,609; Amis group, 27,867; Puyuma group, 6,675; Yaami group, 1,427; Saiset group, 737; total population, 113,163.

Comparative Civilization

The degree of civilization to which these tribes may have attained depends greatly upon the nature of the country in which they dwell

[1]This paper is extracted from a report to the State Department, made by Mr. Julean H. Arnold, American Consul to Formosa, the main portion of which is a translation of the Formosan Government report—submitted by Mr. Oshima, Superintendent of Police of the Japanese Government in Formosa—on the management of savage affairs during the fiscal year 1907.

as well as upon the opportunities they have had for communication with the outside world. The work of civilizing these tribes was begun during the Chinese administration in Formosa, but their present state of civilization is the result of the assiduous efforts of the Japanese.

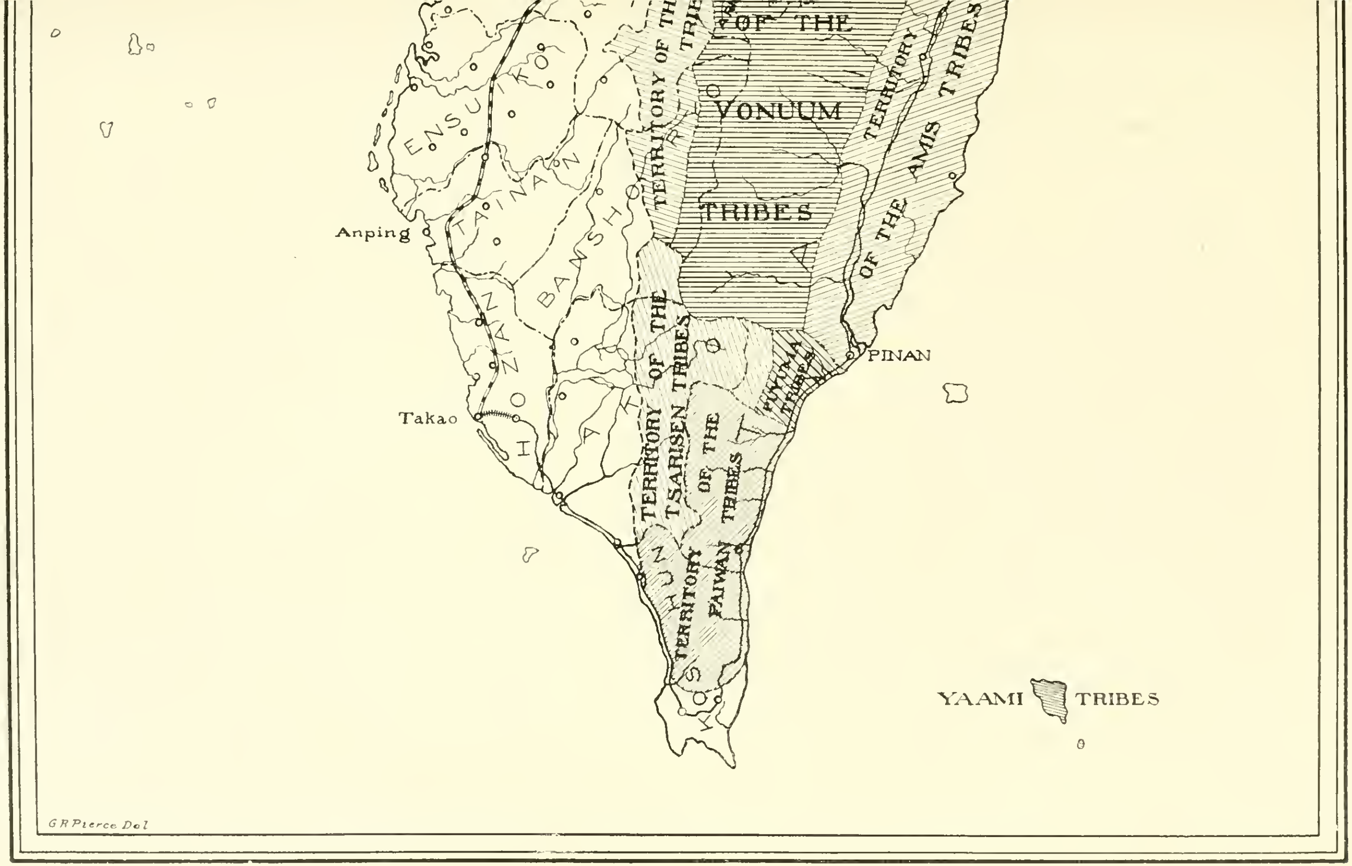
The Yaami and Saiset groups are made up of a very small population. The former group is gentle in nature and dwells upon an isolated island. The latter dwells within the savage guard line, and is quite as civilized as the former. The tribes of the Saiset group are in constant intercourse with native Chinese, whose customs and habits they have adopted to such an extent as to make them quite like the natives. In the near future they will be placed under the regular administration. There is no necessity to enter at length into the descriptions of these two races or groups, and the descriptions which follow will not apply to them.

The Amis and Puyuma groups and a portion of the Paiwan group (about 8,000), living in Koshun Prefecture (the southernmost on the island), have already emerged from a condition of casual cultivation, and now cultivate permanent fields. They are in possession of rice fields and employ plows, hoes, and cattle. Chickens and pigs are also raised by these groups. In their manner of living and in dress they are not very different from the native Chinese, with whom they associate. They willingly send their children to the schools provided for savage children. Up to the present, more than one hundred children have graduated from these schools, and a number of these graduates are holding positions as assistant police, assistant teachers in savage schools, and government interpreters. Postal communications have been established in these districts, which are easy of access, and native postmen deliver the mails.

Next in order of civilization is the Tsou group; then follow the remainder of the Paiwan group and the Tsarisen group. As to agricultural pursuits, manner of living and schooling, the tribes of these groups are not so far advanced as those above mentioned. They are, however, gradually emerging from a state of savagery to one of civilization, and within a short time it is hoped to have them on an equal footing with their semi-civilized neighbors.

The tribes of the Vonuum group dwell in the central range of mountains. Since their contact with civilized people has been very slight, they still retain their savage manners and customs. Moreover, the lands surrounding their houses are poor. By them, head-hunting has been considered the highest achievement. They are


Scale:
0 5 10 20 ri
0 12 24 48 miles
Guard Line
Recent advancement in Guard Line.
Railways.
Ordinary Roads.
Boundary of savage district.
Boundaries of prefectures.
Sub-Prefectural towns.
Prefectural towns.
Tamsui
KELUNG
TAIHOKU
TOEN
SHINCHIKU
So-o
Gotenza
Monauikei
Taiko
TERRITORY OF THE ATAYAL TRIBES
MOUNTAIN RANGE
Wirri
Karenko
TAICHU
SHOKA
NANTO



MAP OF FORMOSA SHOWING DISTRIBUTION OF SAVAGE TRIBES

also addicted to making war on other groups. In 1905 they became particularly troublesome to the Japanese and native Chinese living in the vicinity of their villages, and it was found necessary to make a combined attack on the more atrocious tribes. These were punished, and as a result became partially pacified, no longer giving trouble to the natives and Japanese. Bringing them into civilization will require considerable more work.

The members of the six groups above mentioned, namely, the Amis, Puyuma, Paiwan, Tsou, Tsarisen, and Vonuum are generally known as the southern savages.

The Atayal, or northern savages, tattoo their faces, and for this reason are known as tattooed savages. Their district comprises an area of 500 square ri (2,975 square miles), and is gradually becoming less as the guard line is forced back. They are fierce by nature, and are the largest and most powerful race of savages in the island. They look upon hunting the human head as superior to all else. The human head is necessary as an offering in all of their celebrations. When there is a dispute between members of a tribe, it is settled by awarding the decision to that one who first secures a human head. When a savage lad attains his majority he is not admitted into the tribe as an adult until he secures a human head. Hence, head-hunting has become with them a part of their existence. They take only the heads of Chinese or Japanese (that is, they do not make war among themselves for the purpose of securing heads). The method of taking a head is somewhat after the following order: Several of the tribe, armed with provisions and rifles, approach as near as possible to the frontier and secrete themselves in the jungle in proximity to a frequented path. Here they may await for days a chance of securing a head, and they are not to be satisfied until they secure the much-coveted trophy. Thus, unless afforded proper means of defense, the lives of those engaged in various pursuits in proximity to the savage border are greatly endangered. Under such circumstances it is quite impossible to explore the country inhabited by these tribes. A few of the centrally located tribes of this district never come into contact with the outside world, but, according to the investigations carried on with the neighboring tribes which come down to barter with the native Chinese, their numbers are not great. The Atayal group occupies the northern half of the savage territory, for which reason they are known as the northern savages. In the southern part of the savage territory, with the exception of the lands occupied by the Amis, Puyuma, and Paiwan tribes, most of the country is barren hill land, and not adapted to cultivation. The forests in most of these districts have been destroyed in order to make room for vegetable gardens. Only the forests in the mountain regions west of Niitaka-yama (Mt. Morrison) are available for lumber. On account of the steepness and ruggedness of the country inhabited by the northern tribes arable lands in that district are scarce. But the land of the Atayals is distinctly rich in forest products, especially in camphor. There is also a bright prospect for gold mining in this district. The northern savage district indeed offers prospects of much wealth.

Customs and Practices

The following notes on customs and practices among the savage tribes of Formosa are translated from Mr. Ino's investigations of this subject:

Marriage

In the following particulars marriage customs are uniform throughout the savage district of Formosa:

1. Marriage is effected by a definite ceremony.
2. When the marriage state is once entered into, the relation of husband and wife continues perpetually unless a divorce be made, the reasons for which must be publicly announced.
3. A woman having married once, is not allowed to remarry.
4. Monogamy obtains throughout the various tribes, and is strictly adhered to.
5. Intermarriage between near blood relatives is forbidden.
6. Husband and wife possess equal rights.

The method of effecting marriage differs with the various groups. Among portions of the Vonuum and Tsou groups, there is still a trace of marriage by capture. The Atayal and Vonuum groups practice the "competitive marriage." Among some of the tribes of the Vonuum group "exchange marriages" obtain. The Tsarisen, Paiwan, Puyuma, and Amis tribes effect marriage by exchange of gifts.

The relations of husband and wife are, generally speaking, distinctly cordial throughout all the groups, and divorces are very exceptional. However, in the case of the Tsarisen tribes, if a marriage results in the birth of no children after a certain prescribed period, then divorce ensues. Should the husband die before the wife gives birth to a child, the woman is privileged to remarry; but should the child be born before the death of the husband, the mother, in the event of the death of her husband, is not privileged to remarry, but shall attend to the bringing up of her child. As already mentioned, husband and wife possess equal rights, so that cruelty to a wife is scarcely known.

Birth

The customs pertaining to births which are common to all tribes prescribe that the mother giving birth to a child shall herself cut the navel cord with a piece of sharpened bamboo. The baby is then immediately washed with hot or cold water. In ordinary cases, the day following the birth the mother resumes her regular work in the tribe, although for the period of a month following the birth she confines her attention to work indoors. Among some of the tribes special customs pertaining to births obtain. For instance, with the Tsarisen tribes, when a woman is pregnant the husband performs for the wife certain sacred rites, and at the time of the birth of a child the husband offers prayers for the expulsion of evil spirits. Dinners celebrating births are given, and to these dinners only married couples are invited. It appears that in former times the Paiwan tribes considered giving birth to twins as an ill omen, and the babies (twins) were tied to a tree and allowed to perish.

Burial

The customs pertaining to burial of the dead among the tribes throughout the island are as follows:

1. In case of a death in a family, the members of that family indulge in the bitterest lamentations.

2. The manner of interring the dead is not uniform; some tribes bury their dead within their houses, others without.

3. For a fixed period after the burial ceremonies are completed the members of the family do not leave the inside of the house, while at the same time they divest their bodies of all decorations.

4. Among the tribes of the Tsarisen, Paiwan, and Puyuma groups mourning dress is worn. The superstition obtains with most of the tribes that the spirit after death requires the personal belongings of the one who died, and for that reason these are buried with the dead body.

Sickness

The most common sickness prevalent among the savage tribes of Formosa is malarial fever. Eye troubles are next in order of frequency. Among the northern Atayal tribes there are considerable lung troubles. * * * As to the cause of sickness, it is generally believed to be punishment inflicted by the spirits of the dead. Among the tribes of the Atayal and Paiwan groups a superstition obtains to the effect that if a sick person can balance a round particle on the end of a pipe then recovery is certain; on the other hand, should the particle fall to the ground it is a sign that spirits are opposed to recovery. Among the Vonuum, Tsou, Paiwan, and Amis groups, in advanced stages of disease the body of the patient is cleaned with leaves. The tribes of the Tsarisen group shampoo their sick members in advanced stages of disease, while in the early stages of suffering from snake bites, sucking the wound is resorted to.

Religion

The ideas concerning after-death which commonly obtain throughout the various tribes are as follows:

1. After death the spirit continues to live.

2. Dream is a medium through which the spirits of the dead may communicate with the living.

3. The spirits of the dead are sometimes given to the acts of the devil.

4. The spirits of one's ancestors are able to counteract the evil done by other spirits.

5. The spirits of one's ancestors have also the power to cause disaster.

As a natural outgrowth of these superstitions ancestor worship became a recognized institution. The Atayal and Paiwan groups believe the virgin forests to be the abode of the spirits of their ancestors. The tribes of the Tsou and Tsarisen groups consider certain old trees to be the abode of the spirits of their ancestors, while the Vonuum, Puyuma, and Amis tribes believe they live in the azure skies. The idea is so far advanced with the tribes of the Paiwan group that they never destroy the trees within a certain designated sacred precinct, which precincts are in reality their places of worship. All of the savage tribes worship with much reverence the supposed dwelling places of the spirits of their ancestors. In fact, this worship seems to constitute the greater part of their religion.

It is generally recognized by all tribes that good or bad crops depend upon the extent of the protection which they afford to the spirits of their ancestors. Accordingly before the sowing of the seed or after the harvesting of a crop, certain ceremonies are indulged in, these ceremonies partaking of the nature of ancestral worship.

In case of sickness it is supposed that all suffering is due to a visitation of evil spirits, and ancestral worship is indulged in for the sake of combatting the work of such spirits.

In soliciting the aid of the spirits of their ancestors certain forms are used, as, for instance, three whistles or the pouring of wine on the ground three successive times.

This idea of appealing to the spirits of their ancestors for aid in whatever undertakings they may be desirous of embarking upon has advanced a step farther in most of the tribes, in that the appeals are made through the interposition of a third person. Generally the old men and women of the various tribes are supposed to possess powers akin to those attributed to witches, and for this reason perform the religious rites for the tribes.

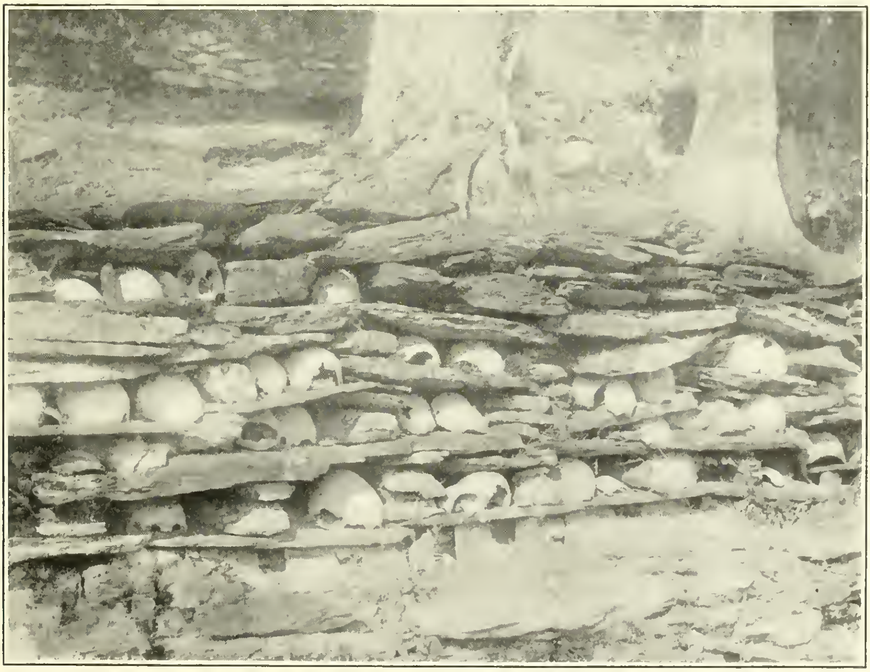
As the idea of worshiping the spirit of ancestors advanced, there developed a strong hatred for the spirits of others than ancestors. Originally the word for spirit in the various savage dialects or languages conveyed but one idea; gradually the term came to suggest reverence as well as hatred—reverence when the term was applied to the spirit of the ancestors and hatred when applied to other spirits.

There exists among the various tribes a faith termed "parisi." It embraces the idea of religious purification to dispel evil spirits or the work of such spirits. This ceremony of purification is performed at the time of the ancestral festival. Abstinence from food or drink during sickness and the ceremony of cleansing from evil spirits at the time of death are also classed as acts of "parisi." A neglect to perform the ceremonies of "parisi" at the required times is considered to be a forerunner of calamity.

Superstition

Mr. Ino cites a large number of instances of superstitious ideas which prevail among the various tribes. Probably the most interesting among these is that which has to do with head-hunting. He states that the practice of head-hunting originally stood for nothing more than a mark of superiority in combat. Gradually this practice became part of their superstitions. For instance, the tribes of the Atayal group now consider that the spirits of their ancestors will not be satisfied unless a human head is part of the offering made at the ancestral ceremonies. Likewise in the case of a dispute between two or more persons, the spirit of his ancestors will guide and protect the one whose cause is just, so that he may secure the first human head, and thereby win his case.

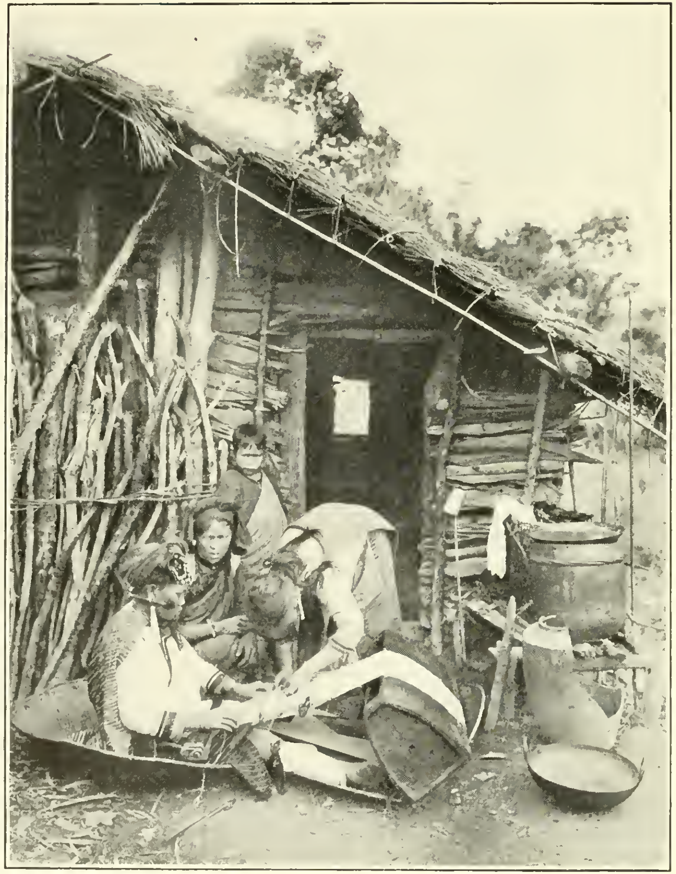
THE "KONKAI" OR DWELLING HOUSE OF THE UNMARRIED MALES OF THE TSOU GROUP



HUMAN SKULLS ON THE SKULL SHELVES OF THE TSARISEN SAVAGES

SAVAGE "DUG-OUTS" ON LAKE CANDIDIUS IN CENTRAL FORMOSA

ATAYAL SAVAGE VILLAGE



ATAYAL WOMEN WEAVING CLOTH

MARRIED ATAYAL WOMAN. TATTOO MARKS ON SIDES OF THE FACE

OUR PRESENT KNOWLEDGE OF CANAL RAYS: A DETAILED BIBLIOGRAPHY

By GORDON SCOTT FULCHER

Introduction

My object in compiling the following collection and correlation of the chief facts and theories regarding canal rays, as published to date by various experimenters, is two-fold.

First, it is hoped that the paper will prove valuable in itself. It aims to be complete, to include all important phenomena discovered, and to give exact references where details and methods may be found. It should be an accurate map of the boundaries of knowledge in this domain of Physics, and should prove suggestive to research by indicating unexplored regions, and helpful to theorists by containing the important phenomena to be explained and the suggestions put forward by others.

Second, it is hoped that the paper may illustrate the general method well enough to commend its use by others in connection with other branches of Physics, that these, too, may be mapped. Every physicist would value greatly such a boiling down of the literature in his field.

In making the compilation, the articles were read as far as possible in chronological order, notes of facts reported being made on cards and slipped into a card index under suitable heads. When all the articles had been read, it was a simple matter to put together the facts thus garnered. The method is perfectly flexible; results reported later can easily be incorporated.

I shall be under deep obligation to any who will let me know of such mistakes or omissions as they may find in the following article.

I am indebted to the authorities of Clark University for the privilege of using their fine Physical Library.

The subjects included in the present paper are arranged under the following heads:

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PARTIAL LIST OF ARTICLES ON POSITIVE RAYS OTHER THAN CANAL RAYS.

POSITIVE RAYS IN GENERAL: GR(726-9, 380-5); also Ann. Phys. 25, 882.
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K_1-RAYS: G1(698, 47); G3(207); G6(229, 373).
S_1-RAYS: G2; G6(230, 374); Tm7(363); Kz1; Tm8(664).
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II. GENERAL DESCRIPTION.

When a discharge is passed through an exhausted tube divided into two compartments by a perforated metal cathode, luminous bundles of rays appear, extending from the holes in the cathode back away from the anode. These are the canal rays, discovered and named by Goldstein—G1 (692,39). Similar rays may be obtained with other arrangements of the cathode, but the rays obtained under the simplest conditions, *i. e.,* when the two compartments communicate only through the perforations in the cathode, alone will be considered in what follows.

The rays move in straight lines except in a magnetic or in an electric field. They excite glass and some other substances placed in their path to fluoresce temporarily, thus rendering the place where they strike them visible. They consist for the most part of positively charged particles of matter, with a mass not less than the hydrogen atom. With these preliminary remarks, we proceed to give a summary of their properties as determined so far by experimental research.

Several authors have suggested changing the name from canal rays (Kanalstrahlen) to anode or positive rays—W8(660), Ew3(300), Tm3(561). By "canal rays" as used here is meant a specific form of positive rays.

For brief general discussion of canal rays, see the following: S1; Tm1; Sm4; S4; Wly1; Ew3; And1; S17; Tm4; Tm5; Mn1; GR(726-9); of which the most complete is Ew3. For photo of rays see Prt1 Taf. VII, f14.

III. EXPERIMENTAL RESULTS.

1. APPARATUS.

Illustrations of Discharge Tubes.

Original tube: G1f1; Sm4f49.

Simple tubes: G1ff2 and 3; Bg1f1; WSff1 and 2; W1f2; W3f3; Ew1ff1 and 2; Bo1f1; G3f1; S13f1; Hl2ff5, 6; SHf1; Tm7f12; Mn1f17.

To show charge: Prn1ff1 and 2; V1f6; WSff1, 2, 3 and 4; Ln2ff1, 2; Au1f1; Au2f1; Tm8f5.

To show magnetic deflection: W2f1; W3f4; W5f7; S1f119; W9ff1 and 2; S4ff224 and 225; Tm3f2; Tm8ff1, 2 and 6.

To show electrostatic effects: V3f2; W5ff2, 5, 6 and 7; W6f1; W9ff1 and 2; S13f8; Tm3f2; Tm7f2.

To show fluorescence: Ar1f3; W7f1; Sm2ff1 and 2.

To show secondary emission: Tm2f1; F1ff1 and 2; Au2ff1, 2, 3 and 4; F2f1.

To show ionization: WSff2, 3, 4 and 5.
To show mechanical action: Sw1ff1 and 3.
To measure energy radiated: W11(420).
With alkaline gases: SSff1 and 2.
For very slow rays: S2f1; cf. Wh3(464), Ew3(308).

Suggestions for Obtaining the Canal Rays.

To obtain "Pure" Canal Rays, that is, to prevent cathode rays from "striking back," thus obscuring the canal rays:

1. Perforations in cathode must not be too large. The lower the gas pressure and the thicker the cathode, the larger they may be: G1(697,45); G3(205); Ew3(298). With extreme vacuum, however, cathode rays may appear: W1(170); W3(446).
2. Cathode rays may be bent aside with a weak magnet: G3(206); W5(523,245). They may be distinguished from canal rays by their magnetic or electrostatic deflection or by their charge: W5(523, 245); or by fluorescence excited: G4(11, 101).

To obtain "Slow" Canal Rays, even with high vacuum:

1. An alloy of Na and K, or Ca may be used on cathode: Wh3(464); Ew3(307); Tm3(562).
2. Gas may be ionized by some other agent: S2(585); Wh3(464); Ew3(308).

Fluorescent Screen; a willemite screen is best: Tm3(562).

Pure Gas filling is necessary for some experiments. For precautions and devices used see the following:

H_2. W4(423); W5(525, 255); W6(591, Hittorf); SH(93); F1(154); S13(28,407); S19(400); Ps2(248).

O_2. W4(423); W5(525, 256); W8(661); SH(93); Ps3(261).

He. Rau1(422); Tm3(568).

Hg. W5(525, 255); S19(400).

2. COLOR OF THE BUNDLES OF RAYS.

In N or Air. Apparently bright chamois yellow: G1(692, 696, 39, 44); G3(205). Due to diffuse secondary rays: G2(133); G6(229).
Really bluish: Bg1(695); G2(133); G6(229); Kn3(37).

In O_2. Yellow-pink: G1(696, 44). Turns bluish as potential rises: Ps4(999);

In H_2. Rosy: G1(696, 44). Color very sensitive to impurities in gas, is red for pure H: S13(28, 407).

In H_2 and Na vapor. Brilliant sodium yellow: SS(459).

In H_2 and K vapor. Beautiful violet like potassium Bunsen flame: SS(460).

In CO_2. Greenish gray, white: G1(696, 44).

In N_2O. Momentarily gray, becomes blue in 5 sec.: Kn3(37).

In illuminating gas. Gray: Kn3(37).

In General.—Color is the same as that of first cathode layer: G1(696, 44).
Color is independent of the material of cathode: G1(697, 45).
Color depends to some extent on velocity: S10(254); S23(811).

3. PROPAGATION OF THE CANAL RAYS.

PROPAGATION IS RECTILINEAR except in a magnetic or electrostatic field: G1(694, 41); Sm4(109). Any obstacle in their path casts a sharp shadow on a screen: G1(698, 46).

DIRECTION OF PROPAGATION.

Relation to Cathode.

Plane cathode: G1(694,41); Ew3(299).

Each bundle slightly divergent: V3(15); Tm3(1017).

Axes of the various bundles converge slightly toward a central axis: W5(469); G5(70); S13(29, 408); G6(236).

Convergence increases with vacuum, bundles may cross.

Convergence greatest for circle of holes farthest from the center.

Front surface of cathode sufficiently concave.

Axes of various bundles may be parallel or diverge from a central axis: G1(695, 43); S13f3b.

Front surface convex. Bundles converge and may cross: S13f3a.

In general:

Direction is approximately normal to the front surface of cathode: Wh2(424); G3(205).

Direction is independent of shape of back surface, that is, the surface turned away from the anode: G1(695, 43).

Direction is independent of the obliquity of the canals, but intensity may be decreased by rays striking the sides: G1(695, 43).

Relation to Cathode Afflux and cathode rays.

Apparently the rays are the prolongation through the cathode, of the cathode afflux, both always having the same direction: V1; Wh2(423); V3(15). By deflecting the cathode afflux the canal ray bundles are deflected. Relation to cathode rays only apparent: G1(695, 43); G6(236).

Canal rays come from those holes alone which are covered by the first cathode layer: G1(695, 43); Wh2(423)f1; G5(70); G6(236).

DISPERSION, due to collision with gas molecules.

Dispersion greater the larger the molecules: SH(96), least in H_2: S1(346), greater in Hg vapor: SH(96).

Little dispersion for high discharge potentials: S16(81).

Diffuse rays produced: G6(239); Tm7(359).

ABSORPTION OF THE RAYS.

By gas.

Independent of the material of the cathode (Al, Fe, Pt): Ew1(182).

Decreases as velocity increases, pressure being constant: Ln2(196).

With constant velocity, the maximum distance penetrated by the rays as measured with an electrode, depends merely on the mean free path of the gas molecules, at a given pressure being greater in H_2 than in O_2, in O_2 than in CO_2: Ew1(182, 198); Ew3(309); S4(606); Ln2(196); W11(437).

Also shown in connection with the Doppler effect: Ew3(312).

Absorption of the Rays.

By thin film of grease.

Thin film on electrode reduced charge received 95%. After polishing electrode with flannel, only 50% penetrated: Au2(314).

Length of rays increases with decreasing pressure; visible rays may be over 50 cm. long: G1(695, 43); Sm4(109).

Reflection on Striking an Obstacle.

Diffuse: Au2(318).

Per cent reflected is a function of the discharge potential, reaching a maximum at a low potential: F1(156).

At 2,500 volts, more than 10% are reflected from Pt, Ag, or Cu: F1(155).

At 600 volts, about 50% are reflected from Pt, Ag, or Cu: F1(156).

Reflection on glass wall produces thick bright layer when near enough to cathode: Rau1(421).

Shown by Doppler effect in spectrum of light received by a slit at the end of tube: HK(566); S13(41, 423).

20 to 35% of H rays reflected: S13(41, 423).

4. FLUORESCENCE EXCITED.

On Glass Wall.

In air.

Color shows great variations, even with same glass: W5(524, 252).

Green, yellow, reddish yellow, and salmon observed: G1(697,45); G3(211); Ar1(326); W2(10); W3(447); V3(15); G4; W5(524, 252).

Differences due to variations in gas filling: W5(524, 252).

Color differs for deflectable and non-deflectable rays.

Deflectable excite bright green fluorescence; non-deflectable, a weak yellow brown fluorescence: W4(432, 435); W6(589); W9(675); Sm4(111); S4(649).

In helium. Sodium light and green fluorescence: Rau1(421).

Deflected fluorescence blue: Rau1(422).

In hydrogen. With pure H, fluorescence is pure green: W5(525, 255); W6(590); S4(649); Rau1(421).

With impure H, undeflected part is yellowish: W5(525, 255).

With potassium glass, fluorescence is weak blue: W5(525, 256).

In mercury vapor. Brownish or salmon red, no green: W5(525, 255); W6(590); S4(649).

White?: SH(96).

In nitrogen. Sodium light persists in spite of all efforts to get rid of oxygen: Rau1(421).

Glass wall previously exposed to cathode rays, at first shows no sodium light: Rau1(422).

In oxygen. Brown fluorescence, no green: W5(525, 256); W6(590); S4(649).

Sodium light alone appears after careful drying: Rau1(421).

No fluorescence with potassium glass: W5(525, 256).

In general. Weak effect compared with that of cathode rays: Ew3(302).
Temporary effect, soon dying down, but may be revived by heating: Ar1(326).
Color depends on gas filling, very sensitive to impurities: W5(524, 253); W6(589). Also depends on glass: W5(525, 256).
Differences persist even for very low pressures, hence are not due to differences of absorption: W6(590).
Spectrum is always a line spectrum: Ew3(302).
Strongest fluorescence in the case of H: W4(435), cf. G3(210).
Sodium light appears inside of glass wall and is easily distinguishable from cathode ray fluorescence: G4; V3(15); Ew3(302).

ON METALS AND METALLIC SALTS.

Cobalt, Manganese, Mercury, Nickel, and Thallium Salts show no fluorescence: Ar1(326); Sm2(706).
Solid solutions: See Ar1(326); Sm2(706, 708).
Aluminum. Polished metal shows no fluorescence: W7.
Oxide. Pure Al_2O_3 does not fluoresce: Sm3(625).
One part in 10,000 of chrome oxide causes bright red fluorescence: Sm3(625); Ew3(304). A trace of CuO causes weak green fluorescence, which becomes bluish and then blue as more CuO is added: Sm3(626); Cf. W7; S4(649).
Cadmium salts show yellow fluorescence: Ar1(326); Sm2(706).
Oxide. Weak greenish fluorescence in H_2 or O_2: W7; S4(649).
Calcium salts. White fluorescence: Ar1(326). Bluish; Sm2(706).
Caesium salts show bright blue fluorescence: Tr1(142).
Copper oxide. No fluorescence in O_2 or H_2: W7.
Iron salts. No fluorescence: Ar1(326); Sm2(706).
Oxide. No fluorescence: W7.
Lithium. Salts show weak red fluorescence: Ar1(326); G6(229); Tr1(141); Tm3(1017). Chloride becomes black in H_2: Tr1(141).
Magnesium. Salts show green fluorescence, line spectrum: G6(229).
Oxide obtained by burning Mg shows red fluorescence in O_2 or H_2: W7; S4(649).
Fluorescence probably due to an oxide impurity held in solid solution: Sm3(633).
Potassium. Pure metal shows no fluorescence: Tm3(1017).
Rubidium salts show red and blue fluorescence: Tr1(142).
Sodium. Pure metal shows no fluorescence: Tm2(214); Tm3(1017).
Sodium glass. Gold yellow fluorescence, D-line: G4; G6(229).
" oxide. Greenish yellow: Tm2(214).
" salts. Red yellow, D-line, no noticeable discoloration of salts: Ar1(326); Sm2(705).
Strontium salts. Rose-white fluorescence: Ar1(326).
Zinc. Salts show green fluorescence: Ar1(326).
Willemite dusted on glass fluoresces brightly, especially in H_2: Tm3(562, 570).

Zinc oxide.

1. When prepared by burning thoroughly in O_2, it showed an intense green fluorescence: W6(590); Tf1(613); S4(649).

Oxide became coffee-colored and sticky: Tf1(614).

Oxide permanently discolored yellow during fluorescence: W6(590); W7.

White color and power to fluoresce restored by heating: Tf1(616).

Oxygen is released during the fluorescence: W6(590); Tf1(613).

No chemical change occurs large enough to detect by balance: Tf1(614).

Oxide can be discolored and power to fluoresce be removed by intense pressure: Tf1(615).

2. Chemically precipitated oxide shows little or no fluorescence: W6(590); Tf1(616).

Oxide may be purified chemically until it will no longer fluoresce: Sm3(623, 628).

Minute traces of cadmium oxide caused it to show an intense green fluorescence: Sm3(628).

Flakes or smoke from burned Zn show no fluorescence unless heated: S3(390).

Explanation offered is that pure ZnO does not fluoresce except when it contains some other oxide in solid solution: Sm3(623, 628); cf. Tf2.

Metallic Oxides in General.

Pure oxides, chemically obtained, do not fluoresce: Sm2(707); Sm3(625, 628, 633); Ew3(303).

Oxides obtained by burning the metal may fluoresce: Ew3(303).

Oxides containing other oxides in solid solution may fluoresce: Sm2(707); Sm3(625, 628, 633).

Fluorescence the same in either H_2 or O_2: Ew3(303).

Fluorescence in General. S4(649).

Temporary. All substances soon lose capacity to fluoresce in canal rays: Ar1(326); Sm2(706); W6(590); W7.

Extremely sensitive to minute quantities of impurity: Sm2(710).

Superficial: Ar1(326); Sm2(706).

Spectrum. As fluorescence dies down spectrum bands widen out and finally disappear in a continuous spectrum: Sm2(707, 711).

5. CHARGE CARRIED BY THE RAYS.

Rays Positively Charged for the most part.

Shown by the direction of the magnetic and electrostatic deflection (see below): Tm1(521); Sm4(110).

Shown by the positive charge received by a Faraday cylinder or electrode struck by the rays, cathode being earthed: Prn1; W1; W3(446); Ew1(175); Bg1(692); W5(524, 251); Ln2(198); W9(671); Au1; F1(153); Pry1.

Note.—In order to give the true current carried by the rays, charge received by an electrode must be corrected for two secondary effects elsewhere described, viz:

(1) Reflection of rays from electrode (see § 3), and

(2) Secondary emission of cathode rays excited (see § 9).

Nevertheless, Austin's work seems to be conclusive: Au1.

Failure to consider these effects may account for the following negative results reported: Ar1(327); V1; V3(16); Ln2(180); Bg1(692).

SOME NEGATIVELY CHARGED, as shown by the direction of the magnetic deflection: W5(262); Tm3(568); Tm8(671).

Proportion of negative rays to whole is small: W10(212).

SOME RAYS UNCHARGED for a portion of their path: Tm8(670).

CURRENT CARRIED BY THE RAYS.

Ratio of current flowing to earth from electrode, to total discharge current, determined under varying conditions of pressure and tension, in air, O_2 and H_2: Ew1(176-82), plate I; Ln2(198); cf. Pry(448).

Maximum current measured about 10^{-1} amp.: Ew1, plate I.

No correction for secondary emission: F1(153).

Ratio reaches a maximum about at pressure when cathode ray fluorescence begins: PryI(448).

Undeflected rays also charged in part: W4(434); W9(671, 673).

6. MAGNETIC DEFLECTION.

DIFFICULTY IN OBSERVING EFFECT.

First overcome by W. Wien, in 1898: W2(11); W3(448); W4(423).

Effect a thousand times smaller than in the case of the cathode rays.

Main discharge must be protected from the influence of the strong magnetic field employed: W2(11); W3(448); W4(422); G5(70); W5(523, 244); G6(237); Tm3(563).

Negative results reported: G1(698, 46); Ar1(325); Prt1; V1; V3(15); G3(208).

Suggestions for observing effect: W5(523, 245); Tm3(562).

SENSE OF DEFLECTION, such as to prove the positive charge carried by the rays: W2(12); W3(448); W5(523, 245); Tm3(568).

Part of the rays are deflected in the opposite sense, indicating that part of the rays for a portion of their path are negatively charged: W5(262); Tm3(568).

CHARACTER OF THE DEFLECTION.

Non-uniform, spot drawn out in streak, part undeflected: W2(12); W3(448); W4(431); Rau1(422); Tm3(564), 568).

Diagram of deflection streak in air, also in H_2 shown in Tm3.

Not due to impurity in the gas filling: W4(431).

Deflected fluorescence brighter than undeflected, in H_2: W4(432); W6(589).

May differ in color from undeflected: W4(432); W9(675); Sm4(111); S4(649). Most deflected fluorescence is always green, but becomes very faint if gas is carefully purified of H_2: W10(213).

Deflected beam much less bright than undeflected: W4(432, 435).

MAGNITUDE OF MAXIMUM MAGNETIC DEFLECTION.

Maximum deflection about 2 cm. with field of 500 C. G. S. units, tension 30,000 v., screen at a distance of 7 cm. from cathode: W4(431); W5(561, 263); W8(663).

Originally reported deflection much smaller: W2(12); W3(448).

Independent of gas and also of cathode material. In H_2, however, a larger proportion seem to be deflected nearly the maximum amount: W4(431); W9(674); Tm3(575).

LONG CANAL RAY BEAM. Curious behavior in magnetic field: Pl1(1008).

7. ELECTROSTATIC DEFLECTION.

DIFFICULT TO OBSERVE because gas becomes ionized by the rays, and electric field cannot be maintained: W2(11); W3(447); W4(425).

Effect small; first observed by W. Wien in 1898: W2(10); W3(447).

SENSE OF DEFLECTION same as that of magnetic deflection: W2(11), etc.

CHARACTER. Same as that of magnetic deflection: W5(560, 259); Tm3(564).

MAGNITUDE. With a field of 400 v./cm., discharge potential of 10.000 v., length of plates 5 cm., distance of screen 10 cm., a deflection of about 1 cm. would be obtained: W5(561, 259, 264).

ELECTROSTATIC ACCELERATION OF RAYS.

By applying a field parallel to the rays, the fluorescence can be weakened or brightened according to direction of field: W5(561, 260).

8. SIMULTANEOUS MAGNETIC AND ELECTROSTATIC DEFLECTION.

EXPERIMENT due to W. Wien: W5(561, 261).

Magnetic and electrostatic fields are superposed, and so arranged that they tend to deflect the rays in mutually perpendicular planes. The resultant deflection streak is observed on the glass or willemite screen at the end of the tube.

WITH ORDINARY LOW PRESSURES.

Fairly straight diagonal streak extending from origin, in air, H_2 or pure O_2: W5(561, 263); W6(588); W8(661-3). For diagrams see Tm3(568, 571).

WITH EXTREMELY LOW PRESSURES.

Undeflected spot and negative branch disappear: Tm3(572).

Streak breaks up into two or three patches.

Same two patches for all gases air, H_2, O_2, He, CO_2, Ar, and Ne. He giving, in addition, a third patch: Tm3(573, 575); Tm6(295).

One patch is deflected the amount to be expected if canal rays are singly charged hydrogen atoms.

Second patch corresponds to singly charged hydrogen molecules.

Third patch, obtained under certain conditions with helium, corresponds to singly charged helium molecules: Tm3(571).

Effect not due to presence of H_2 as impurity. Brightness of fluorescence patch measured photometrically and found to be the same whether extreme precautions were taken to eliminate H_2 or not: Tm6(295); Tm7(360); cf. W10(212).

Hydrogen canal rays abundant when no hydrogen ions can be detected in other parts of the tube: Tm8(680).

As pressure increases, patches enlarge, overlap and merge to form the continuous, fairly straight streak: Tm3(574).

9. SECONDARY EMISSION OF NEGATIVE RAYS FROM A METALLIC SURFACE STRUCK BY CANAL RAYS.

INTENSITY OF SECONDARY RADIATION.

Function of the *velocity* of the canal rays, few negative rays for low tensions (600 v.): F1(156); F3(301).

Kinetic energy of canal rays must exceed a certain value: Pry1(448).

Function of the *angle of incidence.*

Much less for normal than for greater angles of incidence in case of Al and brass: F1(153); F2(749); Au2(315); F3(306).

In case of Cu, variation is slight: F1(153); F3(306).

Depends on the *metal struck.*

For high tensions (30,000 to 75,000 v.), the secondary negative current emitted is the following per cent of the canal ray current: Al, 300 per cent; Zn, 170 per cent; Cu and Ag, 100 per cent; Pt, 80 per cent: F1(155). For brass, 6,000 v., 45 per cent: Au2(314).

Measurements complicated by the positive reflection, which for the lower tensions may overbalance the negative emission: F1(155).

Relation to cathode fall.

Metals which used as cathodes have the greatest cathode fall for a given pressure, show the least negative emission when struck by canal rays: Ew3(310).

VELOCITY.

Not very great, since emission is stopped if electrode is charged to a low positive potential: Tm2(213).

Varies considerably among the rays: Au2(318).

AVERAGE VELOCITY, that is, the velocity of most of the rays, measured by deflecting them magnetically through a curved canal, and determining the current received by an electrode at the end as a function of the field strength: F2(749).

Value is 3.2 to 3.5×10^8 cm. for Pt or Al: F2(749); F3(301, 304).

Independent of the velocity of canal rays: F2(749).

Independent of the gas (H_2 or air): F2(749).

Independent of the angle of incidence: F2(749).

Independent of the metal struck (Pt or Al): F2(749); F3(301, 304).

Same as that of secondary rays produced by cathode rays striking a metal: Ew3(310).

Distribution of the rays among different velocities shown by curves: F3(303). Varies with gas and with metal: F3(304).

10. CHEMICAL EFFECTS.

REDUCING EFFECT.

In H_2, $HgCl_2$ reduced to Hg_2Cl_2 to some depth, no fluorescence: Sm2(709). $FeCl_3$ reduced to $FeCl_2$: Sm2(710).

Various other metallic compounds reduced: Sm3(622).

In O_2, these reducing effects do not take place: Sm2(710).

Metallic oxides in solid solution are reduced, oxygen being evolved during fluorescence: W6(590); W7; Tf1(613); S4(654).

OXIDIZING EFFECT.

All oxidizable metals are superficially oxidized by the rays: Wh2(425); Sm2(708); S4(654); Sm3(622); Sm4(112).

Cu shows effect better than Cd, Al or Zn.

Oxidization proved by chemical analysis: Sm2(708).

Shaded parts of surface also oxidized as well as parts directly struck by the rays: Sm2(708).

Au, Ag, and Pt show no oxidization in four hours: Sm2(609).

PbO turns brown by formation of PbO_2: Sm2(709).

Hg_2Cl_2 turned black: Sm2(709).

Not a heat effect, red HgI_2 not changed to the yellow iodide: Sm2(708).

DISSOCIATING ACTION.

With acetylene, carbon is deposited on walls: Kn3(35).

No deposit where rays strike walls: Kn3(35).

N_2O and CO_2 easily dissociated by the rays: Kn3(37).

Dissociation of H_2 and O_2 may account for apparent chemical effects described above: Sm2(711); Sm3(622); Sm4(113); S4(654); Ew3(304).

Metallic compounds decomposed: V2; V4; Tr1(142); Ar1(327).

ACTION ON SENSITIZED PAPER.

Canal rays affect sensitized papers, rendering them less sensitive to daylight, so that by exposing a canal ray positive to sunlight, it may be changed to a negative: Zn1(38).

Celluloid paper is rendered more reflecting where rays strike: Zn1.

Photographic action slow, long exposure necessary: Prt1.

11. MECHANICAL EFFECTS.

DISINTEGRATION OF METALS struck by the rays: S4(630); Tm2(214).

Too small in amount to weigh: Kl1(871).

Varies for different metals: Al, none; Cu, small; Au and Pt, distinct deposit on walls of tubes; brass disintegrated but no deposit: Kl1(871).

Varies with gas, greater in air than in H_2 in case of Au and Pt.

Not sensitive to traces of impurity in gas: Kl1(872).

PENETRATING POWER.

Canal rays will penetrate only extremely thin thicknesses of metal, paper, or mica: W1; W3(445); V3(15). Metallic compounds decomposed: V2; V4; Tr1(142).

Penetrate deeper in Al than in Cu, a possible explanation of some of the secondary cathode ray emission phenomena: F3(307).

HEATING EFFECT.

Obstacles struck are warmed: V1(1341); Ar1(327); Sw1(393).

Heating of end of tube measured calorimetrically; 10 to 20 per cent of total energy of discharge regained as heat: Ew1(183, 199). Measured bolometrically: W4(425).

Mica mill-wheels rotated, probably a thermal radiation effect: Sw1(393).

12. MISCELLANEOUS EFFECTS.

CHARGED ELECTRODES do not appreciably affect rays: V1; V3(15); G3(208).

BUNDLES CROSS without any apparent interference: G1(698, 46).

IONIZATION OF GAS takes place if canal rays have sufficient velocity (500 v.): S13(170, 427).

Second discharge may be passed through part of tube traversed by the rays using only one-fourth the potential otherwise required: WS(470–3).

Effect makes the use of an electrostatic field difficult: W3(447).

SCREENING EFFECT. Electric waves are absorbed by a tube traversed by canal rays: WS(470).

13. SPECTRUM OF LIGHT FROM CANAL RAYS.

The light may be received in a collimator pointed in a direction parallel or perpendicular to the rays. In the former case, whatever light is being radiated from the particles forming the rays while they are in motion should show a Doppler effect, since the wave length of the light from the moving particles will be slightly altered by the motion in the line of sight, causing a shift in the position of the lines in the spectrum. There is always besides the "displaced line" the "rest line" with, usually, an "intensity minimum" between: S22(905).

ALUMINUM LINES show Doppler effect.—$\lambda\lambda$ 3944, 3962. Intensity weak: S23(822).

IN AIR. Band spectrum of N appears: G1(692, 39).

IN ARGON. Doppler effect observed for 20 lines surely; for ten more, probably: D1.

IN CARBON DIOXIDE.

Contains C line λ 4267 and H lines, all very bright. N, Swan, and C bands also present: Kn3(37).

Doppler effect shown by H lines and λ 4267: Kn3(37); S19f2(photo).

λ 4267. Shift of 5Å with 10,000 v.: Kn3(37).

H lines more intense for lower pressures: Kn3(37).

Band spectrum shows no Doppler effect: Kn3(37).

IN HELIUM.

Doppler effect shown by λ 4472 and other lines: S19f1(Rau); D1(589).

Negative results: Rau1(423); Hl2(15, 16).

IN HYDROGEN.

Contains main series line spectrum: Wlr1(132); SH(94)f4; S5(894, 462); S9(112, 249).

Also λ4688: S13(43, 425); S9(112, 249).

Also H band spectrum and sometimes metal lines: SH(94)f4; S5(461, 893); S13(43, 425).

Line spectrum relatively more intense, the greater the discharge potential: SH(95).

Intensity of shorter wave lengths increases faster: S10(253); S21(799). Hence, as potential increases, the intensity maximum in the series shifts to shorter wave lengths: S13(184, 444).

Doppler effect—see photo S5f1; Ps2, plate III; S20f1; SWff3 and 4.

Shown by all lines of line spectrum: S5(462, 894); S13(33, 414); Hl2(12); D1(589); Ps2(250).

Cathode fall must exceed 700 v.: S20(64).

Rest line sharp, intensity less than that of displaced line: S5(462, 894); S13(183, 443). Intensity closely related to that of band spectrum: S13(173, 43).

Intensity of displaced line not a function of pressure: S13(34, 415); not related to stationary intensity: S13(175, 434).

Ratio of intensities of displaced lines of different wave length in the same series is a function of the cathode fall: SSt(924).

Intensity distribution, or cross section of intensity is similar for all lines of series: Ps2(250); Ps4(997); cf. S13(182, 442); S21(799); SSt(924-5). For diagrams of intensity distribution see: HK(565); S13f5; Ps2(250).

Shift as a function of wave length.

$\Delta\lambda/\lambda$ constant for maximum displacement of all lines showing effect: S5(462, 894); S9(112, 249); S13(33, 414).

Constant for maximum intensity of displaced line: Ps2(251); Ps4(997); cf. S21(799).

Shift as a function of discharge potential. See Fig. 61.

Maximum shift proportional to the square root of potential approximately: S5(462).

Shift of about 5Å for velocity of 3×10^7cm.: Hl2(12); S13(33, 414).

Shift the same for light from all parts of rays: SW(745).

Second displaced line appears with low velocities, 800 to 2.000 v.: Ps2(252 and plate III).

Sharp for the lower velocities, widening for higher.

Band spectrum shows no Doppler effect: S5(463, 894); S13(43, 425).

IN SODIUM VAPOR.

Difficulties of experiment: SS(457); S5(463). Only one plate of a number, intense enough.

Contains main and first and second sub-series of line spectrum: S5(463).

Doppler effect observed in case of two doublets of first series, a fine, displaced line, shift not measurable: SS(460); S5(463).

IN MERCURY VAPOR.

Contains first and second sub-series of triplets: S9(112, 250).

Also λλ 4358, 4047, and 2537: SHK(463, 467).

Doppler effect. Unquestionably observed for 12 Hg lines: S18(233); S20f3.

λ 5461. Small displacement: S5(463).

Observed by Paschen: S20(65). No displacement observed with echelon, tension 60,000 v.: Hl1; Hl2(13).

λλ 4347, 4078. Distinctly observed only with high voltages, 45,000 to 60,000 v.: SHK(468); S13(180, 439).

Shift points to trebly charged atom as carrier: SHK(468).

λ 2537. Shift points to singly charged atom as carrier: SHK(467).

Lines of 1st and 2nd series of triplets: S5(463); SHK(468); S20(64).

Same modified shift, $\Delta\lambda/\lambda$, for all components of a triplet and for all triplets of both series: S9(112, 250); SHK(466); S13(181, 440).

Shift points to doubly charged atom as carrier: SHK(465).

Displaced intensity relatively very weak, greater for higher velocities and for shorter wave lengths: S13(176, 434); S20(63).

Effect independent of the presence of H_2: S20(65).

Discussion of Hull's negative results: S18; Hl3; S20; Hl4.

IN NITROGEN. See SHff2 and 3.

Contains both the band and series line spectra of N, but band spectra subside as potential increases: Hr3(568); SH(95).

Doppler effect.

λ 3995. Shift distinctly observed: S5(463); SH(94); Hr3(569) (photo).

Intensity minimum well defined: S10(256).

Width varies but slightly with cathode fall: Hr3(569).

Maximum shift points to singly charged N atom as carrier: Hr3(569).

λλ 5006/03, 4643/31/22/14/07/01, 4530, etc., all show shift similar in appearance and amount to λ 3995: Hr3(569).

Band spectra show no Doppler effect: S5(463); Hr3(568).

IN OXYGEN.

Contains:

(1) elementary line or spark spectrum of O: G1(696, 44); Wlr1; Ps3(261); Ps4(999); S23(814).

(2) series of triplets: Ps3(261). Become weaker with higher discharge potentials: **Ps4(999).**

(3) traces of bands: Wlr1.

Doppler effect shown by elementary line spectrum: Ps3(263); Ps4(998).

All lines in question show same displacement and appearance: Ps3(263); S23(814).

Doppler effect for triplets even with high velocities doubtful: Sg3(129); Ps3(263); Ps4(998); S21(804); S23(819).

Intensity very weak, shift not measurable: S23(821).

Intensity of displaced line obeys different laws from that of rest line increasing with the velocity of the rays: S18(232).

Displaced intensity varies with gas and, in any series, with λ: S13(176, 434); S20(63).

Ratio of stationary to displaced intensity same on any one spectrogram for all lines of one series: S13(182, 441).

Stationary intensity appears to vary in step with that of band spectrum, increasing with the pressure: S13(175, 434).

Absence of Doppler effect in some cases not well understood: Hl4(119).

Shift of Lines Toward Red, observed with collimator perpendicular to rays.

Definitely observed on all spectrograms taken, determined by measuring the position of lines in question with reference to certain band lines, most probably unshifted: S7; S8(107); S13(191, 452).

Amount 0.7 Å for H_β with 8,000 v.: S13(194, 453).

No shift observed by Hull for H or Hg lines: Hl1; Hl2(19).

Apparent shift may be due to error in setting collimator and may be the Doppler effect: S13(189, 450).

Broadening of Lines observed with collimator perpendicular to rays.

H lines greatly broadened, most just behind cathode: Hl1; Hl2(19).

Broadening increases with velocity, shorter wave lengths broaden more rapidly: S7; S8(107); S13(190, 451).

Also with pressure: S(42, 423).

Partly a Doppler effect: S13(191, 452).

Less than Doppler effect in the ratio, velocity of rays to that of light: S8(109).

Hg lines show slight broadening: Hl1.

He lines show no broadening: Hl2(19).

14. PARTIAL POLARIZATION OF LIGHT.

Slight effect reported by Stark in case of H lines, vibrations parallel to rays being more intense than those perpendicular to their direction, difference very small and difficult to observe: S7; S8(105, 106); S18(230).

No polarization as great as one-half per cent of light was detected by Hull, using optical glass window and very sensitive Nicol prism and Savart plate: Hl1; Hl2(17); Hl3(234).

IV. MATHEMATICAL THEORY.

1. NOTATION.

c = velocity of light.
e = charge on each particle.
E = energy of n particles.
F = electrostatic field strength.
H = magnetic field strength.
l = distance from cathode to screen.
m = mass of each particle.
n = number of particles.
$q = ne$ = charge on n particles.
ρ = radius of curvature of path in magnetic field.
v = velocity of particles.
V = cathode fall.
x = *electrostatic deflection* on screen.
y = *magnetic deflection* on screen.
$\Delta\lambda_n$ = shift of line λ_n in Ångstrom units or tenth-meters.

$A = \frac{1}{2} F (l^2 - b^2)$
$B = \frac{1}{2} l^2 H.$

2. EQUATIONS.

(1) $\frac{e}{m} = \frac{v^2}{2V}$; W4(431); S5(464, 894); W5(560, 258); Ew3(309).

Kinetic energy of rays:

(2) $E = \frac{1}{2} nmv^2.$

(3) $E = \frac{v^2 qm}{2e}$; from definition of q.

(4) $E = neV$; from (1) and (2).

(5) $E = \alpha^2 a$; where α = some number greater than one. a = heat, in absolute mechanical units, generated by n particles striking an obstacle.

Velocity of rays:

(1) $v = \sqrt{2V \frac{e}{m}}$.

(6) $v = \alpha \sqrt{2 \frac{a}{q} \cdot \frac{e}{m}}$; from (2) and (5): Ew1(184).

(7) $v = \frac{l^2 H}{2y} \cdot \frac{e}{m}$: W4(431); W5(561, 261); S4(603).

(8) $v = \frac{4Vy}{l^2 H}$; from (7) and (1).

(9) $v = \frac{B}{y} \cdot \frac{e}{m}$; Tm3(565).

(11) $v = H\rho \frac{e}{m}$: Tm3(564).

(12) $v = \sqrt{\frac{F(l^2 - b^2)}{2x} \cdot \frac{e}{m}}$: W5(561, 261); S1(346); Tm3(564).

$$v = \sqrt{\frac{A}{x} \cdot \frac{e}{m}}.$$

(12a) $V = \dfrac{A}{2x}$.

(13) $v = \dfrac{F(l^2 - b^2)}{l^2 H} \cdot \dfrac{y}{x} = \dfrac{A}{B} \cdot \dfrac{y}{x}$: Tm3(564); W5(561, 261). [(12) and (7)].

(20) $v = c \dfrac{\Delta\lambda_n}{\lambda_n}$; S5(459, 464, 893, 894); Ew3(313).

Specific charge, e/m.

(1) $\dfrac{e}{m} = \dfrac{v^2}{2V}$.

(6) $\dfrac{e}{m} = \dfrac{v^2 q}{2a^2 a}$: Ew1(184). [(2) and (5)].

(7) $\dfrac{e}{m} = \dfrac{2yv}{l^2 H}$: W4(431); W5(561, 261); S4(603).

(9) $\dfrac{e}{m} = \dfrac{vy}{B}$: Tm3(565).

(10) $\dfrac{e}{m} = \dfrac{8y^2 V}{l^4 H^2}$: W4(431); S1(310, 345); S4(600). [(7) and (1)].

(11) $\dfrac{e}{m} = \dfrac{v}{H\rho}$: Tm3(564).

(12) $\dfrac{e}{m} = \dfrac{2xv^2}{F(l^2 - b^2)}$: W5(561, 261); S1(346); S4(603); Tm3(564).

$$\frac{e}{m} = \frac{v^2 x}{A}.$$

(14) $\dfrac{e}{m} = \dfrac{A}{B^2} \cdot \dfrac{y^2}{x}$: W5(561, 261); Tm3(567). [(7) and (12)].

(21) $\dfrac{e}{m} = \dfrac{c^2}{2V\lambda^2_n} (\Delta\lambda_n)^2$: S5(464, 894).

3. CALCULATIONS.

For calculation of the effect of lack of uniformity of the magnetic field upon the deflection see W4(426). For experimental method of integrating non-uniform field see Tm3(565).

Velocity of Rays, from simultaneous magnetic and electrostatic deflection using formula (13).

Maximum velocity is a function of the cathode fall and varies from 10^7 to 2×10^8 cm. (15,000 v.): W3(449); Ew3(306); W5(561, 263); Tm3(571); cf. Ew2(501); Ew1(186).

Maximum velocity for voltages above 15,000 v. is 2×10^8 cm.; W5(561, 263); Tm3(571); Tm8(668).

Velocity approximately the same for all the rays of one kind, as shown by the shape of the deflection streak: W5(561, 261); W6(588); Tm3(569); W8(664); St1(686). H rays have velocity $\sqrt{2}$ times that of H_2 rays.

VELOCITY OF THE SOURCES OF THE LIGHT SHOWING THE DOPPLER EFFECT.

Maximum velocity varies from 30 per cent to 85 per cent of the velocity of the canal rays computed from the cathode fall and the probable value of e/m: Ps2(257); SHK(464); S13(36, 417); S19(399).

Sources of the H series lines: Ps2(252); S13(36, 417). See Fig. 61. For low voltages the displaced line is composed of two lines whose maximum shifts are to each other as $1 : \sqrt{2}$

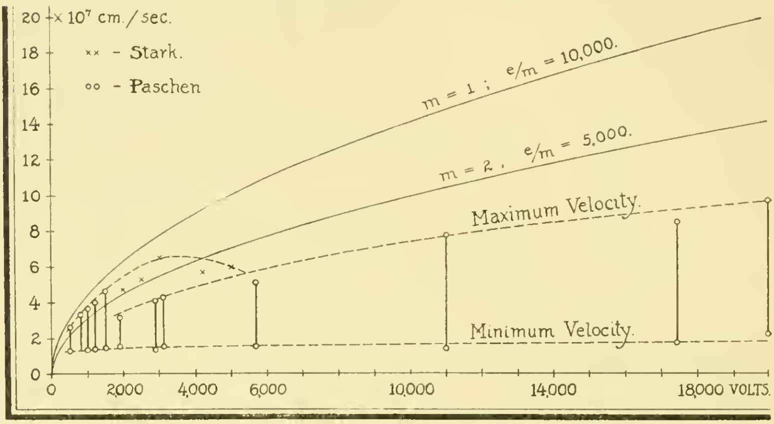

FIG. 61.—Range of velocities of sources of H lines as a function of the cathode fall in volts. Full lined curves are calculated, using formula (1).

Sources of O spark lines: Ps3(263); S23(815). See Fig. 62. Phenomenon seems similar to that with H, data not so complete.

Sources of He lines:

Maximum velocity half that calculated for the canal rays assuming e/m = 2500, m = 4: D1(590).

Sources of C lines:

Maximum velocity 0.9 times that calculated for canal rays assuming e/m = 800, m = 12: Kn3(36).

SPECIFIC CHARGE, e/m.

From magnetic deflection, equations (7) and (10), maximum values are:

In air. $e/m = 10^4$ (H_2 carefully eliminated): Tm3(569). Other values obtained range from 3×10^2: W2(12); W3(449), and 3.6×10^3: W5(561, 264), to 3.6×10^4: W4(432, 435).

In H_2. $e/m = 10^4$: W8(660, 662, 663); Tm3(571); Rau1(422).

In O_2. $e/m = 10^4$ (approximately): W5(562, 265): W8(663); Ew3(306).

In He. $e/m = 10^4$: Tm3(571); cf. Rau1(522).

In Ar. $e/m = 10^4$: Tm3(573).

At extremely low pressure, deflection strip divides into two patches, the maximum deflection of second giving for all gases (H, He, Air, Ar, Ne) $e/m = 5 \times 10^3$: Tm3(571); Tm8(664).

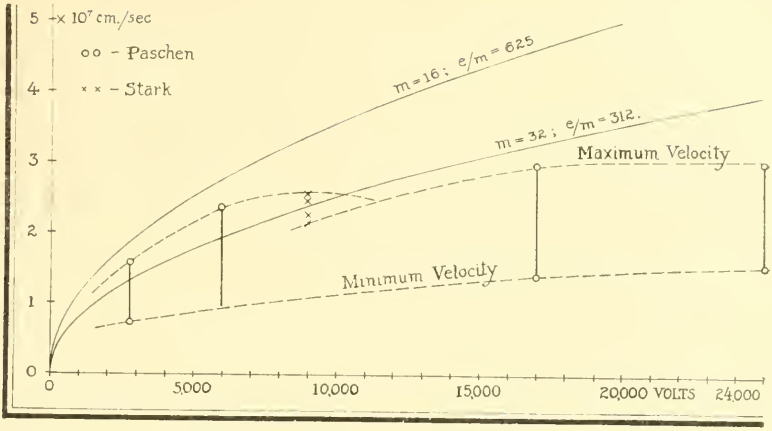

FIG. 62.—Range of velocities of sources of O spark lines as a function of the cathode fall. Full lined curves calculated from formula (1).

With He, a third patch may be divided off for which maximum e/m = 2.9 x 10^3: Tm3(571).

Maximum value of e/m independent of the pressure of gas: Tm3(575).

From Doppler effect, assuming the canal rays are the sources of light:

For H. e/m = 7,500 for V < 2,000 v.: S13(35, 416); Ps2(253).
= 3,000 for V > 2,000 v.: Ps2(253).

For O. e/m = 500 for V < 3,000 v.: Ps3(264); e/m = 584, S23(816).
= 180 for V > 3,000 v.: Ps3(264).

For C. e/m = 500 to 670: Kn3(36, 37).

For Al. e/m = 200: S23(823).

In general. As judged from the magnetic deflection, results are of same order for O, H, CO_2, He, Ar, and Air: W6(588); Tm3(575); Tm6(295).

Extreme precautions to get rid of H_2 do not affect result: Tm7(361); W8(661). In each gas, however pure, there seem to be besides rays characteristic of the gas (detected by the Doppler effect), also two kinds of rays having a specific charge equal to that of a singly charged hydrogen molecule and atom respectively: cf. W10(213).

V. THEORETICAL DISCUSSION AND EXPLANATION.

1. CONSTITUTION OF THE RAYS.

WHAT ARE THE CANAL RAYS?

Not Roentgen rays, do not affect photographic plate: Ar(327); GR(726).

Not cathode rays, much greater mass: Bo1(717).

Identical with first cathode layer particles: G1(692, 699); Wh2(423); Sm4(109). Prolongation of cathode afflux: V1; Wh2(422); Bg1(692).

Consist mostly of positively charged gas atoms, together with some metal atoms from electrodes, according to Doppler effect: Gr; W4(421); Ew3(316); W5(561, 263).

Always contain some rays with same mass as hydrogen atom, as shown by magnetic deflection: Tm3(575). Hydrogen seems to play a unique role in discharge tube phenomena: V2; V4. These singly charged H atoms and molecules may form the greater part of the rays even at high pressures: Hl3(235).

At extremely low pressures, consist mostly of two kinds of particles, singly charged hydrogen atoms and molecules, irrespective of the gas filling the tube: Tm3(575); Tm6(295).

Professor J. J. Thomson's results seem to prove that *various gases under the action of strong electric fields in extreme vacuum, give off identical carriers of positive electricity:* Tm3(575); Tm6(295).

Similar to α-rays: Ew3(310).

PLACE OF ORIGIN.

In gas beyond cathode dark space: W3(451); W4(422); G3(207); S1(133, 507); S4(602); Ew3(301).

Theory: Gas molecules ionized by cathode rays or positive rays from anode, start to move along a line of force, acquire considerable velocity, forming the cathode afflux, and shoot through the canals, forming the canal rays: S4(602). See diagram of lines of force in canals: S1(134, 508).

Not on cathode front surface or in canals because of shadows cast: Wh2; cf. G1(699); Gr; Ew3(299).

Not in dark space, since there is no ionization there and they could not acquire sufficient velocity: S2(583); Ps2(257); Ew3(307).

Not an anode: Ew1(193); Ew3(300); cf. Bg(696); Bo1(717).

EXPLANATION OF NON-HOMOGENEITY (shown by non-uniform magnetic deflection).

Not due to variations of velocity, slower rays would be more deflected, not less: S2(583); Ps3(257); Ew3(307).

Must be due to continuous variation of e/m since deflection streak is not fluted at ordinary pressures: Tm3(569, 572).

Assumption that e or m or both may be integral multiples of unit charge and unit mass (the H atom) respectively, is not sufficient: S2(583); Ps2(255); cf. W9(669, 675); Gr.

Complex nature of the rays, perhaps containing H, N, Al, Hg. atoms, not a sufficient explanation, since carefully purified gases have been tried, and no fluting effect obtained: Tm3; cf. Ew3(316).

Probable explanation. The mean value of e/m for each ray during its passage through the magnetic or electric field, is evidently the quantity which determines the deflection. By collision with stray corpuscles or negative electrons, any canal ray may become discharged and charged again so that its average charge may have any value between +e and —e. This also explains the negative deflection observed: S2(585); W5(561, 263); Tm3(570). See also W4(433, 435); W9(669, 670, 675, 677); Sm4(111); S4(604, 605); Tm1(520); SH(95); Ew3(307).

Other effects mentioned above, as the variation of e and m by steps, complexity of the rays, probably do enter, but are insufficient in themselves to explain the phenomena reported.

Mass may also change en route, molecules being formed of atoms and vice versa: Ew2(501).

Non-homogeneity disappears at very low pressures as then collisions are much less frequent: Tm3(575); Tm6; Tm7.

CHARGE.

While for the most part the rays are positively charged, by collision with negative electrons some of them at various stages of their career become neutralized and later perhaps negatively charged, as evidenced by magnetic deflection experiments: Tm8(670).

2. LIGHT FROM CANAL RAY REGION.

CENTERS OF EMISSION. The negative electrons, from the Zeeman effect: S13(23, 401).

SOURCES OR CARRIERS OF SERIES LINE SPECTRA.

All lines of one series have same carrier: S5(464, 894); S9(113, 250); S13(33, 414).

Sources are positively charged. For confirming experiments see S13(24, 403).

First hypothesis: Sources are the canal rays themselves, positive atoms, singly, doubly, or trebly charged: S5(464, 894); SH(95); S9(113, 250); Rau1(423); S13(34, 39, 415, 419); S23(830).

Main and first and second series of doublets (H, Ca, Hg, C, K, Na) have singly charged atom as carrier: S9(112, 249); S13(36–38, 416–419); SS(461); Kn3(36). Doubtful: S23(830).

Series of triplets of Hg have doubly charged atom as carrier: S9(112, 250); S13(38, 419); SHK(465). Doubtful: S23(830).

Some Hg lines, λλ 4078, 4347, appear to have trebly charged atom as carrier: S13(38, 419); SHK(468).

NOTE.—This hypothesis seems to be rendered doubtful by the discrepancy between the maximum velocity of the rays and that of the sources of the light showing the Doppler effect. If true, since the canal rays must probably be rendered luminous by the collision which ionized them, and emit most light while speeding up, no intensity minimum would be expected.

Second hypothesis: Sources are gas molecules hit and ionized by the rays. To see how this explains the curve of maximum velocities Fig. 61, consider the case of H rays and H_2 rays, having velocities u and 0.71 u respectively. Assuming perfectly elastic collision, maximum possible velocity is, for the collision of

(1) H ray with H atom, 1.00 u; (4) H ray with H molecule, 0.71 u;
(2) H_2 " " H " 0.94 u; (5) H_2 " " H " 0.67 u;
(3) H " " H_2 ray, 0.90 u; (6) H " forming " 0.71 u;

Assuming collision is not perfectly elastic, energy being lost in radiation and ionization, and that collisions of types (1), (2), (3), are less important with the higher cathode falls, the curve is accounted for.

Now to see whether this hypothesis explains the intensity minimum. Assuming; that gas molecules hit squarely enough to be ionized, alone emit light, the canal rays being mostly neutralized by the collisions; that ionization occurs only when the energy imparted exceeds a certain minimum; and that the intensity of the light emitted is proportional to the momentum given to the molecule as a result of the collision; the author has calculated by a laborious statistical method (starting with 10,000 canal rays and computing the directions and magnitudes of the velocities of the gas atoms hit in five generations of collisions) the probable distribution of intensity in the resulting Doppler effect. One set of curves is shown in Fig. 63.

The intensity minimum is seen to be distinct and of fairly constant width, in spite of the fact that the number of sources with small velocities is much greater than the number of the swifter sources. The importance of more data regarding the deflection streak and the Doppler effect so as to decide between these two theories is obvious.

CARRIERS OF BAND SPECTRUM. (Stark's hypothesis.)

Not the positive atoms while in motion since light shows no Doppler effect: S5(464, 894); SH(95).

Probably neutralized atoms formed by the collision of charged rays with gas atoms, the former being stopped by the collision: S4(605); S5(461, 893); S12(355); S13(43, 425); S19(399); Ew3(314).

Why canal rays neutralized by electrons and retaining their velocity do not emit the band spectrum is not explained.

DOPPLER EFFECT, INTENSITY MINIMUM.

Explanation. Either

(1) Rays of slow velocity are relatively few: W5(561, 263); W6(588); W8(663); S2(583); S13(31, 412); St1(686); Tm3(569). This assumption fails to explain the constancy of width of the intensity minimum; or

(2) Intensity of radiation is a function of the velocity: S10(253); S13(31, 177, 180, 412, 435, 439); Kn3(36); Ps2(259).

Velocity must exceed a certain minimum or no displaced line is obtained: S13(180, 439).

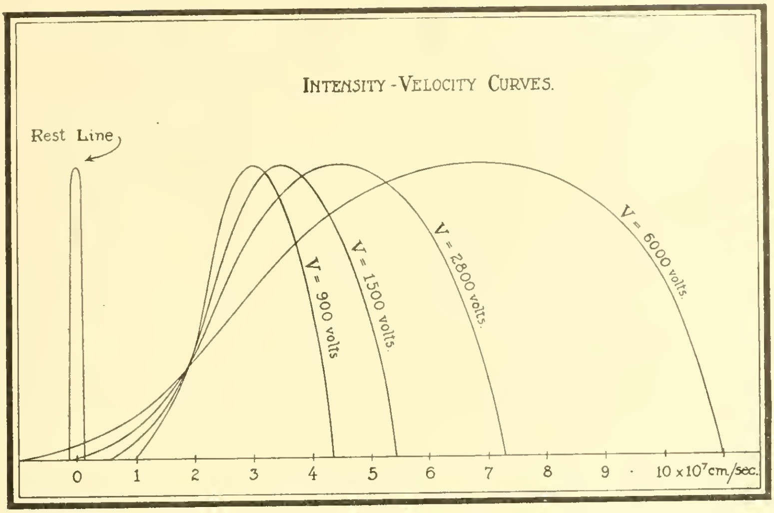

FIG. 63.—Doppler effect to be expected if sources of light are H gas atoms hit by H canal rays of fairly uniform velocity.

DOPPLER EFFECT, STATIONARY INTENSITY.

Explained as due to emission of light either

(1) By a positive atom on collision with a neutral atom which stops it, the intensity being proportional to the gas density: S13(172, 430). This hypothesis is not reconcilable with the existence of the intensity minimum; or

(2) By neutral atoms ionized by secondary negative rays created by the canal rays: S19(398); S22(917).

SHIFT TOWARDS THE RED.

Theoretical importance in deciding between the various electromagnetic theories of the emission of light by electrons in motion, those of Bucherer, Einstein, and Lorentz: St1(293).

EMISSION OF LIGHT BY AN ATOM.

The Doppler effect shown by light assumed to come from canal rays, since it may give a means of distinguishing the light emitted by singly charged atoms from that emitted by those which are neutral or doubly charged, promises valuable data as to the circumstances, even the mechanism concerned in this radiation of light. However, no theories advanced so far explain satisfactorily the phenomena observed, hence deductions from them seem premature. The theories are as numerous as the writers and at the present stage, it seems unnecessary to attempt the difficult task of abstracting them, but a partial list of articles on the emission of light by an atom based on the results of investigations with canal rays is subjoined: S8(104, 109); S10(251, 253); S12(360); S13(40, 174, 422, 432); Hl2(17–20); W11(428, 437); S16(80); SW; Ps2(259); St1; St2(683); S22. Also—

P. Lenard..............Ann. Phys. 17, 187.
C. Fredenhagen..........Verh. Deutsch. Phys. Ges. 9, 393-401.
C. Fredenhagen..........Phys. Zeitschr. 8, 729-737, 927-9.
G. Schott................Phys. Zeitschr. 9, 214-216.
G. Schott................Phil. Mag. 15, 172-198.
G. Schott................Ann. Phys. 25, 63-91.
J. Stark..................Phys. Zeitschr. 9, 85-94.

3. CHEMICAL EFFECTS.

No Direct Chemical Action of the rays other than that of splitting up the gas molecules, releasing their latent chemical activity.

Hence in O_2 oxidation takes place, in H_2 reduction: Sm2(708-710); Sm3(622); Sm4(113); S4(654); Ew3(304).

Disintegration. Double dependence on metal and gas indicates chemical process, perhaps indirect. Not sensitive to traces of impurity: Kl1(872).

Fluorescence.

(1) Explained as due to pressure of impact of rays: Tf1(616); Tf2; Ew3(304).

(2) Explained as accompanying chemical reaction indirectly produced by the rays, varying with the gas: Sm2(710).

Na light not the result of heating or oxidizing process: Rau1(421).

Solid solutions. Fluorescence explained

(1) as accompanying reduction of higher oxides: W7.

(2) as accompanying reduction of active compounds: Sm3(622).

4. SECONDARY EMISSION OF CATHODE RAYS.

Uniform Maximum Velocity explained by assuming electrons are merely released by canal rays, being shot out by the atom with a definite velocity. Distance penetrated by the rays determines how thick a layer the cathode rays must pass through before emerging, hence determines the distribution of cathode rays of less velocity: F2(750); F3(302).

Increase of Intensity with Angle of Incidence is explained by assuming canal rays do not penetrate so far, hence negative rays are not so much absorbed in emerging. Effect is more marked with Al than Cu since rays penetrate farther in the former: F3(306, 307).

Negative rays may be created by ultra-violet light or Roentgen rays, but probably not: F2(750); F3(301).

Amherst College, Amherst, Mass.,
November 1, 1908.

OBSERVATIONS ON LIVING WHITE WHALES (DELPHINAPTERUS LEUCAS); WITH A NOTE ON THE DENTITION OF DELPHINAPTERUS AND STENODELPHIS

By FREDERICK W. TRUE

Head Curator of Biology, U. S. National Museum

With One Plate

In June, 1908, I had an opportunity of studying two living white whales which were kept in confinement in a large tank on one of the piers at Atlantic City, New Jersey. Although living individuals of this species have been many times exhibited to the public, very little has been published regarding them, so far as I have been able to ascertain, and it seems to me, therefore, desirable to place on record the observations which I have made.

The two specimens exhibited at Atlantic City were both youngish, and one of them (which I will designate as specimen A) was in an enfeebled condition, either through disease or lack of nourishment. It died soon after I saw it, and the remains were towed out to sea. This individual was about 10 feet long and was reported to be a female.

The second individual (specimen B) was a young female 8 feet 2½ inches long in a straight line. It was very active when I saw it, but died about a month later, and the body was presented to the National Museum by Mr. A. M. Renshaw through Mr. J. S. Young.

The larger female (specimen A) was of a purplish white color, with darker purplish gray spots, lines and mottlings. The principal mottled area was on the head. There were several straight lines on the back about a foot long, each consisting of three striæ—a central dark purplish one, with a white edging, and a lighter purplish line on either side. The dorsal fin, or ridge, and the anterior edge of the pectorals were purplish gray, and some faint purplish lines indicated the position of the digits. The posterior margin of the pectorals was white. The flukes were similar in color to the pectorals. The head presented the blunt, rounded form characteristic of the species. Its girth increased from the eyes backward, but the neck, seen from above, presented a slight constriction. The thorax was nearly flat on top. The dorsal fin, or ridge, was quite sharp and distinct, beginning about opposite the tip of the pectorals when laid back against the body, and was about one foot long and of a grayish color. Beginning opposite the anterior end of the dorsal fin, the body, seen from above, assumed a form resembling a pillar consisting of three attached columns, laid horizontally. It was made up of a median dorsal rounded ridge, with a similar rounded mass below it on either side. This form, which was quite unlike that represented in any published figure of the animal, was probably due to extreme emaciation. The body tapered rapidly toward the flukes, the pedicel of which was very slender. The pectoral rested in a furrow which ran backward along the side of the body, and was probably due to emaciation.

From the same point of view, the upper lip appeared as a thick rounded ridge, above which was the protuberance of the "forehead," marked off by a concavity in front. The blowhole was nearly linear when closed, but oblong or elliptical when open.

This whale remained nearly motionless in a corner of the tank, with its head under water and its flukes held almost vertically downward, but raised its head from time to time to spout. The expiration took place as soon as the head came to the surface, and was very feeble and quick, and usually noiseless, but occasionally accompanied by a sound similar to that which a person makes in blowing dust off of an object, though rather more metallic. At the same time, drops of water ascended in a curve and fell forward some three or four feet beyond the head of the whale. Then the blowhole opened wider, the lower internal folds were seen to move, and inspiration took place with a rather faint sound. The flukes, as already mentioned, were held downward, and were waved about gently, the axis of motion being at the anterior base of the flukes. The pectorals were held horizontally and were nearly motionless.

The smaller female (specimen B) was of a light purplish color, with whitish "forehead," upper lip and blowhole. The posterior edges of both pectorals and flukes were dark purple, but with a white marginal line. On the top of the head a dark purplish band about 8 inches wide extended backward from the blowhole. Between this and the pectoral was a large oval area lighter in color than the surrounding parts, which area extended across the upper surface of the pectorals.

The external orifice of the ear was situated in a depression. The dorsal fin, or ridge, appeared smooth, except for a few cross-furrows at intervals of less than an inch apart. There appeared to be glandular openings in the longitudinal furrow below the dorsal ridge. The surface of the back along the median line began to assume a ridge-like shape about opposite the insertion of the pectorals, while the dorsal ridge, or fin, itself began about opposite the tips of these limbs when laid backward. The sharpness of the back in front of the dorsal fin nearly disappeared when the head was raised. A rounded ridge, or swelling, extended from the pectoral to the orifice of the ear. The posterior edge of the pectorals, or that nearest the body, was curved upward, as was also the outer edge, but in much less degree.

This female (specimen B) was constantly in motion, swimming back and forth across the tank in an irregular fashion. It usually remained under water from 2 to 3 minutes, then came to the surface with the head up, and spouted 5 or 6 times irregularly, lying between times with the top of the back out of water. Its swimming movements were also irregular. It sometimes "rolled," as dolphins do at sea—that is, with an undulating motion in a vertical plane. At other times it turned about lazily from side to side. Occasionally it turned suddenly on its side and gave a sharp stroke with its flukes, causing the body to move in a curve, but much of the time it remained motionless with a curved portion of the back out of water from about opposite the insertion of the pectorals to the posterior end of the dorsal fin, and both head and flukes curved downward. The head was occasionally turned from side to side at a considerable angle.

This whale, as already mentioned, spouted 5 or 6 times at irregular intervals of a few seconds each, after which it went down quite suddenly and remained under water from 1 to 5 minutes. At the expiration there was a distinct rather metallic sound, and at the same time drops of water ascended in a curve and fell forward invariably some 3 or 4 feet beyond the head of the whale. A gentler sound sometimes accompanied the inspiration, but it was usually noiseless.

The whale moved by strokes of the flukes. The flukes were held downward much of the time, with the two lobes in the same plane, but occasionally the lobes were at different angles, probably from unequal pressure of the water. The flukes were not put out of water at any time while the whale was under observation, although an attendant stated that it sometimes put them out. In sounding they were turned upward, but did not quite reach the surface. The whole tail was extremely flexible, and as it was turned about, the flukes were often at an angle with the surface of the water, but no screw-like motion was observable in them. They seemed, however, soft and flexible.

The pectorals were held out from the body, but quite close to it, with the posterior margin tilted upward. They were moved but little, and apparently only for steering and not as an aid in swimming. To turn the head down, the whale seemed to thrust the thorax upward violently, rather than to effect the movement by a stroke of the flukes. This peculiar movement was repeated many times and always in the same connection, so that it would appear to be characteristic rather than exceptional.

This whale was at times especially active, rolling and churning up the water, and on such occasions the expiration was accompanied by a louder "puff" than usual. It appeared to swim on its side under water a great deal of the time. Occasionally it made convulsive movements, as if shuddering, and moved its pectorals rather rapidly.

On one occasion I timed the movements of this whale, as regards remaining at the surface and below the surface, respectively. The results were as follows for 26½ consecutive minutes, the time under water being denoted by black-faced type and the time at the surface by light-faced type: **1**, 1, **2**, 1, **2**, 1½, **2**, 1, **1¼**, 6¼, **½**, 2, **½**, 2, (*a trifle*), 1, **1**, 1½.

The body of this whale was received at the National Museum on August 18, 1908, and the following measurements were taken:

Measurements of specimen B; female, Atlantic City, N. J., Aug. 18, 1908: Total length from tip of snout to notch of flukes in a straight line, 8 ft. 2½ in. (98½ in.); the same along the curves of the body, 8 ft. 11 in. (107 in.); greatest girth of body, 52½ in.; girth of head at eyes, 35; girth of neck, 38½; length from tip of snout to highest point of dorsal ridge (straight), 48; to blowhole, 8¼; to eye, 9; to ear, 14; to anterior base of pectoral, 22; to posterior base of pectoral, 27; to navel, 47; to anus, 71; length of pectoral along center, 12¼; length of pectoral from anterior base, 14; from posterior base, 10½; greatest breadth of pectoral, 7¾; breadth between axillæ, 17; transverse breadth of flukes, 23½; greatest antero-posterior breadth of flukes, 12½; depth of notch of flukes, 3; vertical depth of caudal peduncle, 7; length of eye, ¾; breadth of blowhole, 1¾; length of dorsal ridge, or fin, 10½; length of genital slit and anus, 9½; length of mammary slit, 1½; distance between anterior ends of mammary slits, 2½; distance between posterior ends of mammary slits, 2¾; distance from mammary slit to anus, 2; distance from notch of flukes to posterior end of pelvic bone when in the natural position, 31.

For purposes of comparison, I append measurements of a male observed at Provincetown, Mass., Aug. 16, 1893: Total length from tip of snout to notch of flukes, 13 ft. 1 in. (157 in.); length from tip of snout to anterior base of pectoral fin, 32 in.; to eye, 14¼; to ear, 21½; length of pectoral, 18; greatest breadth of pectoral, 13; transverse breadth of flukes, 37½; greatest antero-posterior breadth of flukes, 17 in.; depth of notch of flukes, 4; distance from notch of flukes to anus, 41; to prepuce, 54½.

Note on the Dentition of Delphinapterus and Stenodelphis.

In the literature relating to the white whale, the teeth are described as having simple conical crowns, like the typical dolphins. Dr. John Struthers, for example, remarked in 1895 that "the teeth of Beluga have all originally a simple conical fang and a simple conical crown."[1] An examination of young skulls in the National Museum, however, having the teeth, or a part of them, entirely unworn, shows that the crowns of at least four of the posterior teeth on either side of the lower jaw, and perhaps some in the upper jaw, are really trituberculate when perfect. The crowns of the teeth mentioned are somewhat flattened internally and curved inward at the apex. Situated on either side of the main cusp (anteriorly and posteriorly) and a little internally is a small, linear accessory cusp, which is attached to the crown of the tooth throughout its length. These accessory cusps do not reach the level of the apex of the main cusp.

The presence of these accessory cusps would at first appear to lend support to Professor Abel's opinion[2] that the genus *Delphinapterus* belongs in the family Iniidæ (Acrodelphidæ of Abel) rather than in the Delphinidæ. It seems to me probable, however, that the character of the teeth adds one more item to the evidence, chiefly paleontological, which is accumulating, that the two families cannot be kept separate, if the fossil forms are taken into consideration. Leaving out of account the genus *Stenodelphis,* the affinities of which are still in dispute, there are two other genera, at least, beside *Delphinapterus* in the family Delphinidæ in which the crowns of the teeth are not entirely simple cones. These genera are *Phocœna,* in which the teeth are appressed, and many of them multituberculate; and *Steno,* in which the enamel of the teeth is rugose. It is reasonable to suppose that the teeth in the earlier representatives of the Delphinidæ were furnished with a number of cusps, and I believe it will be found eventually that neither simple teeth nor conjoined cervical vertebræ can be regarded as an essential character of the

[1] Journ. Anat. and Phys., vol. 30, 1895, p. 137.

[2] Mém. Mus. Roy. Hist. Nat. Belgique, vol. 3, 1905, p. 129.

family. In spite of differences observable in living species, it seems to me probable that the Delphinidæ and Iniidæ were derived from common ancestors.

In accounts of *Stenodelphis* which I have examined, the teeth are described as having simple conical crowns. Professor Abel remarks regarding the dentition of the genus that it presents "pas de trace d'hétérodontie."[1] In two youngish skulls which I have examined, however, ten or twelve pairs of teeth at the posterior end of the series, in both the upper and the lower jaws, have incurved and somewhat spatulate crowns, with rugose enamel, which is raised into more or less linear denticles on the internal surface. Each tooth usually presents a median denticle and indications of another on either side of it, the general form being not unlike that occurring in *Delphinapterus*. I do not regard this character as differentiating the rather composite genus *Stenodelphis* from the Delphinidæ, but as strengthening the evidence that the Delphinidæ were derived from forms having tuberculate teeth.

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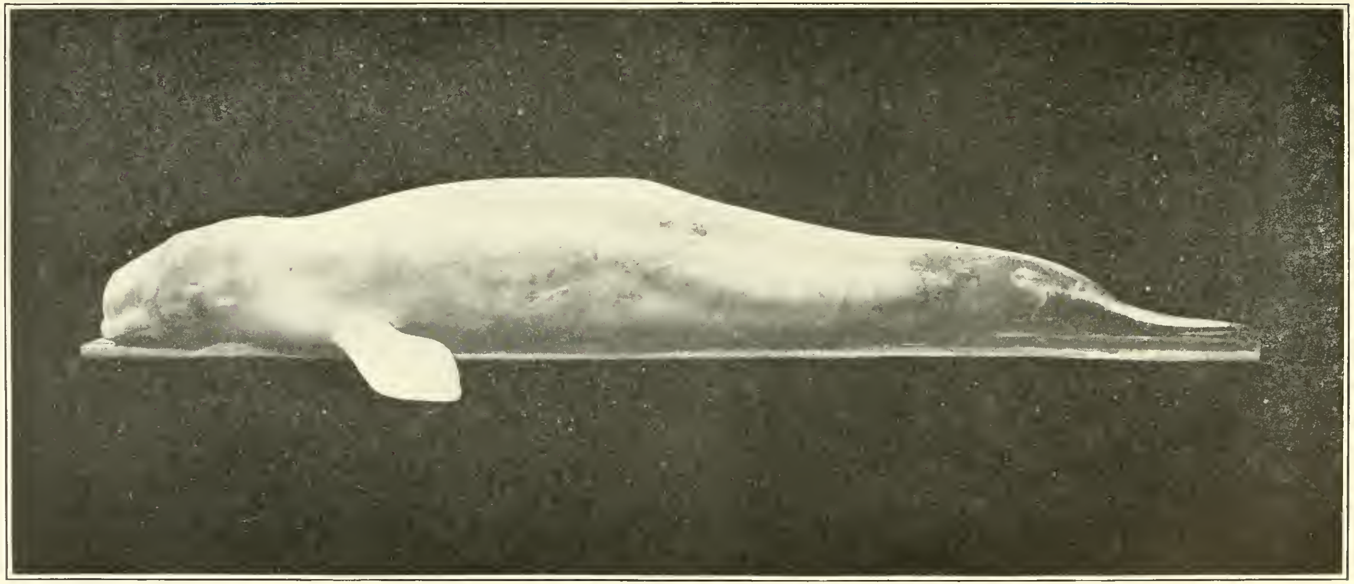
[1] Mém. Mus. Roy. Hist. Nat. Belgique, vol. 3, 1905, p. 42.



YOUNG FEMALE WHITE WHALE (Delphinapterus leucas)

SOME RECENT CONTRIBUTIONS TO OUR KNOWLEDGE OF THE SUN[1]

By GEORGE E. HALE, Sc. D., LL.D.

Director of Solar Observatory of Carnegie Institution of Washington, at Mount Wilson, California

With Thirteen Plates

Mr. Secretary, Ladies and Gentlemen: When I was honored by an invitation to deliver the Hamilton Lecture, and to describe in it some of our recent solar investigations, I accepted with special pleasure, since it would afford me a fitting opportunity to acknowledge the important debt owed by the Mount Wilson Solar Observatory to the Smithsonian Institution. Soon after the Carnegie Institution of Washington was organized, Doctor Walcott, then Secretary of its Executive Committee, requested Secretary Langley, of the Smithsonian Institution, to express an opinion as to the advisability of establishing a solar observatory at some mountain station. Doctor Langley, who knew, from personal experience at Mount Whitney and other elevated points, the importance of conducting solar research above the denser and more disturbed portions of the atmosphere, strongly recommended to the Carnegie Institution that provision be made for the proposed observatory. In the subsequent consideration of this project by the Executive Committee, Doctor Walcott gave it his full support, and thus contributed in an important way toward the favorable decision finally reached. It is therefore easy to understand why we of the Solar Observatory owe a debt of gratitude to these Secretaries of the Smithsonian Institution. I beg to assure Doctor Walcott that his interest in our work is most heartily appreciated.

When one pauses to reflect that the United States possesses more astronomical observatories than any other nation, and that it is unsurpassed in its contributions to astronomical discovery, one may naturally ask why it seemed advisable to establish another new observatory. If it were a question of duplicating existing instruments, or of entering fields of research already well occupied, it is probable

[1] Lecture delivered at Washington, D. C., April 22, 1908, under the auspices of the Hamilton Fund of the Smithsonian Institution.

that a more effective use of available funds might have been found. But the aim of the Solar Observatory differs essentially from that of any other American institution. Hitherto the study of the Sun has been conducted at a disadvantage, partly for lack of suitable instrumental means and partly because of the obstacles arising from unfavorable atmospheric conditions; yet it would be easy to demonstrate that no other star in the heavens is so well worthy of our investigation. As the central body of the solar system, controlling the motions of the planets, and making life possible upon the Earth, the Sun has always been an object of admiration, and sometimes even of worship, to mankind. A permanent decrease of one hundred degrees (about 0.6 per cent) in the effective temperature of the Sun is considered by good authorities to be sufficient to produce another Ice Age on the Earth. So great a change could hardly occur; but smaller variations, due to internal causes, or to modifications in the absorbing power of the Sun's atmosphere, are very probable. Since solar phenomena follow more or less definite cycles of change, a better understanding of them might conceivably permit variations in its radiating power, sufficient to determine seasons of good or bad harvest, to be in some degree anticipated. The importance of solar research from this standpoint is thus sufficiently obvious.

But if the Sun commands our attention as the source and support of terrestrial life, it must appeal no less strongly to every intelligent person as the unique means of opening to us a knowledge of stellar development; for the student who would untangle the secrets of the universe recognizes in the Sun a typical star, placed conveniently within reach and exemplifying the physical and chemical conditions which are repeated in millions of other stars so far removed that they appear to us only as minute points of light. If we are to form a true estimate of the nature of these distant stars, and find the means of tracing out the progressive stages in their development from the nebulæ, we must base our investigations upon solar research.

The great disk which the Sun exhibits in our telescopes would shrink to the size of a needle point if removed to the distance of the other stars. This may be made clearer through a simple comparison. Consider the dimensions of the solar system so reduced that the diameter of the Earth would be one foot and that of the Sun 109 feet. The distance between them would then diminish from 95,000,000 to 2.2 miles, but the proportionate distance of the nearest fixed star would be 600,000 miles. This illustrates the comparative nearness of the Sun and the great advantages thus afforded of observing its various phenomena.

In this presence it is quite unnecessary to dilate upon the importance of the general question of evolution, or to discuss the relationship of the problems of the astronomer to the more complex ones encountered by the student of evolution in biology. It is evident that if we are to acquire a correct understanding of evolution in all of its phases, we should start from a knowledge of those processes which result in the formation of stars and the development of planetary systems. The generalizations of thinkers like Kant, Laplace, and more recent writers who have furnished hypotheses to explain the origin of suns and planets must be put to the test of observation. But these hypotheses leave untouched scores of questions relating to the physical state of stars in various stages of growth; their relation to one another and to their environment; their connection in systems, and the part they play in the universe as a whole. All of these questions lie within the province of the student of stellar evolution and call for the exertion of his best efforts to contribute toward their solution.

We thus see that solar research may be divided into two classes: (1) measurement of the intensity of the Sun's radiation, to determine whether the heat received by the Earth is constant or undergoes fluctuations; and (2) observation of the various phenomena of the Sun's disk, to determine the laws by which they are governed. The first of these subjects has been investigated with great success by the Smithsonian Astrophysical Observatory, established by the late Secretary Langley and directed by Mr. Abbot. The work of the Mount Wilson Solar Observatory lies in the second field. The two departments are closely related, and I am glad to say that through a plan arranged with Doctor Langley and extended by Doctor Walcott, the work inaugurated here in Washington is being continued by Mr. Abbot on the summit of Mount Wilson, in close coöperation with our own investigations.

It has been conclusively shown by Köppen, and confirmed by Newcomb, that the average temperature of the Earth, as determined by the combination of a great number of thermometer observations made at several stations, indicates a fluctuation of from 0°.3 to 0°.7 C. during the eleven-year Sun-spot period. The mean temperature is greatest at the time of minimum Sun-spots, and least at the time of maximum Sun-spots. This relationship having been proved to exist, it remains to inquire whether there is any direct connection between the mean temperature of the Earth at a given time and the total heat radiation of the Sun as measured at a point outside of the Earth's atmosphere. Since all observations must be made within the atmosphere, the determination of the correction to be applied to eliminate the loss by absorption becomes the most important and, at the same time, the most difficult part of this investigation. It is in this connection that the transparency and the uniformity of the atmosphere on Mount Wilson have proved to be so great an advantage in the work of the Smithsonian expeditions. The results already obtained by Mr. Abbot show that the heat radiation of the Sun ranges in value from 1.93 to 2.14 calories per square centimeter per minute, and seem to indicate a real variability outside of the Earth's atmosphere.

Newcomb. in his recent paper on "A Search for Fluctuations in the Sun's Thermal Radiation through their Influence on Terrestrial Temperature," is inclined to believe that such apparent variability must be due to changes in the absorption of our atmosphere, rather than in the heat radiation of the Sun. He was led to this conclusion by the fact that short-period temperature changes, such as would result from a change in the Sun's heat, are not shown to exist in an extensive examination of the Earth's mean temperature as recorded during a period of 34 years at 13 stations. Langley and Abbot, on the contrary, maintain that the method employed in their observations eliminates the effect of atmospheric absorption so completely that the observed variations must be due to changes within the Sun. The fact that the thermometer records employed by Newcomb were all made at seacoast stations, where the steadying effect of the ocean might tend to eliminate short period fluctuations, leads Abbot to doubt the validity of Newcomb's conclusions. His method having proved capable of showing the small progressive differences in the solar heat due to the change in the Earth's distance from the Sun during the period of observation, he sees no reason to dispute the solar origin of the larger differences. Since variations in the Sun's heat radiation could not fail to be accompanied by changes in other solar phenomena, investigations on the nature of these phenomena, and on their relationship to the so-called "solar constant," may yield reliable information as to the origin of such differences as Abbot has observed. The possibility of predicting variations in the mean temperature of the Earth caused by the influence of the Sun must depend upon the acquirement of much more complete knowledge than we now possess of the solar constitution. We thus perceive the intimate connection which unites the work of the Smithsonian Astrophysical Observatory with that of the Mount Wilson Solar Observatory, and recognize the importance, from this standpoint, of continuing and greatly extending solar research in all its phases.

Coöperation in Solar Research

The widespread appreciation of the importance of solar investigations is illustrated by the formation of the International Union for Coöperation in Solar Research, which counts among its members astronomers and physicists in many parts of the world. In the establishment of the Union the initiative was taken by our National Academy of Sciences, which invited various academies, as well as astronomical and physical societies in Europe and America, to send delegates to a preliminary meeting at Saint Louis in September, 1904. The favorable responses and the presence of delegates from the academies of Paris, Stockholm, Saint Petersburg, and Vienna, the Royal Society and the Royal Astronomical Society of London, the physical societies of Paris and Berlin, and other leading scientific bodies on both sides of the Atlantic promised well for the future of the Union. The preliminary organization effected at Saint Louis was given more definite form at Oxford a year later, where coöperative work was set on foot in the study of the spectra of Sun-spots, solar photography with the spectroheliograph, and the measurement of the solar radiation. It was also decided to adopt a new system of standard wave-lengths, based upon Michelson's determination of the length of the international meter in terms of the wave-length of the cadmium lines. The high degree of precision attained by Rowland in his *Table of Solar Spectrum Wave-lengths* no longer suffices for the needs of spectroscopists. The new system, based upon standards measured with extraordinary accuracy by the interferometer method, should provide a firm foundation for all spectroscopic investigations, whether of an astronomical or physical nature, for many years to come. As the primary standards are being measured by French, German, and American physicists, it will soon be possible to prepare new tables of the wave-lengths of the lines in solar, metallic, and gaseous spectra. A grant to assist in this work has been made by the Bache Fund, and it is hoped that the publication of the tables may be undertaken by the National Academy.

The spectra of Sun-spots, as will be shown later, contain a great number of lines, which require the most careful study. Hitherto our knowledge of spot spectra has been derived almost exclusively from the results of visual observations, made by individual observers without the aid of a general plan. As a natural consequence certain regions of the spectrum have been altogether neglected, and the time required for the identification of the lines has seriously limited the amount of work accomplished. A committee of the Solar Union, numbering among its members most of the active observers in this field, has now divided the spectrum into limited regions, one of which is selected by each observer. With the aid of the photographic map mentioned below, an observer may easily make an exhaustive study of the lines he has chosen. Although it will be shown that photographic observations are far superior to visual ones in most work on spot spectra, there are various phenomena in which the eye still has the advantage of the sensitive plate. The Solar Union has already secured valuable results through this coöperation, and many more may be expected in the future.

In accordance with a plan prepared by another committee of the Solar Union, the Sun is photographed almost every hour of the twenty-four with spectroheliographs in India, Sicily, Germany, France, Spain, England, Wisconsin, and California. This nearly continuous record of the calcium flocculi will soon be supplemented by similar work in Mexico, and there is some reason to hope that the Japanese and Australian governments will assist in overcoming the breaks in the record due to the absence of spectroheliographs between California and India.

Other committees are formulating plans for a coöperative attack on the problem of the solar rotation, securing greater uniformity in the methods of recording observations of the solar prominences and inquiring as to the advisability of coördinating the plans of eclipse expeditions. In every phase of the work the results to be derived from personal initiative and individual effort are recognized as likely to transcend in importance any that may follow from routine coöperation. From this standpoint the best accomplishment of the Solar Union is the creation of a renewed interest in solar research and in related problems of physics and astronomy. Every member is strongly encouraged to develop and extend his own ideas and methods, an aim by no means incompatible with the prosecution of coöperative work in fields where routine observations are essential. It is hoped that the large attendance and hearty interest which characterized the recent meeting of the Solar Union in Paris may not be lacking when the members again come together on Mount Wilson in 1910.

The Mount Wilson Solar Observatory

The Carnegie Institution was not slow to recognize the exceptional opportunities which, through a fortunate combination of circumstances, lay open to its proposed solar observatory. These included:

1. The application to the study of the Sun and stars of powerful

Fig. 1.—AT THE YERKES OBSERVATORY
Exposure $9^h 47^m$

Fig. 2.—AT MOUNT WILSON
Exposure $3^h 48^m$

THE PLEIADES

Photographed with the Bruce telescope (Barnard) spectroscopes and other instruments developed during the preceding quarter of a century in the physical laboratory, but still unused in the observatory.

2. The development of the spectroheliograph and of other research methods involving new principles.

3. The development of the reflecting telescope, in forms adapted for solar research and for physical investigations of the stars and nebulæ.

4. The more adequate recognition of the close union which should unite laboratory researches with solar and stellar investigations.

The opportunities enumerated above relate to the possibility of improving and extending the methods of astrophysical research. Another special opportunity had its origin in the basic principles which underlie the Carnegie Institution. A large proportion of the world's observatories are connected with universities or with institutions affected by local interests. The Carnegie Institution establishes its laboratories and observatories on the islands of the Carribbean Sea, the deserts of Arizona, the mountains of California, and at other points where their work can be done most effectively. On Mount Wilson, the long periods of cloudless weather, the purity of the atmosphere, and the absence, during a large part of the year, of winds and atmospheric fluctuations which seriously hamper astronomical work in most parts of the world afford great advantages. To illustrate the purity of the night sky, two photographs of the Pleiades, one made with an exposure of $9^h\ 47^m$ at Williams Bay, Wisconsin (1,200 feet), the other made at Mount Wilson (5,886 feet), with an exposure of only $3^h\ 48^m$, are reproduced in Plate XXIV. These were both taken by Professor Barnard with the 10-inch Bruce photographic telescope, on plates of equal sensitiveness and on nights of normal clearness at each station. Though the exposure time was two and one-half times longer at Williams Bay, yet the number of stars recorded at Mount Wilson is fully as great and the details of the nebula much sharper. Other proofs of the fine quality of the Mount Wilson atmosphere are afforded by many visual and photographic observations, made by night and by day, during the past three or four years.

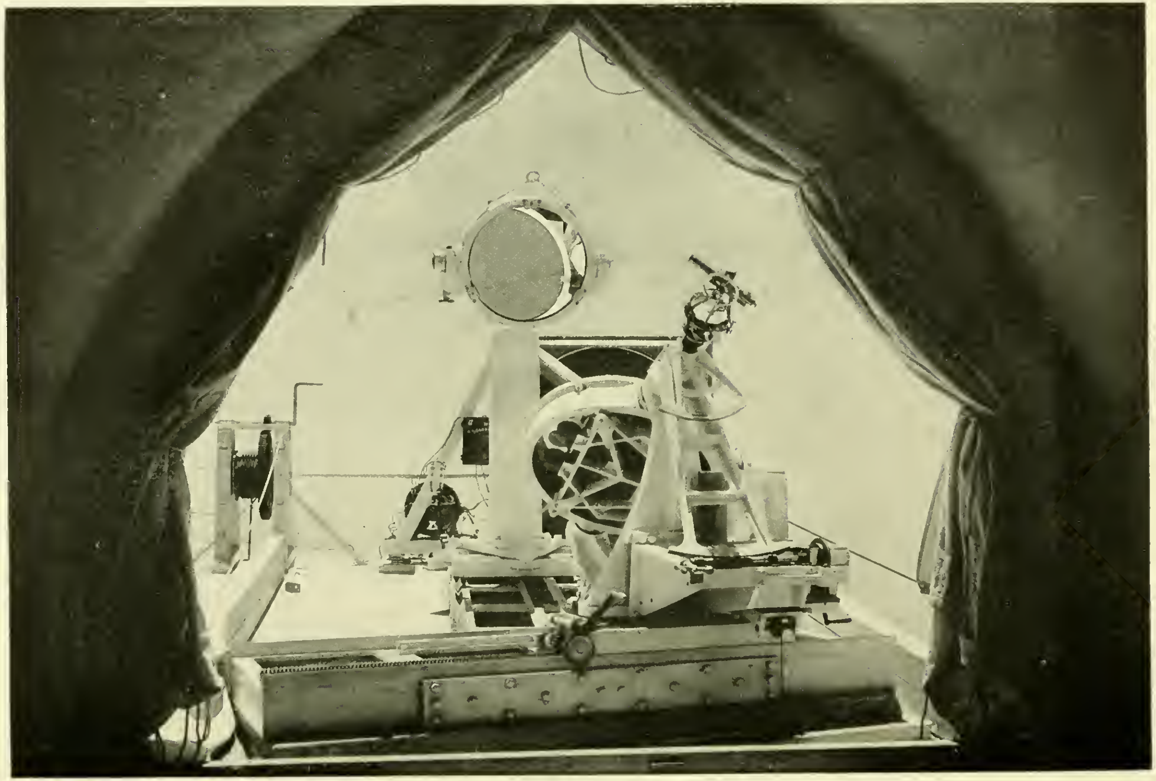
Plate XXV shows the summit of Mount Wilson, where a large tract of land has been set apart for the purposes of the observatory. This site commands a magnificent view of southern California, extending on the east to the snowy peaks of the San Bernardino Range, on the west to islands lying far out in the Pacific, on the north to an endless succession of mountains tributary to the high Sierras, and on the south to the Mexican frontier. In the San Gabriel Valley, lying at the base of Mount Wilson, and about eight miles distant in an air line, is the city of Pasadena. Here a large part of the observatory work, such as various laboratory investigations, the design and construction of instruments, and the measurement and discussion of astronomical photographs taken on the mountain, is conducted. By confining the work on Mount Wilson almost entirely to observations, the expense of maintaining the rest of the establishment there is avoided and many other advantages are secured.

In enumerating the various opportunities which lay open to the Solar Observatory at the time of its inception, the possibility of bringing into use large and powerful spectroscopes, which had been developed in physical laboratories, was first mentioned. In 1859 Kirchhoff discovered with the spectroscope the chemical composition of the Sun, and proved that this instrument is capable of analyzing the light which reaches us from any luminous source. When applied later to a study of the phenomena of the Sun and stars, the spectroscope, then of small dimensions, was simply attached to the end of a telescope tube. The invention of the concave grating by Rowland in 1882, and the widespread use of this powerful instrument in physical laboratories, introduced a new era, through the great increase in precision of measurement rendered possible by its high dispersion. In astronomy, however, the equatorial refractor continued to be the popular form of telescope, and the spectroscope, though improved in many particulars, did not increase greatly in size. It was obviously impossible to attach a concave grating spectroscope over 21 feet in length to the end of a moving telescope tube. Consequently the precision of measurement in astronomical spectroscopy has been far inferior to that attained in the laboratory.

The Snow Telescope

At the period when the plans for the Solar Observatory were taking form, the principles which should govern the construction of a fixed telescope were partly understood, and had been frequently applied in eclipse observations. Almost simultaneously with our experiments with fixed telescopes at the Yerkes Observatory, a large instrument of this type, giving a solar image well suited for bolometric work, was constructed for the Smithsonian Astrophysical Observatory. Such telescopes, however, had not been used for researches demanding a large and sharply defined solar image. The Snow telescope, constructed in the instrument shop of the Yerkes

MOUNT WILSON AS SEEN FROM MOUNT HARVARD



COELOSTAT AND SECOND MIRROR OF SNOW TELESCOPE

Observatory, with the aid of funds given by Miss Snow, of Chicago, had its first trial shortly before our work on Mount Wilson was undertaken. It was afterwards brought to California in connection with an expedition sent out by the Yerkes Observatory, with the aid of a grant from the Carnegie Institution, and was ultimately purchased by the Mount Wilson Solar Observatory as a part of its permanent equipment.

This instrument is designed to give a sharply defined image of the Sun, nearly 7 inches in diameter, at a fixed position within a laboratory, where its various details can be investigated with spectroscopes or spectroheliographs of any desired dimensions. The cœlostat shown in Plate XXVI carries a mirror 30 inches in diameter, mounted so that the plane of its front (silvered) surface is exactly parallel to the Earth's axis. When this mirror is rotated by a driving-clock at such a rate that it would complete a revolution in forty-eight hours, a beam of sunlight reflected from it is maintained in a fixed position, in spite of the apparent motion of the Sun through the heavens. This beam falls upon a second silvered mirror, 24 inches in diameter, which sends the rays toward the north. Both of these mirrors have optically plane surfaces, and their function is merely to bring the Sun's rays into the telescope house and to direct them upon a concave mirror 24 inches in diameter, mounted 95 feet north of the cœlostat. This mirror, which may be regarded as the telescope proper, returns the rays 60 feet toward the south to a point just outside of the entering beam, where it forms an image of the Sun nearly 7 inches in diameter. By setting the concave mirror at the proper angle, the solar image can be made to fall upon the slit of a spectrograph of 18 feet focal length, or upon the slit of a large spectroheliograph. Both of these instruments are mounted on massive stone piers. Thus all restrictions as to the dimensions and weight of such auxiliary apparatus are removed.

The house in which the Snow telescope is mounted (Plate XXVII) was designed with the object of keeping the temperature of the air within it as nearly as possible the same as that of the outer air. It is constructed of a light steel framework covered with canvas louvers and provided with a ventilated roof. Without such precautions the air within the house would become heated during the day, and the difference in temperature between the inner and outer air would cause distortion of the solar image and consequent blurring of its details. In practice, on day after day in the summer months, the image of the Sun given by the telescope during the early morning hours is nearly as clear and distinct as a steel engraving.

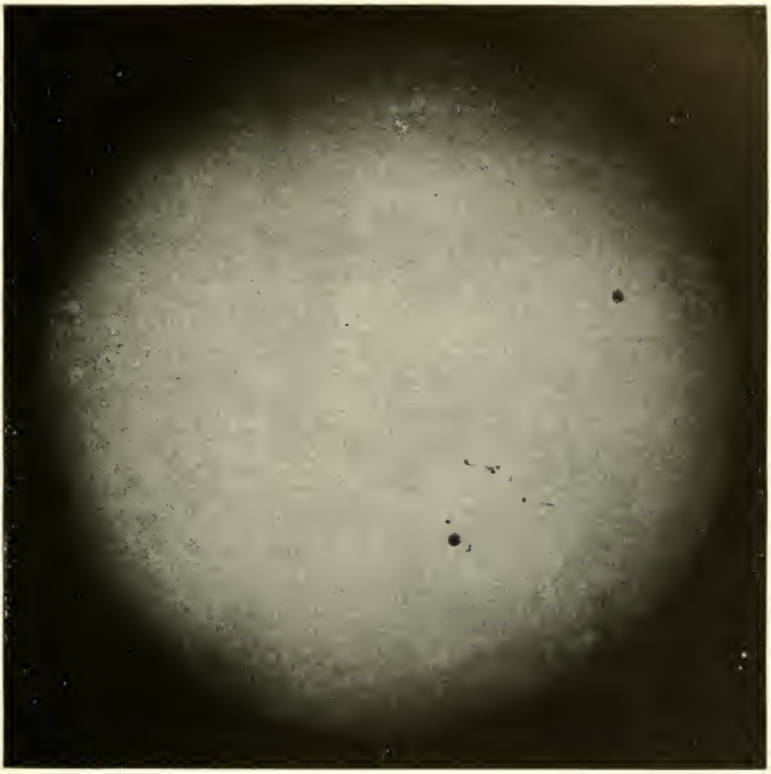
If this solar image (obtained with reduced aperture of the concave mirror) is permitted to fall for less than the thousandth part of a second upon a photographic plate, a picture of the Sun will result. Such pictures are made every clear day, in the early morning or late afternoon, when the atmospheric conditions are at their best. They show the Sun as it appears to the eye in visual observations. The principal solar phenomena visible on such photographs are the Sun-spots, several of which appear in Plate XXVIII. These spots, when observed under the best conditions, are found to have an extremely intricate structure, which changes from hour to hour, and sometimes from minute to minute, under the observer's eye. Individual spots sometimes exceed 90,000 miles in length, but their area is very small as compared with that of the entire solar disk. Thus the great group of February, 1892, had a length of 166,000 miles and a breadth of 65,000 miles. Its area was eighteen times as great as that of the Earth, but only 0.15 of one per cent of the solar surface.[1]

Photographic Investigations of Sun-spot Spectra

In spite of the fact that Sun-spots have been under observation for nearly three hundred years, little is known as to their true nature. Various theories to account for them have been brought forward, but the complexity of the phenomena and the lack of sufficient observational data have stood in the way of accurate knowledge. It is not certainly known, for example, whether Sun-spots are to be regarded as elevated regions or as depressions below the general level of the solar surface. Even the cause of their darkness has remained uncertain, and astronomers have differed as to their temperature, some contending that they are much hotter than other parts of the Sun, and others believing them to be comparatively cool. In support of his theory that the chemical elements are broken up into simpler constituents at very high temperatures, Lockyer adduced observational evidence of a periodic change in the Sun-spot spectrum. At times of maximum solar activity, when spots are numerous on the Sun, Lockyer found the most conspicuous lines in their spectrum to be of unknown origin. Five or six years later, when the solar activity had declined to a minimum, these lines seemed to be replaced by the well-known lines of iron and other familiar substances. Lockyer accordingly concluded that at the maximum the temperature of Sun-spots was sufficiently high to break up iron and

[1] Maunder, *Journal British Astronomical Association*, vol. XVII, p. 126.

SOUTH END OF SNOW TELESCOPE HOUSE ON MOUNT WILSON



DIRECT PHOTOGRAPH OF THE SUN
August 25, 1906, 6^h 09^m A. M.

other elements into simpler substances, whose spectra, being unknown on the Earth, could not be identified.

If we analyze the light of a Sun-spot with a spectroscope, we find that the Fraunhofer lines of the solar spectrum are almost all present, though their relative intensities are greatly changed. Many solar lines, for example, are much strengthened or widened where they cross the spot, while others are weakened or, in some cases, completely obliterated. Lockyer's method of observation is to record, day after day, the most conspicuous lines in the spot spectrum—those of the solar lines which are most widened or strengthened. Under the ordinary conditions of visual observation, the study of the spot spectrum is a difficult operation, on account of the immense number of lines affected. Recognizing this, Lockyer confined his attention to only twelve lines, in the expectation that their variations would sufficiently indicate the nature of any changes going on within the spot. The inadequacy of this method has been shown by recent results, which give no indication that the spot spectrum undergoes a radical change in passing from maximum to minimum solar activity, and demonstrate that an interpretation of the true meaning of the strengthened and weakened lines must involve the systematic study not merely of twelve lines, but of a far larger number.

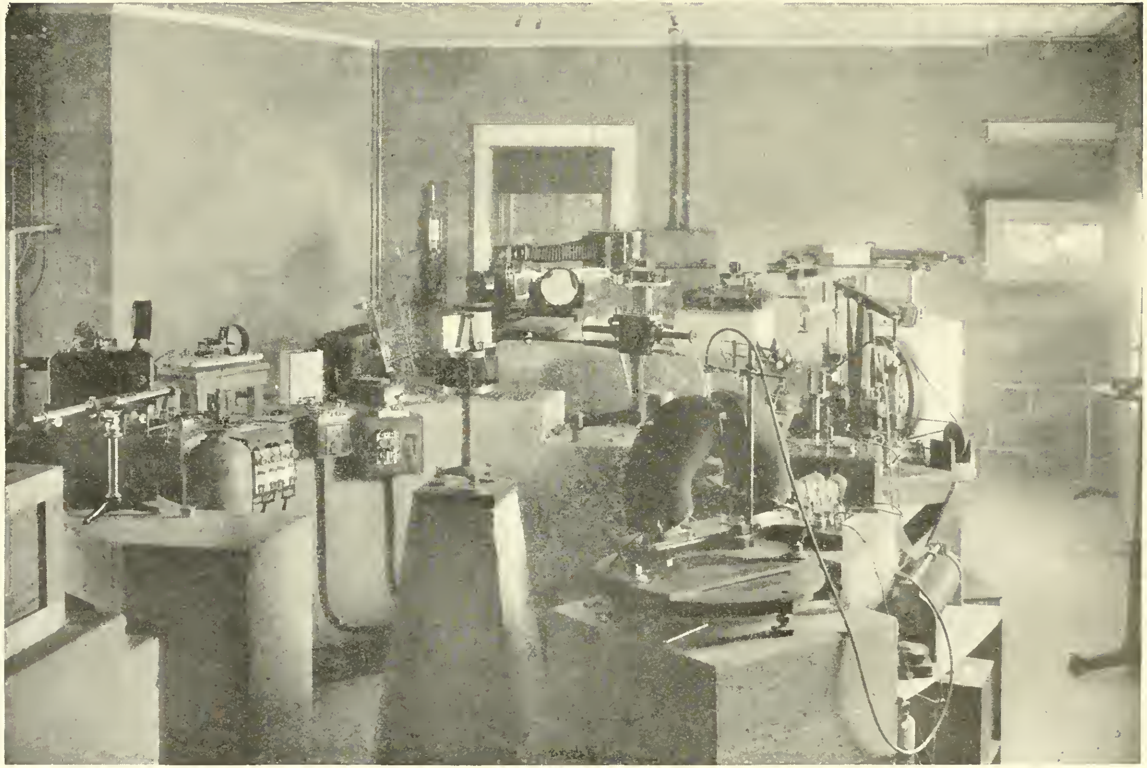
When the Snow telescope was first employed for this work, only a few hundreds of lines had been catalogued in the entire Sun-spot spectrum. Previous experiments at the Kenwood and Yerkes observatories had indicated that the application of photography would probably make possible an important advance, provided a spectrograph of sufficiently high dispersion were employed. A Littrow spectrograph of 18 feet focal length, having a plane Rowland grating ruled with 14,438 lines to the inch, was accordingly constructed for use with the Snow telescope. Good photographs of spot spectra were soon obtained with this instrument. After some minor technical difficulties had been overcome, it appeared that the photographs could be counted upon to show nearly all that can be seen visually, while at the same time they would permit the positions of the lines to be accurately measured and their relative intensities to be determined. From negatives taken with the Snow telescope, Ellerman prepared a preliminary map of the Sun-spot spectrum, extending from the violet to the extreme red. Casual inspection of this map, which comprises twenty-six sections of one hundred Ångströms each, is sufficient to show that the number of lines whose intensities are affected in Sun-spots is several thousands. In the hands of observers coöperating in the work of the International Solar Union, this map has greatly facilitated visual observations, and has considerably strengthened the view, now almost universally held, that the Sun-spot spectrum undergoes few striking variations from spot to spot or at different periods in the eleven-year cycle of solar activity.

The negatives having been secured and a preliminary map of the spectrum prepared, it became necessary to draw up a catalogue of all the lines affected, showing their intensities in the spot and in the ordinary solar spectrum. The first section of this catalogue, extending from λ 4000 (the extremity of the visible spectrum) to λ 4500 in the violet, has been published by Adams.[1] In this limited region of the spectrum, where the Sun-spot and solar spectrum were previously regarded as identical, about eight hundred lines of altered intensity are recorded. The publication of the second section of the catalogue has been somewhat delayed by the fact that negatives of the spot spectrum made with the 30-foot spectrograph of the new "tower" telescope (p. 356) are so much superior to the earlier plates that the results obtained from them must also be added. As the complexity of the spot spectrum increases from this region toward the green and yellow, it is evident that the complete catalogue will comprise many thousands of lines.

Having thus acquired suitable data, the next step was to attempt to interpret the true meaning of the Sun-spot spectrum. At this point the need of laboratory experiments presents itself. Take, for example, the spectrum of iron in a Sun-spot. The photographs show that many of the iron lines are relatively much stronger than the corresponding ones in the solar spectrum, others are reduced in intensity, and others are essentially unchanged. From experiments on the spectrum of iron as observed in the laboratory, it is known that the relative intensities of its lines depend upon the physical conditions under which the vapor is observed—*i. e.*, that variations in the pressure, temperature, density, or electrical state of the vapor are competent to affect their relative intensities. Adequate information on this subject, however, is lacking. It was therefore necessary to observe the effect of varying these physical conditions, in the hope that the results might be applied to the interpretation of spot phenomena.

The apparatus provided on Mount Wilson for work of this character is illustrated in Plate XXIX. Around the annular pier are ar-

[1] *Contributions from the Solar Observatory*, No. 22, *Astrophysical Journal*, vol. 22, pp. 45–65, January, 1908.



THE SPECTROSCOPIC LABORATORY ON MOUNT WILSON

ranged various light sources, in each of which the physical conditions can be controlled by the observer. One of the simplest ways of vaporizing iron is to place fragments of the metal between the carbon poles of an ordinary arc light. By varying the amount of metal present in the arc, the effect of change of density of the vapor can be observed. To study the influence of change of pressure. the arc must be inclosed within a chamber, so constructed that air or some other gas can be admitted and raised to the desired pressure. The effect is to shift the lines of the spectrum toward the red, and by measuring the displacement produced by an increase in pressure of one atmosphere, the pressure within a Sun-spot or in a star, corresponding to any observed shift of the lines, can be determined. To ascertain the effect of change of temperature upon the spectrum, the iron vapor at the very hot center of the arc may be compared with the cooler vapor in the outer part of the flame. If the highest temperature of the arc is not sufficiently great, a powerful electric spark, taken between two poles of iron, will afford a still hotter light-source. Apparatus suitable for all of these purposes and for other similar ones is arranged upon the annular pier. When the light from any particular source is to be investigated, it is reflected from a plane mirror at the center of the circle to a concave mirror (shown near the middle of Plate XXIX), which forms an image of the source on the slit of a powerful spectrograph.

For various reasons it seemed probable that reduced temperature might be the cause of the strengthening and weakening of lines in spot spectra. Accordingly, special attention was directed to a study of the effect of temperature change on the relative intensities of the lines. After an extensive investigation it was found that the iron lines whose relative intensities increase at reduced temperatures are invariably among the lines which are strengthened in Sun-spots. Moreover it was also found that the iron lines which are weakened at reduced temperatures are weakened in Sun-spots. After these experiments had been extended from iron to titanium, vanadium, chromium, manganese, cobalt, nickel, and other substances conspicuously represented in Sun-spots, the conclusion was reached that a reduction in temperature of the spot vapors is competent to explain a large part of the characteristic spectral phenomena. Assuming this hypothesis to be correct, one would naturally be led to ask whether the temperature of the spot vapors is sufficiently reduced to permit elements existing uncombined at the higher temperature of the solar surface to enter into combination within the spot. Titanium and oxygen, for example, both occur among the vapors which lie above the photosphere. Is the temperature within the spot low enough to permit these substances to combine?

For many years the spot spectrum had been known to contain a number of bands and of faint lines, but none of these had been identified. Fortunately, the photographs obtained with the Snow telescope show these bands far better than they can be seen visually, and bring to light many new bands and thousands of faint lines of unknown origin. Fig. 1, Plate XXX, illustrates a comparison of one of the red titanium oxide bands, made up of a great number of fine lines terminating in three distinct heads, with the corresponding region in a photograph of the spot spectrum. It will be seen that practically all of the lines of the band photographed in the flame of the electric arc are present in the spot. As many other titanium bands have been found on the photographs, we now know not only that many hundreds of the spot lines can be accounted for in this way, but also that the hypothesis of reduced temperature is partially confirmed. This identification of the titanium oxide flutings is due to Adams. Soon after its publication, Fowler, of London, found some of the bands in the green portion of our photographic map to be due to magnesium hydride, another compound capable of withstanding high temperatures. Still later, Olmsted discovered in our Mount Wilson laboratory that certain spot bands in the red are due to calcium hydride. He is continuing the search for other compounds with improved apparatus in our new Pasadena laboratory. The investigation may be an extensive one, because the spectra of only a few of these compounds, which are formed at the high temperature of the electric furnace, have hitherto been observed. Even in these cases no large scale photographs, or sufficiently accurate measurements of the lines, have been published.

The presence of compounds in spots appears favorable to the hypothesis of reduced temperature, though it does not settle the question beyond doubt. It next became interesting to inquire whether analogous conditions could be found among the stars. As already remarked, the stars are so distant that their images in the most powerful telescopes are mere needle points, so that objects like Sun-spots, if they exist on the stars, cannot be observed. According to current ideas of stellar evolution, the stars pass through a long process of development, during which their temperature, perhaps comparatively low in the embryonic stage represented by the condensing nebulæ, reaches a maximum in the white stars, and then declines during the period of old age exemplified in the red stars. If, then, a Sun-spot is a mass of solar vapors reduced somewhat in

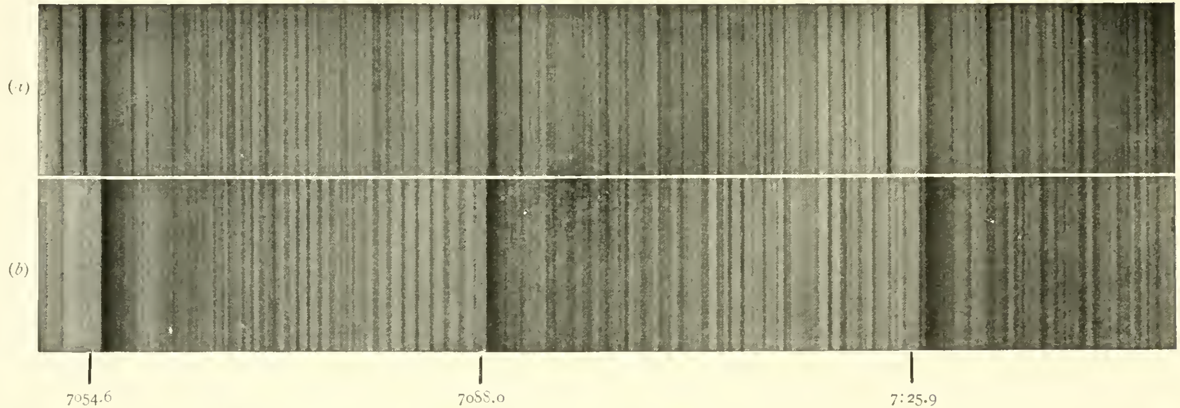


Fig. 1.—TITANIUM OXIDE FLUTINGS IN SPECTRA OF (*a*) SUN-SPOT AND (*b*) FLAME OF ELECTRIC ARC

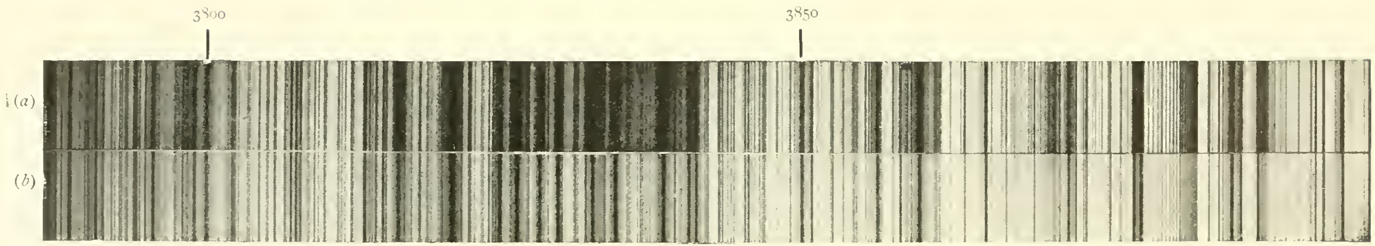


Fig. 2.—SPECTRUM OF SUN (*a*) AT CENTER AND (*b*) NEAR LIMB

temperature, a red star, assumed to have the same composition as the Sun, might be expected to give a spectrum resembling that of a Sun-spot, if its temperature were the same.

In order to test this question with sufficient precision, the spectra of *Arcturus,* an incipient red star, and of *a Orionis,* a conspicuous red star in the constellation of *Orion,* were photographed with a very powerful spectrograph. Here, again, the principle of using a high dispersion spectrograph, mounted on a massive stone pier in a constant temperature chamber, was substituted for the ordinary method of attaching a small spectrograph to the tube of a moving telescope. The Snow telescope provided a fixed image of the star, and it was only necessary to maintain this upon the slit of the spectrograph during an exposure long enough to permit the greatly dispersed light to impress itself upon the photographic plate. With the comparatively small aperture of the Snow telescope, exposures of from fifteen to twenty hours, carried on through several successive nights, were required. The great amount of light which will be collected by our 60-inch reflector will reduce these exposures and will also permit fainter stars to be photographed with high dispersion.

A study of the plates thus obtained showed an interesting parallelism between the relative intensities of the lines in the spectra of these stars and those of Sun-spots. Many of the lines that are strengthened in spots are strengthened in these stars, and many of the lines that are weakened in spots are weakened in these stars. There are some important points of difference, probably due to the fact that the relative intensities of the lines in spots and stars are not determined solely by temperature condition. In general, however, the agreement is sufficiently close to indicate the probability that a common cause—reduced temperature—is at work in both cases. If any doubts remained as to the resemblance between the spectra of red stars and Sun-spots, they were removed when the titanium oxide bands were discovered in our photographs of spot spectra. These bands are the characteristic feature of one of the two great classes of red stars, their spectra showing them in all degrees of intensity, from the comparative faintness which delayed their discovery in Sun-spots to the blackness observed in such deep red stars as *a Herculis* and *Antares.* The absence of these bands in the other great class of red stars, in whose spectra the bands of carbon (not found in Sun-spots) predominate, suggests interesting possibilities in future work on the Sun's stellar relationships.

These results leave unanswered scores of questions involved in the complete interpretation of Sun-spot spectra, and do not even afford conclusive evidence that reduced temperature is the principal agent in determining the relative intensities of the lines. They nevertheless carry us a step forward in our study of solar physics and are of special service in illustrating the interdependence of solar, laboratory, and stellar investigations. They render evident the importance of increasing our knowledge of the Sun, of imitating solar phenomena and interpreting solar observations by means of laboratory experiments, and of using these investigations as a guide to the study of the stars and nebulæ.

Spectra of the Limb and Center of the Sun

Many years ago, when a student at Yale, Hastings made a comparative study of the spectra of different parts of the Sun's disk, devoting special attention to any differences that might distinguish the light of the center from that derived from points very near the limb. Although his instruments were inadequate for the task and his observations necessarily visual, he nevertheless noticed slight differences in the appearance of a few lines. Strangely enough, the importance of this work was overlooked by later investigators, though Halm, two years ago, without perceiving the differences noted by Hastings, detected a slight displacement of certain lines at the limb as compared with their positions at the center of the Sun. Halm's work was also visual and accomplished with a comparatively small spectroscope. Had he used a more powerful instrument and benefited by the aid of photography, he would doubtless have discovered the interesting series of phenomena which the Snow telescope and 18-foot spectrograph have brought to light.

Some of these are illustrated in Fig. 2, Plate XXX, which represents only one region of the spectrum. The broad diffuse wings which accompany many lines are greatly reduced in intensity near the limb, and in a number of cases disappear entirely. The relative intensities of the lines themselves undergo marked changes, resembling in most instances the changes observed in Sun-spots; that is to say, the lines that are strengthened in Sun-spots are usually strengthened near the Sun's limb, while the lines that are weakened in Sun-spots are weakened near the limb. However, the phenomena are by no means strictly parallel, and much work will be required to arrive at their true meaning. Perhaps the most interesting effects observed at the limb are the displacements of the solar lines with respect to their positions at the center of the Sun. In general, the relative displacements for different lines agree fairly well in magnitude with those observed for the same lines in the laboratory when a source of light containing the vapor in question is observed under pressure. That increased effective pressure near the limb is probably the cause of the line-shifts is further illustrated by the fact that the lines in bands or flutings, such as those of cyanogen (shown in Fig. 1, Plate XXX), which are not displaced by pressure in the laboratory, retain the same relative positions at the center and limb.

These changes, and many others which it would be tedious to enumerate, have been observed on photographs taken by Adams and myself for the purpose of extending and perfecting our interpretation of Sun-spot spectra. Almost the entire extent of the spectrum has been photographed and a large scale-map showing the differences between the spectra of the limb and center is now in preparation. The work of measurement is necessarily long and trying, since the positions of hundreds of lines must be determined on many photographs with the extreme precision required to reveal the minute displacements concerned. For the interpretation of the results extensive laboratory investigations on the effect of pressure must be carried out, and special apparatus for this purpose is now being prepared. Moreover, the possibility that anomalous dispersion and other physical phenomena are involved must not be overlooked; and here, again, much laboratory work must be done.

The Solar Rotation

In mentioning the cyanogen band, I remarked that it occupies the same position at the center of the Sun and at the limb. This is true, of course, only after the effect of the solar rotation has been corrected. All the lines of the spectrum, when observed at the east limb of the Sun, are displaced toward the violet, while at the west limb they are displaced toward the red, with respect to their normal place as given by the light of the center of the Sun. The displacements here involved are due to the Sun's axial rotation, and afford the most accurate means we possess of determining its velocity. The east limb of the Sun, in the region of the equator, is moving toward us at the rate of 2.08 km. per second. Such a motion of a luminous source shifts the lines of its spectrum a small distance toward the violet. At the west limb, the motion being away from the observer, the displacement is toward the red. In practice, the spectrum of the east limb is photographed side by side with that of the west limb, so that the double displacements may be measured.

These displacements have been studied by Adams, who has utilized the facilities offered by the Snow telescope and the 18-foot spectrograph to carry out what is probably the most accurate spectroscopic investigation of the solar rotation hitherto accomplished. In the earlier investigations of Dunér and Halm, both of which exhibit a high degree of precision, visual observations were employed, and as all of the measures had to be made at the telescope, the observers restricted themselves to the use of only two lines. The advantages of photography are obvious when it is remembered that in a single short exposure a portion of the spectrum from 15 to 20 inches long, showing opposite limbs of the Sun and containing thousands of lines suitable for measurement, can be recorded upon a sensitive plate. The work on Mount Wilson is limited to making the photographs, which are afterwards measured in the Computing Division at Pasadena, with measuring machines which give the positions of the lines within about one-thousandth of a millimeter. Since iron, calcium, carbon, sodium, hydrogen, and other elements are represented on the plates, it is possible, by measuring the displacements of the corresponding lines, to determine the velocity of rotation of the vapor due to any one of these elements.

The lines measured by Adams (assisted by Miss Lasby) include some for each of the following elements: iron, manganese, nickel, titanium, lanthanum, carbon, chromium, and zirconium. The following table gives the values obtained for different latitudes:[1]

Latitudes.	Velocity, km. per second.	Daily angular motion.	Rotation period, days.
°		°	
0.2	2.078	14.75	24.39
7.7	2.023	14.50	24.83
15.0	1.957	14.39	25.01
22.7	1.808	13.92	25.86
29.7	1.673	13.68	26.32
37.7	1.461	13.11	27.46
44.7	1.279	12.77	28.19
52.7	1.055	12.35	29.15
59.6	0.864	12.13	29.68
65.7	0.696	11.99	30.02
74.9	0.434	11.85	30.38
80.4	0.277	11.84	30.40

It will be seen that, as in the case of Sun-spots, the period of the Sun's rotation increases from the equator toward the poles. Theoretical investigations suggest that this remarkable law of rota-

[1] Adams: *Contributions from the Solar Observatory,* No. 20, *Astrophysical Journal,* vol. XXVI, pp. 203–224, November, 1907.

tion dates from a former epoch in the Sun's history, and that it perhaps arose from the motion of the gases concerned in the formation of the Sun from a nebula. After the lapse of some millions of years, the effect of internal friction will tend to bring the velocities corresponding to different latitudes more and more closely into harmony, and finally the Sun will rotate as a solid sphere.

One of the most important results obtained by Adams is the discovery that the lines of carbon and lanthanum, elements which lie at a low level in the Sun's atmosphere, give values for the daily rate about 0°.1 less than the mean values for all of the lines measured. Two lines of manganese, on the contrary, give systematically high results. It seems probable that these differences are due to differences in the level of the vapors of these elements in the solar atmosphere, and that those substances which lie at high altitudes complete a rotation in a shorter period than the vapors beneath them. This supposition is confirmed by the fact that Adams's recent measures of the velocity of hydrogen, which rises higher above the solar surface than any of the vapors included in the above investigation, give very high values. Moreover, as the following table shows, the rotational velocities of hydrogen in low and high latitudes are in close agreement, and the equatorial acceleration characteristic of lower levels does not exist.

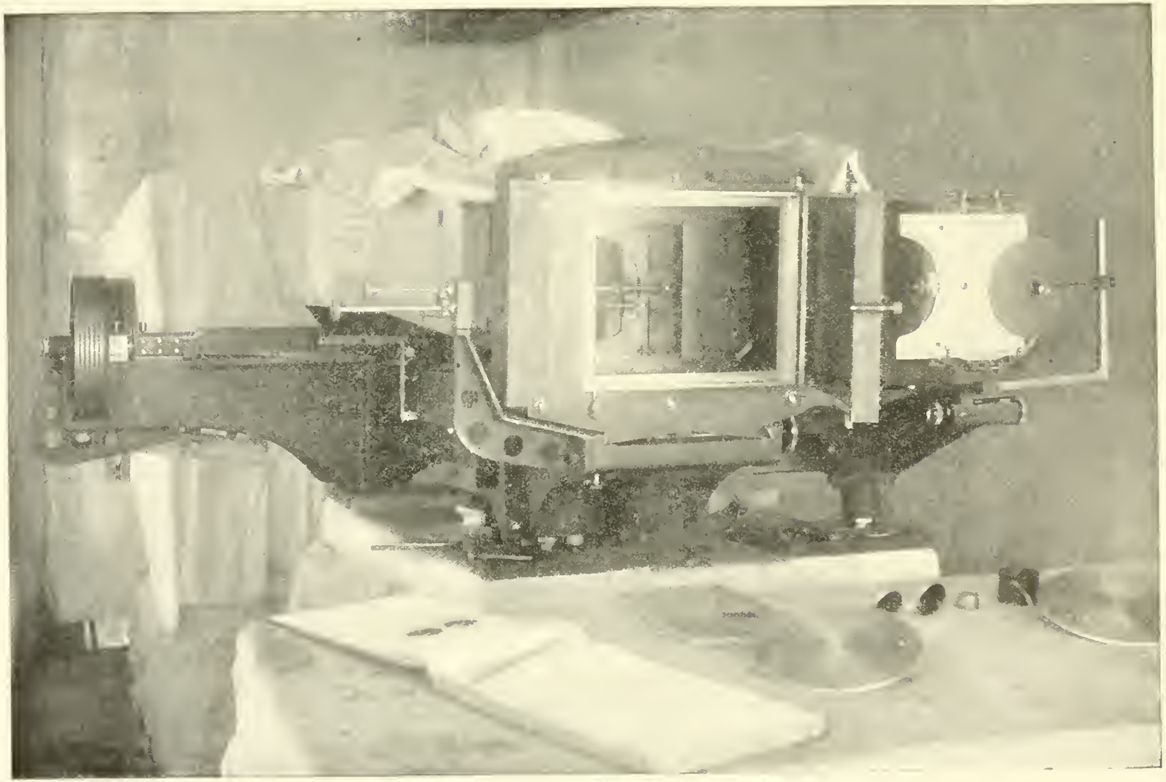
Latitudes.	Linear velocity, km. per second.	Daily angular motion.	Rotation period, days.
° —0.1	2.21	° 15.7	22.9
9.3	2.15	15.5	23.2
14.8	2.10	15.4	23.4
22.7	2.03	15.6	23.1
29.7	1.87	15.3	23.5
44.5	1.55	15.4	23.4
59.3	1.12	15.6	23.1
73.5	0.67	16.7	21.6

This important discovery leads us to inquire whether hydrogen clouds in the solar atmosphere, if observed in projection against the Sun's disk, would show daily motions corresponding to these results obtained with the spectroscope. Fortunately, the spectroheliograph permits these clouds to be photographed, as will be explained in the next section of this lecture.

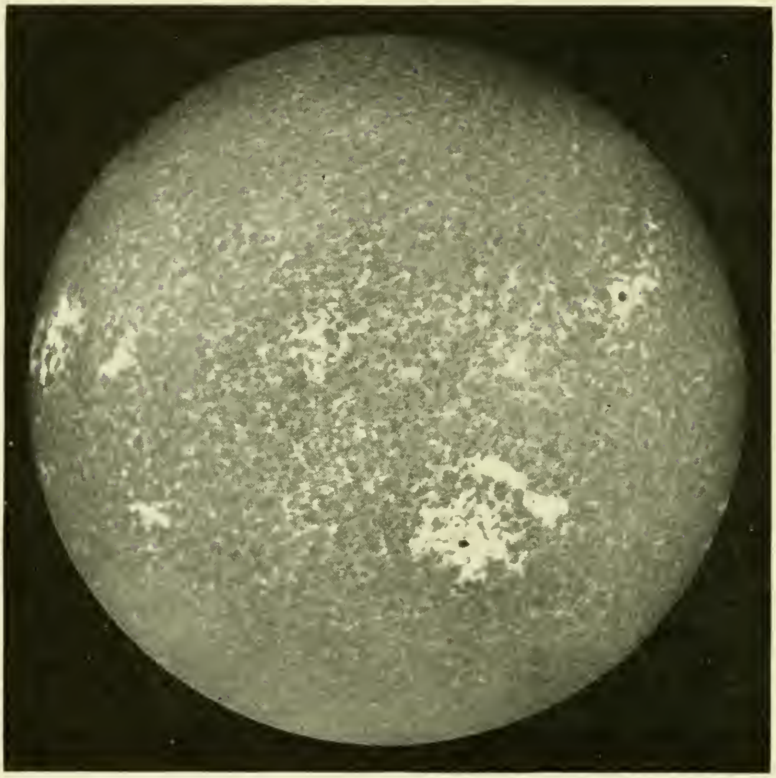
Work with the Spectroheliograph

The spectroheliograph is an instrument for photographing the Sun with the monochromatic light of any of the vapors present in its atmosphere. The instrument consists essentially of a spectroscope, on the slit of which an image of the Sun is formed. The spectroscope analyzes the light of that portion of the Sun's image which enters the slit, and spreads it out into a spectrum, crossed by lines characteristic of the various elements. If a luminous cloud of calcium vapor in the Sun's atmosphere happens to be intersected by the slit, the dark calcium line of the solar spectrum will show a bright line corresponding to a section of this cloud. Suppose the eye-piece of a spectroscope to be replaced by a slit, and assume this slit to be adjusted so that only the line of calcium passes through it. If a photographic plate is placed almost in contact with the slit, and the spectroscope is moved at a uniform rate across the fixed solar image, the second slit moving with it across the fixed photographic plate, it is evident that an image of the Sun will be built up on the plate from the successive images of the slit. The only light that enters into the formation of this image is that of calcium vapor, and the resulting picture therefore represents the distribution of this vapor in the solar atmosphere.

The advantages of using a fixed telescope are as great in the case of the spectroheliograph as in that of the spectrographs already described. The limitations in size imposed by the necessity of carrying a spectroheliograph at the end of a moving equatorial telescope do not obtain here, so that the instrument can be built of the dimensions required to accomplish its purpose to the best advantage. Plate XXXI represents the spectroheliograph constructed in the instrument shop of the Solar Observatory for use with the Snow telescope. The image of the Sun, 6.7 inches in diameter, falls on the first slit of the instrument in about the position of the metallic disk shown on the right of the plate (this disk is removed when the solar surface is photographed). The light, after passing through the slit, falls upon an 8-inch photographic objective, which renders the rays parallel. They then meet the surface of a plane mirror, from which they are reflected to two large prisms. The prisms disperse the light into a spectrum, an image of which is formed on the second slit by a second 8-inch objective. The prisms are so adjusted that the curved second slit, which may be seen near the middle of Plate XXXI, coincides accurately with the calcium line H_2. The photographic plate is placed in the supporting frame in front of the slit and the door



THE 5-FOOT SPECTROHELIOGRAPH, MOUNTED FOR USE WITH THE SNOW TELESCOPE



THE SUN, PHOTOGRAPHED WITH THE 5-FOOT SPECTROHELIOGRAPH
August 25, 1906, 6^h 18^m A. M. Camera slit set on H_2 line of calcium

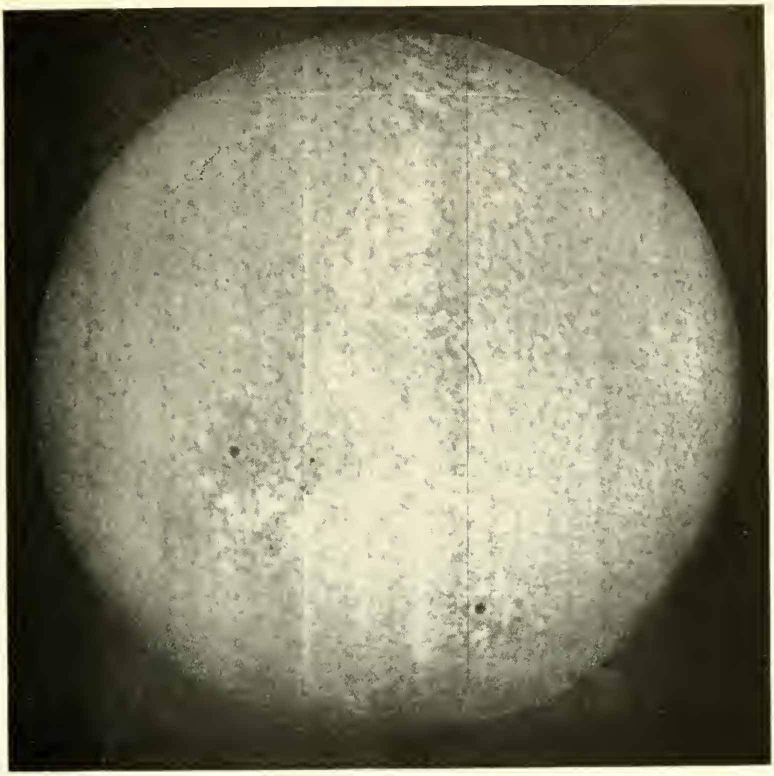
closed, excluding from the plate all light except that which comes through the slit. An electric motor is then started, causing the iron bed-plate, which is mounted on steel balls and carries the two slits, the lenses and the prism-train, to move at a uniform rate across the solar image.

Plate XXXII reproduces a photograph made in this way, for comparison with a direct photograph (Plate XXVIII) showing the Sun as it appears to the eye in the telescope. The luminous clouds of calcium vapor, or "flocculi," are well shown on the monochromatic image, but do not appear in the direct photograph. It will therefore be recognized that this method opens up an extensive field, by permitting the invisible phenomena of the solar atmosphere to be investigated. The wide range of the new information thus to be derived will be appreciated when it is remembered that by photographing the Sun with the lines of hydrogen, iron, sodium, magnesium, or any other element represented among the thousands of lines of the solar spectrum, the distribution of the corresponding vapor can be recorded. For example, Plate XXXIII is a picture of the hydrogen flocculi, made six minutes after the calcium image in Plate XXXII was obtained. It will be seen that most of the hydrogen clouds, instead of giving bright images like those obtained with calcium, are comparatively dark, though certain eruptive phenomena and regions in the neighborhood of Sun-spots appear bright on the hydrogen plates. This spectroheliograph is also used to photograph the iron vapors in the Sun, but, as will be explained later, a larger instrument is required to yield satisfactory solar photographs with the narrower lines of other elements.

The 5-foot spectroheliograph has been in regular use with the Snow telescope since October, 1905. Photographs of the Sun are made with the calcium, hydrogen and iron lines every clear day, both in the morning and in the afternoon. About 3,700 negatives thus obtained give a connected history of the Sun during the period in question, and provide the material for such investigations as will now be described.

The first use of these plates that suggests itself is a study of the solar rotation as determined by the rate of motion of the flocculi. The flocculi change more or less in form from hour to hour, but some of them may be identified on plates taken on several consecutive days. Two plates, taken about twenty-four hours apart, are closely compared and only those flocculi which undergo small change of form are marked for measurement. The process of measurement involves the determination of the latitude and longitude of each of these points, referred to the center of the Sun. As the flocculi are seen in projection on the surface of a sphere, it is evident that a considerable amount of calculation would be required to deduce the latitudes and longitudes if the ordinary methods of measurement, giving their distance along a radius from the center of the disk, and the angle between this radius and the north pole of the Sun, were employed. To obviate this computing, the heliomicrometer was devised for the measurement of these photographs, and constructed in the instrument shop of the Solar Observatory. This instrument consists essentially of two 4-inch telescopes, one of them pointed at the solar photograph, the other at a silvered bronze globe, placed near it. By a suitable device the images given by the two telescopes are brought together in a single eye-piece, so that the observer sees the photographs projected upon the surface of the globe. If, then, the globe is ruled with meridians and parallels one degree apart, and the axis of the globe is inclined at such an angle as to correspond with that of the Sun on the date of the photograph, it is evident that the latitude and longitude of any point on the photograph can be read off to a tenth of a degree, with reference to the nearest meridian and parallel. In practice, many refinements are introduced to increase the precision of measurement. For convenience, the two telescopes are mounted immediately above the globe and photographic plate and pointed at two plane mirrors 30 feet away, in which the globe and plate are seen. It has been found that the rapidity and precision of measurement with this instrument are as great as with the ordinary method, while all of the extensive computations are eliminated.

During the summer season of 1907 the Sun was photographed with the Snow telescope on 113 consecutive days. Such an unbroken series of negatives provides the best of material for the study of changing solar phenomena, since the successive phases can be observed without the interruptions encountered under less favorable atmospheric conditions. In the determination of the solar rotation, for example, a cloudy period of two or three days may prevent the measurement of a large proportion of the calcium flocculi, because their changes of form are so rapid. 2,585 positions of calcium flocculi have been measured on 76 plates, by Miss Ware, with the heliomicrometer, and the combined results furnish the following values for the rotation periods of the calcium flocculi at different latitudes.



THE SUN, PHOTOGRAPHED WITH THE 5-FOOT SPECTROHELIOGRAPH

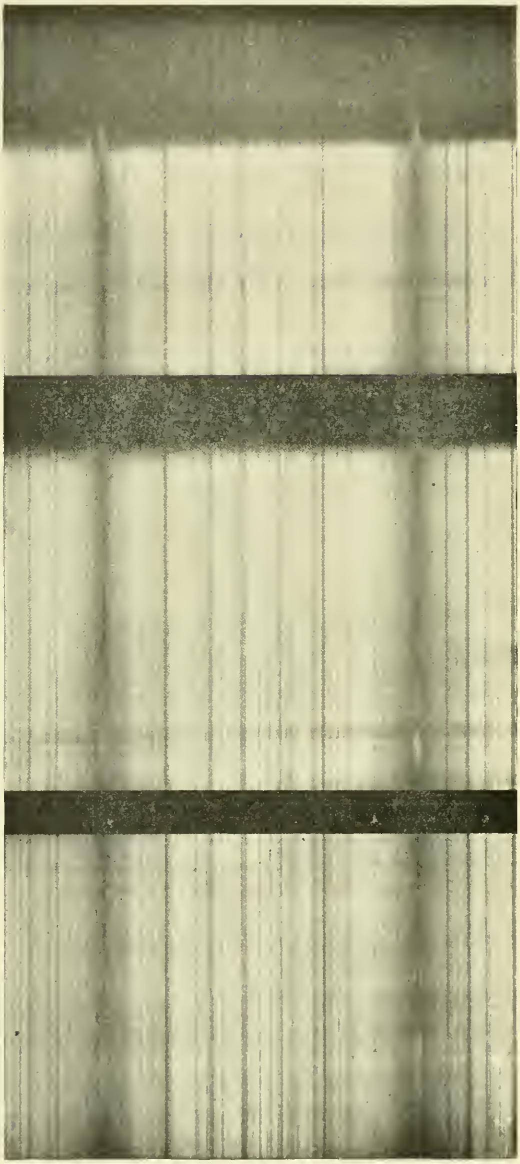
August 25, 1906, 6h 36m A. M. Camera slit set on *Hδ* line of hydrogen

H K

(a)

(b)

(c)



BRIGHT H AND K LINES ON THE DISK (*a*), (*b*), AND (*c*), IN THE CHROMOSPHERE (*b*), AND IN A PROMINENCE (*a*)

Latitude.	Daily angular motion.	Number of measures.	Rotation period, days.
0° ± 5°	14°.43	364	24.95
± 5 ± 10	14 .33	391	25.12
± 10 ± 15	14 .29	518	25.19
± 15 ± 20	14 .26	530	25.25
± 20 ± 25	14 .27	423	25.23
± 25 ± 30	14 .07	215	25.59
± 30 ± 35	13 .86	144	25.97

The measurement of the hydrogen flocculi is complicated by their changes in form, which are much more rapid than in the case of calcium. It is not surprising that this should be true, if the hypothesis provisionally adopted to account for the nature of the flocculi is correct. According to this hypothesis, the calcium flocculi shown by the spectroheliograph correspond to three different levels, defined in any case by the position of the second slit with reference to the H or K line. These lines are of complex structure, as Plate XXXIV illustrates. H consists of a broad hazy band, designated as H_1; superposed on this is a narrow bright line, called H_2; and near the center of this bright line is a very narrow dark line, called H_3. K is similar to H (though somewhat stronger) and contains the constituents K_1, K_2, and K_3. If the second slit of the spectroheliograph is set at some point on the broad H_1 or K_1 band, only the low-lying calcium vapor which is dense enough to produce a band of this width is capable of showing its presence on the photograph (Fig. 1, Plate XXXV). When the second slit is set so as to include H_2 or K_2, the less dense vapor, lying at a higher level (a few thousands of miles above the photosphere), produces the calcium flocculi measured in the above mentioned determination of the solar rotation (Fig. 2, Plate XXXV). The H_2 photographs frequently show evidences of the absorbing effect of vapors lying at the H_3 level, which give rise to *dark* calcium flocculi. When the spectra of these flocculi are photographed, the H_3 and K_3 lines are found to be greatly widened and strengthened in them. There can therefore be but little doubt that they correspond to absorption effects produced at a comparatively high level. Independent evidence in favor of this view is afforded by the fact that spectroheliograph pictures of the Sun's limb frequently show prominences, many thousands of miles in height, to be present at points where dark flocculi extend on to the disk. This question has been specially investigated by Michie Smith and Evershed, at Kodaikanal, India, and their conclusion that these dark flocculi are prominences, absorbing the light of the disk, is in perfect harmony with the Mount Wilson results. In some cases, however, it is probable that calcium vapor lying in the upper chromosphere, below the level of prominences, may produce dark flocculi.

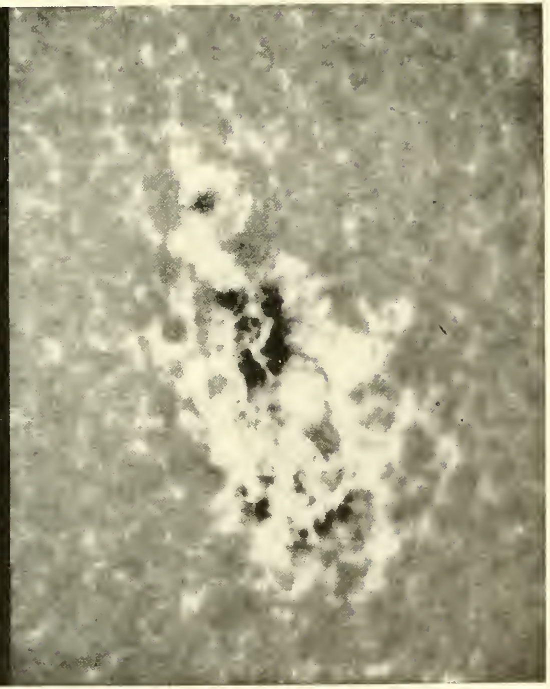
Our discovery at the Yerkes Observatory of the dark calcium flocculi was made soon after we had first photographed the hydrogen flocculi and found them (in most cases) to be dark. On the hydrogen plates there occasionally appeared exceptionally dark flocculi, and when one of these plates was compared with a calcium plate taken at about the same time, a dark object, similar in form to that shown by the hydrogen plate, was found to be present. We thus have strong presumptive evidence, since the hydrogen and calcium plates show these effects in the same way, that these particular hydrogen flocculi are comparatively high-level phenomena.

While it of course does not follow that the ordinary hydrogen flocculi, which are not so dark as these exceptional ones, lie at the same level, the very fact that they are dark suggests the view that they are due to the absorptive effect of the cooler hydrogen in the upper chromosphere. The bright hydrogen flocculi, so frequently recorded in the neighborhood of Sun-spots, are supposed to be due to radiation from hydrogen at a higher temperature.

Assuming for the present the validity of this hypothesis, it appears that the ordinary dark hydrogen flocculi recorded in our daily photographs of the Sun represent a higher level than the bright calcium flocculi obtained in the daily series made with the H_2 line. Thus we might reasonably expect that the rotation period derived from a study of the motion of these flocculi would differ from that of the bright calcium flocculi.

The measures of the daily change in longitude of the hydrogen flocculi at present available are too few in number to give a reliable determination of the solar rotation. Indeed, the marked proper motions of these objects in all directions on the solar surface, and their rapid change of form, will make it necessary to obtain a great number of these measures before final conclusions can be drawn; 547 flocculi measured on 20 different plates give the results obtained in the following table.

Latitude.	No. points.	Daily angular motion.	Rotation period, days.
0° ± 5°	91	14°.3	25.2
5 ± 10	77	14.4	25.0
10 ± 15	95	14.6	24.7
15 ± 20	73	14.5	24.8
20 ± 25	71	14.7	24.5
25 ± 30	65	14.7	24.5
30 ± 35	33	14.9	24.2
35 ± 40	23	14.6	24.7
40 ± 45	19	14.4	25.0



GREAT SUN-SPOT OF OCTOBER, 1903

FIG. 1

October 9, 3^h 43^m. Calcium flocculi as shown with second slit set on H_1

FIG. 2

October 9, 3^h 30^m. Calcium flocculi as shown with second slit set on H_2

The following table brings together the results of various determinations of the solar rotation:

Latitude.	Spots.				Faculæ.	
	Carrington.	Spoerer.	Maunder.	Unweighted means.	Stratonoff.	Reversing layer, Adams.
±0° ±5°	14.42	14.34	14.44	14.40	14.68	14.70
±5 ±10	14.35	14.30	14.41	14.35	14.61	14.58
±10 ±15	14.21	14.21	14.34	14.25	14.31	14.43
±15 ±20	14.06	14.08	14.25	14.13	14.18	14.23
±20 ±25	13.90	13.90	14.13	13.98	14.19	14.00
±25 ±30	13.73	13.69	13.99	13.80	14.08	13.72
±30 ±35	13.54	13.44	13.83	13.60	13.60	13.43

Latitude.	Calcium flocculi (H_2).				Flocculi ($H\delta$).	(Spectrographic.
	Kenwood.	Fox. 1903–04.	Mount Wilson.	Unweighted means.		
±0° ±5°	14.66	14.49	14.43	14.53	14°.6	15°.05
±5 ±10	14.52	14.42	14.33	14.42		
±10 ±15	14.37	14.24	14.29	14.30		
±15 ±20	14.22	13.94	14.26	14.14		
±20 ±25	14.12	13.67	14.27	14.02		
±25 ±30	13.90	13.96	14.07	13.98		
±30 ±35	13.76	13.70	13.86	13.77		

The long series of observations by Carrington, Spoerer, and Maunder furnish ample material for the study of Sun-spot motions, but it is doubtful whether such results should be combined, since they cover long time intervals, during which (as some evidence suggests) the rotation period may undergo variation. The same may be said of the flocculi. The unweighted means of determinations of the motions of the calcium flocculi, made at the Kenwood, Yerkes and Mount Wilson Observatories, differ so little from the mean motions of the spots that no safe conclusions can be drawn. Stratonoff's results for the faculæ are of rather low weight, since they comprise a comparatively small number of measures, necessarily made near the Sun's limb (since the faculæ are not visible near the center of the disk), and therefore subject to greater errors of setting.

But if we are not warranted in concluding that the calcium flocculi move more rapidly than the spots, we may at least recognize the striking differences which distinguish their rotational motions from those of the hydrogen flocculi. The lower calcium clouds follow the motions of the spots, and show the same marked acceleration of angular velocity toward the equator. The hydrogen flocculi, floating at higher levels, and thus escaping the effects of friction experienced by the calcium vapor, move at greater velocities in the higher latitudes, and show little increase in the equatorial zones.

It will be observed that the spectrographic velocities, both in the low-lying vapors of the reversing layer and even more markedly in the case of hydrogen, are decidedly greater than the results obtained by measuring the daily motions of spots, faculæ or flocculi. Is it possible that the flocculi, rising from lower levels, retain, in part, the lower velocities characteristic of these levels? It will be a matter of great interest to study this question, as more measures become available.

Red and Violet Hydrogen Flocculi

Adams's spectrographic measures of hydrogen make it probable (though hardly certain, as yet) that the rotational displacements of the red hydrogen line ($H\alpha$) are greater, on the average, than those of the blue and violet lines ($H\beta$ and $H\gamma$; $H\delta$ was too diffuse for accurate measurement). The $H\alpha$ line is also greatly strengthened and widened near the Sun's limb, while the other lines retain about the same intensity they exhibit at the center of the disk. Hence it might be suspected that photographs of the hydrogen flocculi, made with $H\alpha$, would exhibit corresponding peculiarities.

Fortunately the new "Pan-iso" plates, for which we are indebted to Wallace, are remarkably sensitive to red light. They enabled us to try the experiment of photographing the Sun with the $H\alpha$ line, using the high dispersion of a spectroheliograph of 30 feet focal length, employed with the new tower telescope. The first plate showed large bright hydrogen flocculi, in a region (near a group of small Sun-spots) where an $H\delta$ photograph, taken simultaneously with the 5-foot spectroheliograph and Snow telescope, showed only dark flocculi. This first plate, however, was under-exposed, and full timing also revealed dark $H\alpha$ flocculi. Later it was found possible to make excellent $H\alpha$ photographs of the entire Sun with the 5-foot spectroheliograph. Curiously enough, both the bright and dark flocculi shown by these plates differ in many particulars from the $H\delta$ flocculi, though there is a general resemblance of various details (Plate XXXVI).

These results have been obtained very recently and no complete explanation of the differences between the $H\alpha$ and the $H\delta$ flocculi has yet been worked out. We found at the Yerkes Observatory that the $H\beta$, $H\gamma$ and $H\delta$ flocculi closely resemble one another, and this

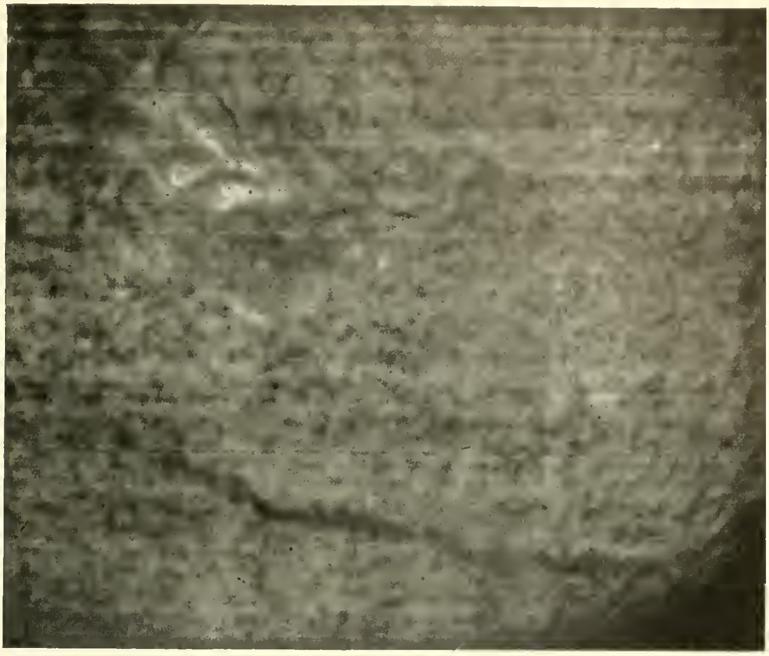


Fig. 1.—HYDROGEN FLOCCULI, PHOTOGRAPHED WITH THE *Hα* LINE

1901, May 1, 4h 48m P. M. Scale: Sun's diameter = 0.2 meter

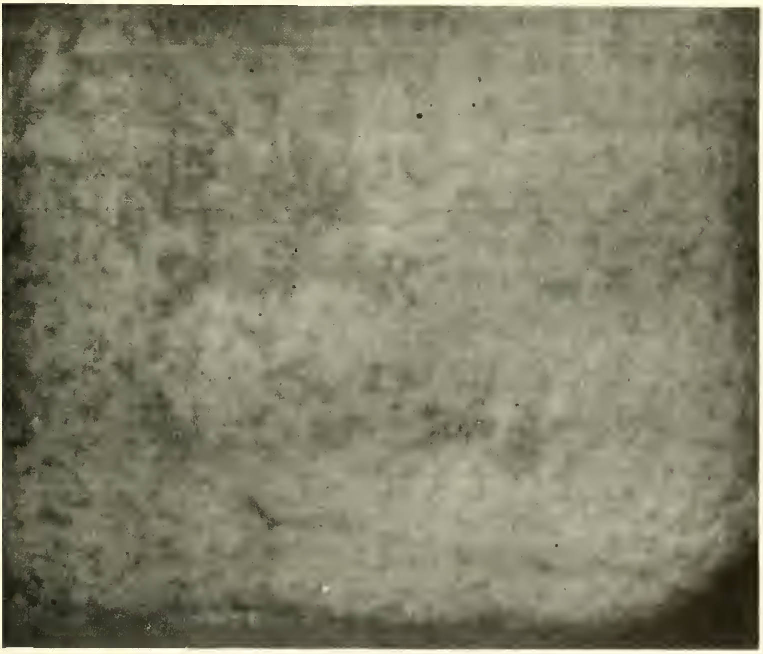


Fig. 2.—HYDROGEN FLOCCULI, PHOTOGRAPHED WITH THE *Hδ* LINE

1908, May 1, 5h 07m P. M. Scale: Sun's diameter = 0.2 meter

has recently been confirmed on Mount Wilson. $H\alpha$, therefore, is the exceptional line, as its spectroscopic peculiarities also indicate. We are at once reminded of the remarkable behavior of the hydrogen lines in the Wolf-Rayet stars, where $H\alpha$ is sometimes bright and the other hydrogen lines invisible or dark. Kayser has explained this condition of things by a simple application of the law of radiation and absorption. But in the well-known variable star *o Ceti,* and others of its type, $H\alpha$ and $H\beta$ are invisible, while $H\gamma$ and $H\delta$, and the more refrangible hydrogen lines, are bright. In R *Andromedæ* $H\beta$ is the chief bright line, while $H\alpha$ is absent. Moreover, the bright line spectra of the nebulæ contain $H\beta$ and $H\gamma$, but $H\alpha$, when visible at all, is very faint. Finally, such stars as γ *Cassiopeiæ* show $H\alpha$ and the other hydrogen lines with the same relative brightness they exhibit in a hydrogen tube.

As the relative temperatures of the radiating and absorbing gases may play a dominant part in determining the character of the spectral lines, and therefore the appearance of the flocculi, the question of their level in the solar atmosphere assumes greater importance than ever. An attempt to photograph prominences at the Sun's limb with the $H\alpha$ line met with instant success, and brought out a most interesting fact: a large prominence appeared at exactly the point where a dark $H\alpha$ flocculus was being carried over the limb by the Sun's rotation. As the structure of the prominence closely resembles that of the flocculus, it is very probable that the latter was simply the prominence seen in projection on the disk, its darkness being due to the fact that the temperature of the gas was low enough to produce perceptible absorption. Most of the $H\delta$ image of the prominence was very weak on the photograph, and thus the absence of a corresponding dark $H\delta$ flocculus is readily accounted for. Furthermore, a portion of the $H\delta$ prominence, which was as bright as the corresponding portion of the $H\alpha$ prominence, is clearly shown as a dark flocculus on the $H\delta$ image of the disk. Hereafter the $H\alpha$ prominences, as well as the $H\alpha$ flocculi, will be photographed daily for comparison.[1]

[1] For an account of the discovery of vortices and magnetic fields associated with Sun-spots, which resulted from work with the $H\alpha$ line soon after this lecture was delivered, see Hale, "Solar Vortices," *Contributions from the Mount Wilson Solar Observatory*, No. 26, *Astrophysical Journal,* September, 1908, and Hale, "On the Probable Existence of a Magnetic Field in Sun-spots," *Contributions from the Mount Wilson Solar Observatory,* No. 30, *Astrophysical Journal,* November, 1908.

Solar Activity and Terrestrial Phenomena

In the introductory part of this lecture reference was made to the relationship between solar phenomena and terrestrial temperatures. The fact that the temperature of our atmosphere undergoes small fluctuations which correspond with the Sun-spot period indicates that the solar heat radiation varies with the number of Sun-spots. Unfortunately, however, since the total area of Sun-spots is only a very small fraction of that of the Sun's disk, and since intervals of several weeks sometimes elapse during which no Sun-spots are seen, the spot area may not prove to be the most reliable index of the solar activity. The total area of the flocculi is always much greater than that of the spots, and even at Sun-spot minimum these objects are never entirely absent from the Sun. For this reason it seems probable that measurements of their area will serve as the best index to the state of the Sun and the surest means of detecting rapid fluctuations in activity, which may be associated with changes in the solar heat radiation or in terrestrial temperatures.

The selection of the flocculi whose areas are to be measured is necessarily a more or less arbitrary matter, depending upon the judgment of the person engaged in the work. As will be seen from Plate XXXII, the calcium flocculi range in size from extensive regions covering a considerable area of the solar surface to minute points barely discernible by the unaided eye on the original negatives. Moreover, the range in brightness of the flocculi is almost as great as the range in area. Evidently many of the fainter and smaller flocculi must be excluded from consideration, especially as their visibility depends upon the quality of the photographs, which differs from day to day with the conditions of the atmosphere. After all has been said, however, the difficulties of selection appear to be no greater than in the case of the faculæ measured on direct photographs at Greenwich. The faculæ are clearly visible only in the immediate neighborhood of the Sun's limb and gradually disappear as they approach the center. Their total area, as measured on any given photograph, is far less than the area of the calcium (H_2) flocculi of the same date, and the effect of atmospheric conditions on their visibility is more marked than in the case of the flocculi.

After experimenting with several methods of measuring the areas of the flocculi, a simple photometric device was adopted. A piece of clear glass is placed over the solar negative and the image of each flocculus selected for measurement is painted over with opaque black paint. The corresponding area is inversely proportional to the measured amount of light, from a source of known intensity, which is transmitted by the blackened plate.

In practice, the investigation has been planned so as to permit the determination, not only of the total area of the calcium flocculi, but also their distribution in latitude and longitude. For this purpose the points on the solar negative corresponding to the intersections of meridians and parallels 10° apart are marked on the glass side with the heliomicrometer, which is provided with an electrical marking pen for this work. The area of the flocculi lying within each square, 10° on a side, is then measured. The sum of these areas gives the total area of the calcium flocculi for the date in question, while the values obtained for the individual squares permit the variations in solar latitude and longitude to be studied. In order to avoid errors incident to the measurement of areas at points near the Sun's limb, the region investigated is confined to the middle of the Sun's disk and extends 40° east and west, and 40° north and south, from the central point.

A large number of photographs have been measured in this way at the Solar Observatory, and in the course of time it will be possible to learn whether these results indicate any significant relationship between solar and terrestrial phenomena.

Conclusion

I trust this account of recent investigations will make clear some of the means at present employed to extend our knowledge of the Sun. Every advance in this department must contribute toward the solution of the great problem of stellar evolution, as well as the lesser problem of the solar constitution. The latter is of special interest to the inhabitants of the Earth, since our very lives depend upon the constancy of the solar radiation, and thus upon the mechanism which maintains it. But the problem of stellar evolution is of even greater philosophical interest. As the biologist withdraws, one by one, the veils which enshrouded the mysteries of organic development, and as the paleontologist reconstructs for us the life of former times, the desire to learn of the earliest steps along the great highway of evolution must grow in every intelligent mind. Fortunately the problems of the astronomer, difficult though they be, are more open to attack than those which confront his biological colleague. With the powerful telescopes and spectroscopes of the present day, and the climatic advantages which well-placed mountain observatories enjoy, unlimited opportunities lie at his command. But if he is to give effective aid in solving the innumerable questions raised by the distant stars, he must first of all profit by the advantages which the proximity of one star affords. From this standpoint I commend to you the far-reaching possibilities of solar research.

SOME NEW SOUTH AMERICAN LAND SHELLS

By WILLIAM H. DALL

Curator, Division of Mollusks, U. S. National Museum

With One Plate

Among some shells collected near the Atrato River, in the Sierra Darien, by Mr. A. E. Heighway, and generously presented to the Museum were *Pleurodonte* (*Labyrinthus*) *plicata* Born, *P.* (*L.*) *sipunculata* Forbes, and the following species which appears to be very distinct from any other heretofore described.

PLEURODONTE (LABYRINTHUS) TENACULUM, new species

Plate XXXVII, Figures 5, 6, 10, 11

Shell dark purplish or chocolate brown, with a broad yellowish-white band near the periphery of the whorls above and below; whole surface finely granulate, and covered with a thin brownish dehiscent periostracum; shell five-whorled, depressed, sharply carinate; upper surface of the whorls (except the nucleus) flattened; the base moderately convex, compressed near the periphery, rounding gently into a deep funicular umbilicus; nucleus pale, with obscurely vermiculate

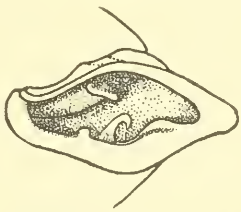


Fig. 64.—Diagram of aperture of *Pleurodonte tenaculum* showing armature.

surface and a deep suture, which is subsequently closely appressed; incremental lines rather distinct and close set; peristome white, the whorl beneath the internal plications impressed externally; the aperture nearly parallel to the basal plane, thick, reflected, with no sulcus at the umbilicus or carina, obscurely subquadrate; parietal lamella low, oblique, thin, strongly reflected outwardly, about five or six millimeters long; basal lamellæ two, the inner not longer than the width of the reflection of the peristome, low, rounded, simple, nearly vertical; the outer similar but longer, beginning externally near the carinal angle and extending backwards obliquely about six millimeters; all these projections are, like the peristome, white; between the two basal lamellæ, slightly nearer the outer one and near its inner end, is a thorn-like projection of a chocolate color, not connected with either lamella, rapidly attenuated and bent forward toward the aperture, the extreme end sharply recurved, white and acute, like a cat's claw; maximum diameter of shell, 30.0; of peristome, 16.0; of umbilicus, 5.0; minimum diameter of shell, 24.0; of aperture, 9.0; altitude of shell, 6.0 mm.

U. S. Nat. Museum no. 111,073.

Two specimens were obtained. The remarkable armature seems to be unique in the group.

HELICINA HEIGHWAYANA, new species

PLATE XXXVII, FIGURES 7, 8, 9

Shell large, depressed, biconic, very sharply carinated, the carina prominently rostrate at the peristome; color pale lemon yellow fading into creamy white, whorls about five; surface finely radially closely striate, the striæ somewhat wavy near the carina; nucleus small, smooth; suture closely appressed; periphery impressed just within the carina, the remainder of the whorl moderately convex, above and below; base imperforate with a very small inconspicuous callus; aperture subtriangular, wider than high, the upper and basal margins thick, strongly reflected, but the callus not carried across the body; at the angle the thickened lip is strongly produced, rostrate, and bent slightly forward with a faint channel internally; operculum lost. Maximum diameter of shell, 25.0; of aperture, 13.0; minimum diameter of shell, 19.0; of aperture (vertical), 7.0; altitude of the shell, 13.0 mm.

One specimen was obtained with the preceding species. U. S. Nat. Museum no. 111,074.

This is the largest and most strongly rostrate species of the group yet described. Its nearest relative seems to be *H. rhynchostoma,* of the same region, which is much smaller, differently colored, and with a polished surface.

With these shells were found *Apcrostoma gigantca* Gray, in some numbers, but a poor state of preservation.

While traveling in the interior of the province of Bahia, Brazil, in 1908, Dr. J. C. Branner, vice-president of Stanford University, observed that landshells, mostly dead, were remarkably abundant, especially *Bulimulus* (*Anctus*) *angiostomus* Wagner, and allied forms. The surface soil, beside silica, contained nearly fifty per cent of lime, over four per cent of carbonate of magnesia, and nearly nine per cent of sodium chloride and sulphate. There is so much salt in the soil that it is leached for the manufacture of common salt. Certain of the landshells, especially the *Anctus*, seemed to thrive best on this salty ground; after the pools of the rainy season had dried up, they were noted upon the stems of weeds which grow abundantly over this low ground. There were found a number of the shells of *Strophocheilus oblongus*, variety *crassus* Albers, which had become remarkably thickened internally; some of the shell was about half an inch thick, and the unbroken specimen felt as if it had been filled with lead. Besides this species, *Bulimulus pachys* Pilsbry and *Odontostomus sectilabris* Pfeiffer were identified, together with the following new species.

ODONTOSTOMUS (CYCLODONTINA) BRANNERI, new species

PLATE XXXVII, FIGURES 2, 3, 4

Shell slender, elongate, subacute, with nine and a half whorls separated by a narrow, deep, but not channeled suture; nucleus small, minutely punctate, with an apical dimple; the subsequent sculpture of fine, even, close-set retractive wrinkles, or riblets, extending from suture to suture and over the base; color white, with irregularly disposed brown lines, usually distant and in harmony with the sculpture; whorls very slightly rounded, the last finally attenuated and externally impressed over the internal denticles; under the reflected lip and behind the large lamina on the pillar is a minute umbilical chink; aperture with a strongly reflected white peristome, with a thin layer of parietal callus, separated from the lip at either end by a channel, shallow at the pillar-lip but deep at the external angle, where it is bounded in front by a small lamina; this sulcus, however, is not indicated externally (as in *O. sectilabris*) by a marginating band in front of the suture; the armature of the aperture externally visible resembles that of *O. sectilabris* Pfeiffer, but, in harmony with the whole aperture, is narrower, and the left hand basal tooth of *sectilabris* is represented by two small but quite separate teeth; an examination of the internal armature shows that half a whorl behind the large pillar-tooth the margin of the pillar is gyrate and swollen, forming a lumpy callosity in the first half of the last whorl; in *O. sectilabris,* however, the same part of the axis is slender, not gyrate or swollen, but merely twisted like the axis in the whorls above. Length of shell, 30.0; of last whorl, 16.0; of aperture, 10.5; maximum diameter of shell, 9.0; of aperture, 7.0 mm.

Two specimens and a fragment were obtained near Rio San Francisco, Serra do Mulato, province of Bahia, Brazil, by Dr. Branner, one of which was donated by him to the National Museum, no. 205,956.

This species differs from the numerous varieties of *sectilabris* by its more slender and elongated form, the internal callus on the axis, and, in the specimen described, by the duplication of the left-hand basal denticle; this last character is, however, probably merely individual. In a large series of *O. sectilabris* from various localities none approached the slender form of *O. branneri*. On plate XXXVII, figure 1, is a figure of *O. sectilabris* for comparison with *O. branneri*, both being in the same scale. The fragment has been utilized to show the callosity on the axis of *O. branneri*, two views being given.

Plate XXXVII

Figures all about natural size and on the same scale

Fig. 1. *Odontostomus sectilabris* Pfeiffer, U. S. Nat. Mus. No. 205957.

Figs. 2, 3. Views of the axis of *Odontostoma branneri* Dall, from slightly different angles, the last half of the outer wall of the last whorl broken away, allowing the callosity to be observed; p. 363.

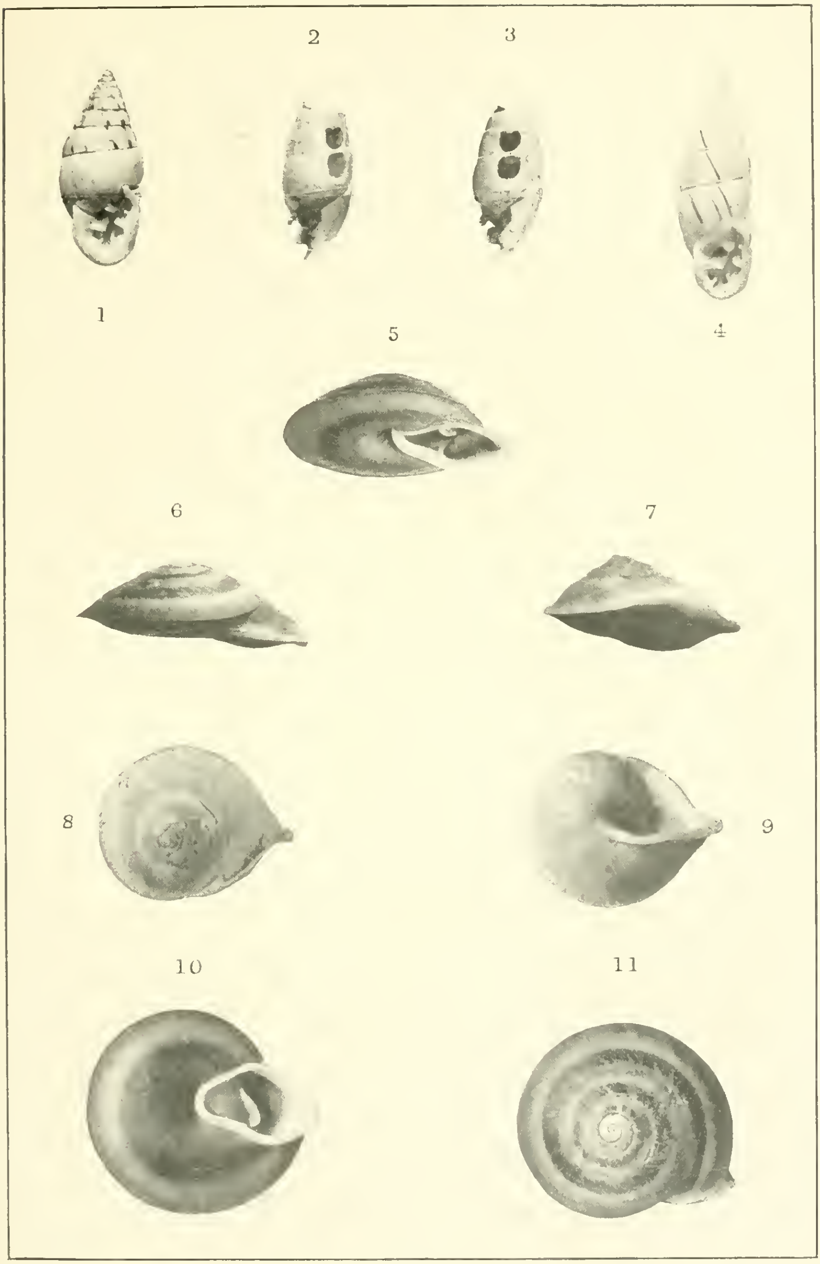
Fig. 4. *Odontostomus branneri* Dall, n. sp., front view, U. S. Nat. Mus. No. 205956; p. 363.

Fig. 5. *Pleurodonte* (*Labyrinthus*) *tenaculum* Dall, n. sp., oblique view of shell showing the hook in the aperture, U. S. Nat. Mus. No. 111073; p. 361.

Fig. 6. The same specimen in profile.

Figs. 7, 8, 9. *Helicina heighwayana* Dall, n. sp., profile, upper and basal views; U. S. Nat. Mus. No. 111074; p. 362.

Figs. 10, 11. *Pleurodonte* (*Labyrinthus*) *tenaculum* Dall, views of base and upper surface of the specimen represented by figure 5.



SOME NEW SOUTH AMERICAN LAND SHELLS

THE AMERICAN FERNS OF THE GROUP OF *DRYOPTERIS OPPOSITA* CONTAINED IN THE U. S. NATIONAL MUSEUM

By CARL CHRISTENSEN, Copenhagen

In a paper entitled "Revision of the American species of Dryopteris of the group of *D. opposita*,"[1] I presented recently a review of the American species of *Dryopteris* having free, simple veins and the bipinnate lamina narrowed downwards. There were mentioned in some detail 82 species, of which I had seen original specimens, or, in some few cases, specimens which could be regarded as typical. Those species of which I had seen no specimens were omitted, as I found it impossible to form an exact idea of these from descriptions alone. Mr. William R. Maxon, Assistant Curator in the U. S. National Museum, offered, however, to send me typical material of some of the species described by Jenman, and at the same time suggested that I examine critically the whole collection of this group in the U. S. National Herbarium, consisting largely of specimens gathered in Central America and the West Indies in recent years by several collectors. Inasmuch as many of the species included in my "Revision" had been treated on the basis of a few specimens, or even of a single specimen, I was anxious to study this material, but for different reasons, partly on account of Mr. Maxon's absence in the field, it did not reach me before my paper was in press. Upon his request I then undertook to work out a separate paper, dealing only with these specimens. Later on, Mr. Maxon sent me a large number of specimens from the John Donnell Smith Herbarium, a collection extraordinarily rich in Central American forms, presented by Captain Smith to the Smithsonian Institution, and now a part of the U. S. National Herbarium. I have thus had in these two lots about 425 specimens, representing practically all the material of this group in the National Herbarium, and in the following paper all of these which I could determine with accuracy are enumerated by locality, collector, and collector's number, with the exception only of the identical numbers enumerated from other herbaria previously, in my "Revision," these being omitted.

[1] Kgl. Danske Vidensk. Selsk. Skrifter, 7 Raekke, Naturvidensk. og Math. Afd. 4: 247–336 1907.

Species.	Central America and Mexico.							West Indies.														
	Mexico.	Guatemala.	Salvador.	Honduras.	Nicaragua.	Costa Rica.	Panama.	Cuba.	Jamaica.	Haiti and S. Domingo.	Porto Rico.	St. Thomas.	St. Kitts.	Montserrat.	Guadeloupe.	Dominica.	Martinique.	Santa Lucia.	St. Vincent.	Grenada.	Tobago.	Trinidad.
Dryopteris—																						
1. concinna	+	+	....	....	....	+	....	+	+	....	....	....	....	....	(+)	....	....	....	....	....	....	....
1a. " elongata	+	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
2. oligocarpa	+	....	....	....	....	+	....	+	+	+	....	....	(+)	....	....	....	....	....	....	....	....	....
3. pilosula	+	+	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
4. navarrensis	....	....	....	....	....	+	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....
5. Nockiana	....	....	....	....	....	....	....	....	*	....	....	....	....	....	....	....	....	....	....	....	....	....
6. piedrensis	....	....	....	....	....	....	....	*	....	....	....	....	....	....	....	....	....	....	....	....	....	....
7. Lindigii	....	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8. caucaensis	....	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
9. velata	....	....	....	....	....	....	....	*	....	....	....	....	....	....	....	....	....	....	....	....	....	....
10. aspidioides	....	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
11. opposita	....	....	....	....	....	....	....	(+)	....	....	+	....	+	+	+	+	+	....	+	+	+	+
11a. " varr	+	....	....	....	....	+	....	....	(+)	....	....	....	....	....	....	....	....	....	....	....	....	....
12. panamensis		+	+	+	....	+	+	+	+	....	(+)	....	....	....	....	....	....	....	....	....	....	....
13. delicatula	....	....	....	....	....	....	....	....	....	....	....	....	....	....	*	....	....	....	....	....	....	....
14. physematioides	....	....	....	....	....	....	....	....	....	*	....	....	....	....	....	....	....	....	....	....	....	....
15. pseudosancta	....	+	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
16. sancta	....	+		....	....		....	+	+	+	+	....	....	....	....	+	....	....	....	....	....	....
17. consanguinea	....	....	....	....	....	....	....	....	+	....	....	....	....	....	....	+	....	....	....	+	....	+
18. scalpturoides	....	....	....	....	....	....	....	*	....	....	....	....	....	....	....	....	....	....	....	....	....	....
18a. " jamaicensis	....	....	....	....	....	....	....	....	*	....	....	....	....	....	....	....	....	....	....	....	....	....
19. firma	....	....	....	....	....	....	....	....	*	....	....	....	....	....	....	....	....	....	....	....	....	....
20. pachyrachis var	....	....	....	....	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....
21. supina var	....	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
22. rustica	....	....	....	....	....	....	....	....	+	....	....	....	....	....	+	....	....	....	+	....	....	....

23. melanochlaena		*																				
24. Germaniana								+							+							
25. dominicensis																*						
26. diplazioides	+	+				+			(+)	+					+							
27. consimilis									+		(+)				(+)							
28. heteroclita									+		(+)											
29. atrovirens						+																
30. Sprengelii	+	+			+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+
31. struthiopteroides		*																				
32. Mercurii	(+)	+				+																
33. Thomsonii									+													
34. Christensenii						*																
35. limbata									(+)				+		(+)							
36. scalaris	(+)	+																				
37. rudis	+	+				+			+													
38. nervosa						+																
39. lanipes		*																				
40. pterifolia		+				+																
41. mertensioides						*																
42. cheilanthoides	+	+				+			+													
Total	10(12)	16	1	1	1	23	2	9(10)	17(20)	5	3(6)	1	3(4)	1	6(9)	5	2	1	4	3	2	3

For the courtesy of the authorities of the U. S. National Museum and the kindness of Captain Smith in lending me these rich collections I wish here to express my most sincere thanks. I have studied these specimens with unusual satisfaction and pleasure, owing to their careful preparation and the detailed data of locality, altitude, and conditions of habitat, in which respect they very far surpass most of the material with which I had previously worked. I have on this account been able to gain a more exact idea of several species and of their distribution.

In the following paper 9 species are described as new, and 3 older species not mentioned in my "Revision" are included; thus, altogether, 94 American species of this narrow group are now dealt with by me. About a dozen more have been described by Jenman and Sodiro, but of these I have seen no specimens. Recently Dr. E. Rosenstock has described a new species of this group from Bolivia, and he sends me another apparently new species from Ecuador. The whole number of valid described species thus exceeds 100, but I have no doubt that the number will eventually prove to be considerably greater. In the vast amount of material examined by me are to be found not a few fragments which, I believe, belong to undescribed species. It is interesting to note that among the few species known from Bolivia at least 2 are new to science. From the Peruvian and other parts of the Andes very few specimens are seen, but it is probable that these regions possess a similar number of species to the Andes of Ecuador, Colombia, and Costa Rica, and that not a few will appear to be new.

I have in my "Revision" pointed out a remarkable difference between the species of southern Brazil and those of the Andes and the West Indies, the fern floras of the last two regions showing an intimate alliance. The rich collections of the U. S. National Herbarium show this alliance to be still closer than supposed. The occurrence of the Jamaican *D. Thomsoni* in Colombia (*D. Stuebelii*), of the West Indian *D. sancta* in Guatemala, and of the continental *D. rudis* in Jamaica are new examples of this relationship.

In the preceding table is shown the distribution of the species occurring north of Panama, as known to me. A "+" indicates that the species is found in the country or island indicated; "(+)" that it is recorded, but not surely in the true form; and an "*" that it is endemic or hitherto not found beyond.

In this table Costa Rica, Jamaica, and Guatemala figure as having the largest number of species; the other Central American republics are not so thoroughly explored as the two named, but will probably be found to have a similar number of species. In Central America and Mexico together 26 species are found, of which number 16 are found south of Panama, 8 in the West Indies, and 7 thus far not found elsewhere. Only 3 Central American species, viz., *D. sancta, D. diplazioides,* and *D. Sprengelii,* are with certainty found east of Jamaica and Haiti. In the West Indies the continental element is strongest in Jamaica, with such species as *D. concinna, D. oligocarpa, D. panamensis, D. rudis, D. cheilanthoides,* and *D. Thomsoni,* which do not occur at all in the smaller islands. It is probable that most of these species are very old, as well in Jamaica as on the continent, but the possibility is not excluded that an exchange of species may have taken place by means of wind-blown spores, or may be taking place today. It will, therefore, always be impossible to decide definitely in what region a species has had its origin, but certainly Jamaica, like the Andine valleys, is an endemic center of a high order.

D. sancta and *D. delicatula* seem to be species of insular origin. The occurrence of the former in Guatemala gives us an example of a West Indian element in Central America. Another instance is found in the Central American *D. pseudosancta,* which has its nearest allies in the West Indies. On the other hand, such species as *D. opposita* (*vera*) and *D. Sprengelii,* both generally dispersed over all the smaller islands, are to me reduced insular, but specifically fixed, forms of species which have had their origin on the continent. More is said as to this in the treatment of these two species below.

GROUP OF D. OLIGOCARPA

Smaller species; pinnæ seldom more than 10 cm. long by 1.5 cm. broad; tertiary veins 3-10 to a side. Lamina gradually narrowed downwards, with 1-4 pairs of abbreviated pinnæ, rarely abruptly attenuate. Basal pair of segments not prolonged.

DRYOPTERIS CONCINNA (Willd.) Kuntze

(REVISION 271, No. 1, FIG. 2.)

I can not find out under what name Jenman may have described this species, which in its typical forms has been frequently collected in Jamaica in recent years. The species is very distinct in habit and pubescence, and especially in its uniformly setose sporangia.

JAMAICA: *Hart* 304. Tweedside, rocky bank in the open, 2,000 ft., *Maxon* 984. Second Breakfast Spring, grassy bank in the open, 2,000 ft., *Maxon* 989*a*. Shaded edge of Green River, *Maxon* 1501 (=*Under-*

wood 2566). Near Silver Hill Gap, on dryish bank, 3,500 ft., *Maxon* 1135 (=*Underwood* 2271).[1]

CUBA: Josephina, north of Jaguey, Yateras, Oriente, about 575 meters, border of forest, *Maxon* 4100. Farallones of La Perla, north of Jaguey, 540–585 meters, moist bank at edge of rocky woods, *Maxon* 4409.

MEXICO: Córdoba, Vera Cruz, *Fink* 62.

GUATEMALA: Cengaguilla, Depart. Santa Rosa, 1,300 meters, *Heyde and Lux* (*Donnell Smith* 4681). Dueñas, *Salvin*. Coban, Depart. Alta Verapaz, 4,300 ft., *von Tuerckheim* (*Donnell Smith* 168 in part).

COSTA RICA: Juan Viñas, Reventazon Valley, 1,000 meters, on bank near road, *Cook and Doyle* 386. Vicinity of the River Tiriví, near San José, 1,100 meters, on shaded bank of river, *Maxon* 131.

D. concinna is known from the West Indies and the Andes from Mexico to Ecuador; it varies but little, mainly in texture. The following variety, connected with the type by intermediate forms, may be distinguished by its longer and broader pinnæ with subfalcate segments and often by its firmer texture; it is the most common form of the species in southern Mexico.

DRYOPTERIS CONCINNA ELONGATA (Fourn.) C. Chr.

(REVISION 272.)

MEXICO: Orizaba, 4,000 ft., *Seaton* 68. Córdoba, Vera Cruz, *Fink* 58.

DRYOPTERIS ARGENTINA (Hieron.) C. Chr.

(REVISION 273, NO. 4.)

Only the following additional specimen has been seen:

BOLIVIA: Near La Paz, 10,000 ft., *Rusby* 421.

DRYOPTERIS OLIGOCARPA (H. B. Willd.) Kuntze

(REVISION 274, NO. 5, FIG. 5.)

Under this name I unite provisionally a number of forms, which in size and habit differ considerably from each other, but in essential

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[1] I collected most of my 1903 Jamaican plants in company with Prof. L. M. Underwood. Frequently material was divided between us at the time of collection and dried separately, Dr. Underwood giving his numbers to the series intended for the New York Botanical Garden and I my numbers to the plants for the U. S. National Museum. For convenience of reference I kept a record of such of Dr. Underwood's numbers as were thus exactly equivalent to my own. Except for a few scattering specimens Mr. Christensen has seen only my series; but as an aid to those who may have received Dr. Underwood's duplicates, his equivalent numbers are here cited in parentheses by Mr. Christensen, these being copied from my labels.—WILLIAM R. MAXON.

characters agree very well. Still, it is very probable that this *D. oligocarpa* is a collective species which includes several "elementary species," the limitations of which I am unable to define at present.

St. Kitts: Summit of Mt. Misery, *Britton and Cowell* 529.
Haiti: Without locality, *Jaeger.* (As the preceding rather doubtful.)
Jamaica: Cuna Cuna Pass, on banks, *Fredholm* 3234. Swift River near Hope Bay, *Alex. Moore.* In the vicinity of Castleton, edge of Ginger River, *Maxon* 835.
Cuba: Upper slopes and summit of Gran Piedra, Oriente, 900 to 1,200 meters, moist shaded bank, *Maxon* 4041*a*.
Mexico: Pedro Paulo, Territorio de Tepic, *Rose* 3330.
Costa Rica: Juan Viñas, Reventazon Valley, 1,000 meters, on bank by road-side, *Cook and Doyle* 193.

DRYOPTERIS NAVARRENSIS Christ

Aspidium navarrense Christ, Bull. Herb. Boiss. II. 6: 160. 1906.
Dryopteris navarrensis Christ, Bull. Herb. Boiss. II. 7: 262. 1907.

Costa Rica: Navarro, *Werckle.*

This species, which in my "Revision" I regarded as a variety of *D. pilosula,* may stand preferably as a distinct species, differing from *D. pilosula* by its exindusiate sori. The rachis, costæ, and veins are, especially beneath, clothed with long whitish patent hairs. Some specimens from Jamaica (*Hart* 304), distributed as *Nephrodium conterminum* var. *pubescens* Baker, agree almost exactly with the Costa Rican plants. Probably this is the species described as "*Polypodium pubescens* Raddi" by Jenman (Bull. Bot. Dept. Jamaica II. 4: 128. 1897).

DRYOPTERIS NOCKIANA (Jenman) C. Chr.

(Revision 279, No. 8, Fig. 7 (small).)

In my "Revision" I have compared this species, endemic in Jamaica, to *D. panamensis* and *D. oligocarpa.* Having now seen numerous specimens, I find that the species very much resembles *D. concinna* in habit and pubescence, but that it can be distinguished at the first glance by its glandular under surface and by its densely setose, persistent indusia. As a rule the hairs of the rachis and midribs below are longer than those of *D. concinna,* but in some specimens one finds the characteristic minute pubescence of that species.

D. Nockiana, besides a type specimen from Jenman's herbarium, is represented in the U. S. National Herbarium by the following specimens from different localities in Jamaica, ranging vertically from 600 to 1,500 meters: *Maxon* 998 (=*Underwood* 2132), 999 (=*Und.* 2134), 1407 (=*Und.* 2533), 1593 (=*Und.* 2643), 1879, 1146 (=*Und.* 2277), 2297, 2285; *Underwood* 110, 449, 1826; *Clute* 101.

DRYOPTERIS PIEDRENSIS C. Chr., sp. nov.

CUBA: Upper slopes and summit of Gran Piedra, Oriente 900 to 1,200 meters, *Maxon* 4041, type; U. S. National Herbarium, No. 522690.

Eudryopteris rhizomate erecto-obliquo, radicibus numerosis. Stipitibus fasciculatis, gracilibus, angulatis, stramineis, 15 cm. longis, minute hirtis, ad basin squamis paucis brunneis instructis. Lamina lanceolata, 50-60 cm. longa, 15 cm. lata, utrinque attenuata, firmo-membranacea vel papyracea, graminea, rachi tenui brevissime puberula, bipinnatifida. Pinnis 2.5–3 cm. inter se remotis, alternis, horizontalibus, sessilibus, inferioribus 3-5 jugis gradatim abbreviatis, infimis auriculiformibus hastatis, inframedialibus maximis, oblongo-lanceolatis, 7.5 cm. longis, 1.5 cm. latis, ad apicem serratum acuminatum sensim attenuatis, supra pilis microscopicis rigidis rudis, subtus ad costas costulasque brevissime puberulis et glandulis rubris sparse obtectis, ad alam vix 0.5 mm. latam pinnatifidis vel ad basin perfecte pinnatis. Laciniis ca. 20 jugis, basalibus aequalibus vel parum reductis, posteriori auricula interna instructa, superioribus obliquis vel subfalcatis, ca. 2 mm. latis, subacutis vel obtusis, marginibus integris vel leviter crenatis revolutis. Venis indivisis, 8-9 jugis, utrinque prominulis. Soris margini approximatis, parvis; indusiis minimis, mox deciduis, glandulosis, ciliatis. Sporangiis glabris.

This species is in size, shape of the lamina, and pubescence, almost identical with *D. concinna,* but it differs from that species by (1) its glabrous sporangia, (2) its firm lamina with prominent veins and reflexed margins, which partly cover the sori. In these respects it may be compared to *D. scalpturoides*, which, however, is much more hairy and has many pairs of reduced pinnæ. The basal pair of segments is in the larger pinnæ quite free.

DRYOPTERIS COLUMBIANA C. Chr.

(REVISION 279, NO. 9, FIG. 8.)

COLOMBIA: Cauca, *Lehmann* 2968.

I now prefer to refer here this number, determined previously by Hieronymus and myself as *D. oligocarpa,* from which it differs by its longer leaf and by the shorter pubescence of the rachis. Nevertheless, I have some doubt if my proposed species can be held distinct from *D. oligocarpa*.

DRYOPTERIS MUZENSIS Hieron.

(Revision 280, No. 10.)

Colombia: Hills of Miraflores above Palmira, Central Cordillera, 1,600 to 1,200 meters, *Pittier* 892.

This specimen is larger than the type (leaf 1 m. long by 22 cm. broad), but is otherwise typical. The main difference from *D. columbiana* is in the absence of long setæ on the veins above.

DRYOPTERIS VELATA (Kunze) Kuntze

(Revision 286, No. 22.)

This, the most beautiful species of the group, was rediscovered in Cuba by Mr. Maxon in April, 1907. His specimens are from the shaded talus of limestone cliffs at the Caverns of Thermopylæ, Monte Libano, province of Oriente, altitude about 600 meters (No. 4238).

DRYOPTERIS ASPIDIOIDES SUBHASTATA C. Chr.

(Revision 287, No. 23.)

Costa Rica: Cañas Gordas, 1,100 meters, *Pittier* 10990.

[Note.—*Nephrodium brachypodum* Baker,[1] mentioned in my "Revision" as unknown to me, is represented in the U. S. National Herbarium by a specimen of the type collection (*im Thurn* 275, not 225 as quoted in my "Revision"). It probably does not belong to the group of *D. opposita,* but is rather an ally of the West Indian *D. sagittata* (Sw.) C. Chr. It is not unlike *D. ptarmica* but is smaller, with the pinnæ sessile, entire or shallowly lobed, often auricled on both sides at the base, the short stipe and rachis clothed with small dark brown scales, the rachis and veins hairy.]

[1] *Nephrodium brachypodum* Baker, Timehri 5: 213. 1886; Trans. Linn. Soc. II. Bot. 2: 290. 1887.

Dryopteris brachypoda (Baker) C. Chr. Index Fil. 255. 1905.

GROUP OF D. OPPOSITA

The old collective species *Aspidium conterminum* Willd. included the species *D. opposita, D. coarctata, D. consanguinea,* and *D. panamensis,* as delimited in my "Revision." While the typical forms of *D. consanguinea* and *D. coarctata* are well marked from the allied species by their whole habit, the line of separation between *D. opposita* and *D. panamensis* is more difficult to define. The collection of these species in the U. S. National Herbarium is very rich in specimens from Central America, Jamaica, and Cuba. Sorting these specimens one can quickly take out the typical forms of the two species. It then appears that the specimens of true *D. opposita* are all from the Lesser Antilles, and those of *D. panamensis* from Jamaica, Cuba, and mainly Central America. Besides these remains a number of specimens, mostly from Mexico and Jamaica, which may as well be referred to *D. opposita* as to *D. panamensis.* The question, then, is whether these intermediate forms are to be considered as real, phylogenetic intermediates, connecting the two proposed species, which in this case ought to be united into one very variable species, or if they represent one or more additional species intermediate between the two. To solve this question a still larger number of specimens from more localities is necessary. I am inclined to believe that the whole series of forms includes at least three or four species, each of which varies considerably in different directions, especially in size; thus, the large forms of *D. opposita* very much resemble *D. panamensis,* and small forms of *D. panamensis* similarly resemble *D. opposita.* Such doubtful forms show some features easily seen by the experienced eye but described only with difficulty. It is evident that all forms are of the same phylogenetic origin; the richest development is reached in Central America, where *D. panamensis* rivals in size species of the group of *D. Sprengelii,* while *D. opposita* of the Lesser Antilles is an insular reduced form derived from the same ancestors. Using the modern terminology, it may be said that the series of forms includes a number of elementary species in the sense of de Vries, some of which seem to be fixed species, while others are at the present period in a state of quick evolution. A more remote derivative from the same ancestors is the common Brazilian form called *D. opposita* var. *rivulorum* (Raddi), which I now consider a distinct, fixed species. I shall here confine myself to pointing out some additional different forms, which I describe as varieties of the species adopted in my "Revision," to which species I refer the whole number of specimens.

DRYOPTERIS OPPOSITA (Vahl) Urban.

(Revision 288, No. 25, Fig. 15.)

Typical Form: Rather small, the leaf narrowed downwards through a long row of gradually reduced pinnæ. Segments a little oblique, obtuse or with rounded apex, short, with 4 to 6 pairs of veins, the basal ones not much prolonged.

Dominica: Laudat, *F. E. Lloyd* 26.
St. Kitts: Wingfield Estate, forest ravine, *Britton and Cowell* 446.
St. Vincent: Ad Calvary, in locis umbrosis, *Eggers* 6732.
Grenada: *Sherring.*
Tobago: Ad Cremorin River, in sylvestribus humidis, *Eggers* 5850.
Trinidad: Without locality, *Fendler* 65; *Jenman.*
Porto Rico: Clay bank, road from Guayama to Cayey, *Underwood and Griggs* 432. Cayey, ad rupes in flumine Morillos, *Sintenis* 2281.

I have seen no specimens exactly agreeing with this typical form either from the larger islands or from the continent. In Central America it apparently does not occur. The specimens in my "Revision" referred to *D. opposita* I now believe to belong to *D. panamensis.*

FORMS INTERMEDIATE BETWEEN D. OPPOSITA AND D. PANAMENSIS

Jamaica: *Maxon* 802, 821, 996 (= *Underwood* 2130), 1000 (= *Und.* 2135), 1528 (= *Und.* 2601); *Hart* 128.
Mexico: Without locality, *Kerber* 437.
Florida: Miry hammock near Fort Meade, Polk Co., *J. Donnell Smith,* March, 1880.

These intermediate forms resemble in size and fewer reduced pinnæ *D. panamensis,* in their opposite pinnæ and short segments *D. opposita;* in general habit most of them agree very well with *D. panamensis,* to which species I am inclined to refer them. The specimen from Mexico belongs to the form named by Fournier[1] *Aspidium exsudans* var. *myriocarpum;* it is a form with linear pinnæ and short segments. The Florida plant is *Aspidium conterminum* var. *strigosum* of North American authors, believed to be identical with *A. strigosum* Fée from Guadeloupe, which, however, is true *opposita.* Jenman (as shown in letters to Capt. Donnell Smith) considered it to be *D. Sprengelii,* which indicates that Jenman quite misunderstood *D. Sprengelii,* as also his descriptions under that name show. The Florida fern is to me not essentially

[1] Mex. Pl. 1: 98. 1872.

different from the common *D. panamensis,* although some of the smaller leaves very much resemble *D. opposita.*

DRYOPTERIS PANAMENSIS (Presl) C. Chr.

(REVISION 292, NO. 28, FIG. 19.)

Under this name I unite a wide range of forms. Presl's type of the species, collected in Panama by Hænke is, according to the original specimens in herb. Presl proper, a long and narrow form (leaf 7 to 8 dm. long by 5 to 8 cm. broad) ; the pinnæ are scarcely 4 cm. long by 0.5 cm. broad, from a hastate base gradually tapering toward the acuminate apex; segments oblong, oblique, acute, with revolute edges. In my "Revision" I have referred this form to *D. opposita,* which it resembles in habit; still the segments are longer and narrower and the reduced pinna not auriculiform, as in true *D. opposita.* To this form belong the following specimens:

COSTA RICA: Rio Turrialba, Prov. Cartago, 1,600 ft., *J. Donnell Smith* 5087. Dans la forêt à Terraba, 260 meters, *Pittier* 3538. El General, *Pittier* 10488.

The form illustrated by fig. 19 in my "Revision" is the most developed of the species, and is very common in Central America. I have examined the following additional specimens:

COSTA RICA: Vicinity of Cartago, rocky border of stream, *Maxon* 32. Vicinity of the River Tiriví, near San José, 1,100 meters, on banks of shaded river, *Maxon* 132. San José, 1,160 meters, *P. Biolley.* Piedades près San Ramón, 1,000 to 1,100 meters, *Brenes* 14236. San Jose, *Pittier* 1067. Surubres prés San Mateo, 200 meters, *Pittier* 4063. Cartago, *J. J. Cooper* (*Donnell Smith* 6027). Rio Reventazon, Prov. Cartago, 2,000 ft., *Donnell Smith* 5088.

SALVADOR: Prope San Salvador, *L. V. Velasco* (*Donnell Smith* 8890). Vicinity of Izalco, 400 to 600 meters, *Pittier* 1943.

GUATEMALA: Moran, Depart. Amatitlan, 1,205 meters, *Kellerman* 4874. Escuintla, 1,100 ft., *Donnell Smith* 2453, 2738. Pantaleon, Depart. Escuintla, 1,370 ft., *W. C. Shannon* (*Donnell Smith* 174). Without locality, *Heyde* 703, 729.

MEXICO: Without locality, *E. Kerber* 440.

CUBA: Valley of the Rio Bayamita, south slope of Sierra Maestra, among rocks in bed of river, *Maxon* 3964. El Guama, Prov. Pinar del Rio, in the bed of a mountain stream, among rocks, *Palmer and Riley* 158.

JAMAICA: *Maxon* 828, 832, 855, 1001 (= *Underwood* 2136), 1002 (= *Und.* 2137), 1107 (= *Und.* 2227), 1737 (= *Und.* 2695), 1743 (= *Und.* 2703), 1744 (= *Und.* 2704), 1745 (= *Und.* 2705), 1746 (= *Und.* 2706), 1757 (= *Und.* 2721), 2789; *Harris* 7377.

In Mexico the species is represented by two forms, of which the first differs from the common large form only in its rather small size and less falcate segments. It is *Polypodium litigiosum* Liebmann and *Lastrea leiboldiana* Presl, according to the original specimens of these. The second form I name:

DRYOPTERIS PANAMENSIS PROXIMA C. Chr., var. nov.

Leaf with a very short stipe, reduced downwards as in typical *panamensis,* glandular beneath, almost wholly glabrous. Pinnæ about 10 cm. long, short-acuminate, the upper ones alternate; segments approximate, oblique, not falcate, oblong-triangular, acute, the basal ones equal sized or a little prolonged.

The type specimen of this was collected by H. Ross (no. 326) in Mexico: Cuernavaca ad riv. umbr. c. 150 m. (Herb. Munich) and was by me considered a distinct species. Another specimen, in the U. S. National Herbarium, also from Mexico, *Rose and Painter* 7320, from the vicinity of Guadalajara, State of Jalisco, is, however, evidently the same, but connects the type with *D. panamensis;* therefore I now prefer to give to these specimens the varietal name *proxima,* originally used as a specific name. Further specimens are: *Pringle* 1844, from wet places near Guadalajara, State of Jalisco, and probably *Pringle* 11794 from the same locality, Sept., 1903, which is a slender and more hairy form, in habit more resembling *D. opposita.*

By its almost completely glabrous leaf, short-pointed pinnæ, and closely placed oblong-triangular acute segments, this variety seems very different from true *D. panamensis.*

DRYOPTERIS LEUCOTHRIX C. Chr., sp. nov.

BOLIVIA: Near Yungas, 4,000 ft., *H. H. Rusby* 432, type; U. S. National Herbarium, No. 828993.

Eudryopteris rhizomate (?). Stipitibus 2-3 dm. longis, rigidis, angulatis, breviter crispato-pilosis, fusco-stramineis. Lamina lineari-lanceolata, 6-7 dm. longa, medio 16-18 cm. lata, versus basin longe et gradatim attenuata, submembranacea, crassiuscula, siccitate brunnea, rachi profunde sulcata molliter crispato-pilosa, bipinnatifida. Pinnis numerosis, oppositis vel sursum alternis, sessilibus, inferioribus 6-7 jugis gradatim reductis, infimis minimis, medialibus maximis, inter se 2 cm. remotis, linearibus, 8-9 cm. longis, 8-9 mm. latis, acuminatis, ubique (maxime ad costas) pilis albidis brevibus hirtis, ad alam vix 1 mm. latam pinnatifidis. Laciniis numerosis, recte patentibus, sinubus latis rotundis separatis, obtusis vel rotundatis, marginibus integris paulum revolutis, basalibus aequalibus. Venis simplicibus ca. 5 jugis indistinctis. Soris medialibus vel paulum inframedialibus; indusiis persistentibus, pilis albis valde pilosis.

This most distinct new species resembles in habit some forms of *D. opposita,* especially the variety *rivulorum* (Raddi); but it differs from that species as well as from all other species known to me by its rather peculiar indusia, which appear as a cluster of white hairs like white dots on the under side of the leaf. It is also remarkable for its long stem, its long and narrow leaf, and its linear pinnæ with patent round-pointed segments. Although the leaf has a long stem and equal-sized basal segments the species must be placed in my system between *D. opposita* and *D. riopardensis.*

DRYOPTERIS PSEUDOSANCTA C. Chr., sp. nov.

COSTA RICA: Rio Toro Amarillo, Llanuras de Santa Clara, 300 meters, *J. Donnell Smith* 6902, Apr., 1896, type; U. S. National Herbarium, No. 828991.

GUATEMALA: Rio Pinula, Depart. Santa Rosa, 4,000 ft., *Heyde and Lux* (*Donnell Smith* 4094).

Eudryopteris rhizomate erecto, breve. Stipitibus dense fasciculatis, tenuibus, brevissimis (2-3 cm.), basi fuscescentibus. Lamina lineari, usque ad 4.5 dm. longa, 5 cm. lata, ad basin longe et gradatim attenuata, tenuiter herbacea, obscure viridi, rachi tenui pilis patentibus mollibus sparse hirta, bipinnatifida. Pinnis subpatentibus, oppositis vel superioribus alternis, sessilibus, inferioribus (e medio laminae) sensim abbreviatis, infimis minimis trilobis, medialibus, inter se 1-1.5 cm. remotis, a basi lata versus apicem acutum sensim attenuatis, equilateralibus, 2 cm. longis, supra basin ca. 5 mm. latis, ad costas venasque utrinque sparse pilosis denique glabris, subtus sparse glandulosis, profunde serrato-lobatis vel pinnatifidis. Laciniis obliquis, acutis, basali anteriore producta. Venis 2-3 jugis, simplicibus. Soris medialibus, parvis; indusiis reniformibus, subpersistentibus, sparse ciliatis.

This species is a very near ally of *D. delicatula* (Fée) C. Chr., from Guadeloupe, but it has a longer and narrower leaf, a shorter stem and medial sori. From *D. sancta* it is more different by its equilateral pinnæ and long, narrow leaf.

DRYOPTERIS SANCTA (L.) Kuntze

(REVISION 295, NO. 32, FIG. 20.)

This species includes a number of forms, some of them probably of local origin. It varies in size from the small Jamaican plants to the large var. *Balbisii* (Spreng.) C. Chr., and in pubescence from almost entirely glabrous (the typical form) to a condition in which the rachis and costa are often rather densely hairy above. It may be mentioned here that while most of the Jamaican forms are nearly glabrous, the specimens from other islands, especially from Porto Rico and partly from Cuba are rather hairy, and that this pubescence is found both in the small, more typical forms and in the var. *Balbisii.* The specimen from Guatemala appears to be identical with the Jamaican type. In the numerous specimens seen the sori are apparently exindusiate.

The different forms may be arranged as follows:

A. SMALL FORMS, often only a few cm. high; pinnæ unequal-sided; stem very short.

1. var. *typica.* Leaf quite glabrous or rachis only finely pubescent.

JAMAICA: Various localities, *Maxon* 1468 (= *Underwood* 2481), 1496, 1559, 1829 (= *Und.* 2794), 1959, 2415, 2550, 2584 (large); *Underwood* 1430, 1908, 2492; *Clute* 252.

CUBA: *Wright* 814. Slopes and summit of El Yunque near Baracoa, *Pollard and Palmer* 125. Monte Verde, Yateras, Oriente, 575 meters, rocky bank of small stream in forest, *Maxon* 4313.

SANTO DOMINGO: In umbrosis ad Rio Mameges, 250 meters, *Eggers* 2780.

PORTO RICO: Road from Utuado to Arecibo, wet limestone rocks, *Underwood and Griggs* 822, 828.

GUATEMALA: Cubilquitz, Depart. Alta Verapaz, 350 meters, *von Tuerckheim* (*Donnell Smith* 8353).

2. var. *hirta* (Jenman) C. Chr.

Nephrodium sanctum var. *hirtum* Jenman, Bull. Bot. Dept. Jam. II. 3:20. 1896.

Upper surface finely pubescent.

JAMAICA: Doll Wood, near Silver Hill Gap, 3,000 ft., wet shaded cliff, *Maxon* 1175. Blue Hole, *Fredholm* 3191.

3. var. *strigosa* C. Chr., var. nov.

Rachis and costa rather densely furnished with patent hairs; surfaces glabrous.

CUBA: Mountain slope, directly north of Jaguey, 420 to 500 meters, rocky bank by stream, *Maxon* 4142, type; U. S. National Herbarium, No. 522848. Josephina, north of Jaguey, Yateras, Oriente, 575 meters, bank by small stream at border of forest, *Maxon* 4096 (large form).

PORTO RICO: Eastern slope of the Luquillo Mts., 1,500 ft., *Heller* 4614. Sierra de Luquillo, in monte Jimenis, *Sintenis* 1753.

B. LARGE FORMS; largest pinnæ equal-sided, pinnate below; segments or pinnules long, linear; stem up to 10 cm. or more long.

1. var. *magna* (Jenman) C. Chr.

Nephrodium sanctum var. *magnum* Jenman, Bull. Bot. Dept. Jamaica II. 3:20 1896.

Segments entire, narrow, distant, as are the pinnæ; leaf quite glabrous.

JAMAICA: Vicinity of Hollymount, Mount Diabolo, 750 meters, rocky border of forest, *Maxon* 2239, 2269; *Underwood* 1781.

2. Segments or pinnules broader, crenate; pinnæ closer (habit of the leaf more compact). (var. *Balbisii* sensu lat.)

I. var. *portoricensis* (Kuhn) C. Chr.

Aspidium sanctum var. *portoricense* Kuhn, Engl. Bot. Jahrb. 24: 115. 1897.

Rachis and costa more or less hairy, as is also the upper surface in some specimens.

PORTO RICO: Maricao ad vias in monte Montoso, *Sintenis* 403. Utuado, in praeruptis ad Los Angeles, *Sintenis* 5956. In wet places beside stream, road from Utuado to Lares, *Underwood and Griggs* 60.

II. var. *Balbisii* (Spreng.) C. Chr. Revision 296, *fig. 20.*

Leaf quite glabrous.

CUBA: Los Caños ad Rio Seco, 200 meters, *Eggers* 4721.
JAMAICA: Road between Port Antonio and St. Margaret's Bay, *Underwood* 1712.
HAITI: Marmelade, 2,450 ft., *Nash and Taylor* 1229.
PORTO RICO: Prope Pepino ad Eneas, *Sintenis* 5828.

This last variety is the most developed form, and is very different, both in habit and size, from the small forms mentioned above.

I have tried above to arrange in a key the forms represented in the U. S. National Herbarium. The arrangement is, however, not a natural one. The order of evolution is, I believe, rather the following:

Series I: var. *typica;* var. *magna;* var. *Balbisii.*

Series II: var. *strigosa;* var. *portoricensis.*

The var. *hirta* is probably only a slight variety of the typical form.

DRYOPTERIS CONSANGUINEA (Fée) C. Chr.

(REVISION 297, NO. 33, FIG. 21.)

The true form of this distinct species is not represented in the U. S. National Herbarium, but I find some specimens, which in most characters agree with it very well. I refer them to a new variety:

DRYOPTERIS CONSANGUINEA ÆQUALIS C. Chr., var. nov.

JAMAICA: Second Breakfast Spring, near Tweedside, 2,000 ft., open grassy bank, *Maxon* 997 (=*Underwood* 2131), type; U. S. National

Herbarium, No. 427229. Banks at the left of Moody's Gap, 4,000 ft., *Jenman.*

GRENADA: In sylvestribus umbrosis ad Mt. Filix, 1,500 ft., *Eggers* 6036.

Differs from the type by its equal-sided pinnæ with patent or a little oblique, oblong segments, which generally bear 3 or 4 obtuse teeth at the apex; veins not prominent.

This variety thus recedes from the type towards *D. opposita* and *D. panamensis;* it differs from these species like the typical form, by its distant pinnæ, by its only a little elongated basal segments, which at their inner side bear an auricle overlying the rachis, by its almost completely glabrous frond and by its caudate-acuminate pinnæ. The natural position of this species in my system must be next to *D. opposita.*

DRYOPTERIS SCALPTUROIDES (Fée) C. Chr.

(REVISION 298, NO. 34, FIG. 22.)

JAMAICA: Moody's Gap, 3,000 ft., *Clute* 173. Vicinity of New Haven Gap, 1,650 meters, border of forest, *Maxon* 2659. Without special locality, 1,500 meters, *Hart* 128.

These three specimens belong to my variety *jamaicensis* (Revision 299), which differs from the Cuban type by the glandular under surface and less pubescent upper side of the lamina. While the specimens from Cuba have their upper side throughout coated with short, hamate hairs, such are rarely found in the Jamaican form, in which the veins above are furnished with more stiff setæ. These constant differences between the specimens from the two islands make it probable that the plants from Jamaica represent a distinct species. This variety can be mistaken for *D. Nockiana;* still, it is much more hairy and more firm, even coriaceous in texture.

DRYOPTERIS FIRMA (Baker) C. Chr.

(REVISION 299, NO. 36, FIG. 24.)

JAMAICA: Slopes of Monkey Hill, 1,800 meters, forest ravine, *Maxon* 2730. At the summit of Blue Mountain Peak, at about 7,400 ft., dry path-edges, *Maxon* 1438 (= *Underwood* 2553).

These beautiful specimens show more fertile leaves, which are on longer stems than the sterile ones and richly soriferous. The young sori are furnished with a densely setose indusium, which sometimes bears one or two glistening yellow or red glands. The basal pair of segments in the larger pinnæ is prolonged as in *D. opposita,* or in the sterile leaves the upper basal segment is somewhat reduced. The rhizome is horizontally creeping, ligneous, with numerous bases of old stipes, and densely clothed at the apex with finely pubescent, brown scales. By its slightly reduced, coriaceous lamina and its creeping rhizome *D. firma* is a most distinct species.

[NOTE.—*D. Pavoniana* (Kl.) C. Chr. must be placed next to *D. firma*. It has, as shown by a specimen from Ecuador, *Rimbach* 118, sent me by Dr. Rosenstock, a long, creeping rhizome.]

GROUP OF D. PACHYRACHIS

DRYOPTERIS PACHYRACHIS (Kunze) Kuntze

(REVISION 305, NO. 44, FIG. 31.)

In my "Revision" I referred the Jamaican *Nephrodium Jenmani* Baker to *D. pachyrachis,* having seen only one specimen, which appeared to be almost exactly *D. pachyrachis,* but without the characteristic sessile red glands of the under side of the lamina. Having now seen additional specimens of *N. Jenmani,* the question of its identity with *D. pachyrachis* becomes more difficult. The specimens seen belong to two somewhat different forms:

(1) A more firm, nearly glabrous and eglandulose form, which in habit and pubescence agrees very well with true *D. pachyrachis* but differs from it, as mentioned, in the lack of glands. In its most developed state this form is considerably larger than the Brazilian forms of *D. pachyrachis* (*Aspidium platyrachis* Fée), much more resembling *D. tenerrima* (Fée) C. Chr. It is the typical *Jenmani,* as shown by type specimens in U. S. National Herbarium.

(2) A very thin-leaved form with the under side densely glandulose and with the midribs of the segments, like the costæ, setose above. This form I referred (p. 311) to *D. Germaniana* as a new variety, var. *glandulosa*. I now think it best to consider it a form of *Jenmani,* resembling *D. Germaniana* in size but differing from that species in being glabrous between the veins above and in its fewer reduced pinnæ.

I dare not consider these two forms specifically different, nor separate them as a species distinct from *D. pachyrachis*. In general habit, texture, pubescence, number of veins, position of sori, shape of indusium they agree very well with the continental forms of *D. pachyrachis*. Still, I see clearly a difference between these West Indian forms and true *D. pachyrachis*, but it is impossible for me to point out even one character by which they may be distinguished from the continental form. However, should some other pteridologist prefer to let *D. Jenmani* stand as a distinct species I shall approve it.

1. Form without glands [*D. Jenmani* (Baker) C. Chr.].

St. Vincent: *H. H. and G. W. Smith* 855.

Jamaica: Without special locality, *Jenman; Hart* 281*a*, 215. Latimer River, 4,000 ft., *Clute* 142. Vicinity of Morce's Gap, 1,500 meters, moist wooded slope, *Maxon* 2679.

2. Glandulose form [*D. Germaniana* var. *glandulosa* C. Chr., Revision 311].

Jamaica: Near the summit of Blue Mountain Peak, 7,000 ft., steep moist wooded slope, *Maxon* 1404 (= *Underwood* 2529); moist woods, *Maxon* 1422 (= *Und.* 2540), 1422*a; Underwood* 1496.

DRYOPTERIS RORAIMENSIS (Baker) C. Chr.

Polypodium roraimense Baker, Timehri **5**: 214. 1886; Trans. Linn. Soc. II. Bot. **2**: 291. 1887.

Dryopteris roraimensis C. Chr. Index Fil. 289. 1905.

British Guiana: Mount Roraima, upper slope, *im Thurn* 168 (type number).

A weakly characterized species, not unlike *D. pachyrachis* in essential characters, but having the under side of the lamina without glands, the segments oblique or subfalcate, obtuse, sori exindusiate, and the 3 or 4 pairs of lower pinnæ reflexed.

Leaf gradually and shortly attenuate downwards, with 2 or 3 pairs of reduced pinnæ, the lowermost about 1 cm. long. The whole leaf glabrous, except as to rachis and costæ, these setose above. Veins distant, 6 or 7 to a side, simple. Sori about medial or slightly supramedial, globose, superficial, exindusiate. Sporangia glabrous.

In the key to species given in my "Revision" (p. 267) this species must be placed between no. 44, *D. pachyrachis*, and no. 45, *D. Hieronymusii*. It differs from this latter mainly in its lower reflexed pinnæ and its more oblique or even subfalcate segments.

DRYOPTERIS RUSTICA (Fee) C. Chr.

(Revision 310, No. 53.)

St. Vincent: *H. H. and G. W. Smith* 1130.

Agreeing very well with the type from Guadeloupe. Known also from Jamaica (*Nephrodium nimbatum* Jenm.).

DRYOPTERIS MELANOCHLÆNA C. Chr., sp. nov.

GUATEMALA: Coban, Depart. Alta Verapaz, 4,300 ft., *J. Donnell Smith* 168 in part, July, 1885, type; U. S. National Herbarium, no. 828982. (Besides the single leaf, which is the type specimen of our new species, this number contains a mixture of other species.)

Eudryopteris rhizomate (?). Stipitibus gracilibus, griseis, basi squamis nonnullis brunneis instructis, minute puberulis, 12 cm. longis. Lamina ad 6 dm. longa, 15 cm. lata, lanceolata, ad basin gradatim attenuata, firmo-herbacea, viridi, ubique pilis albescentibus minute puberula, rachibus costisque stramineis, bipinnatifida. Pinnis inferioribus fere e medio laminae gradatim abbreviatis, infimis auriculiformibus, medialibus maximis, patentibus, sessilibus, suboppositis, inter se 2.5 cm. remotis, oblongis, 8 cm. longis, 1.5-1.75 cm. latis, breviter acuminatis, ad alam 1 mm. latam pinnatifidis. Laciniis patentibus vel parum obliquis, 3 mm. latis, sinubus subobtusis angustis separatis, obtusis vel subacutis, integris, basalibus aequalibus. Venis ca. 7 jugis, remotis, simplicibus. Soris margini approximatis, parvis; indusiis ebeneis, squamiformibus, persistentibus, pilis albidis nonnullis ciliatis. Sporangiis glabris.

A very remarkable new species, resembling *D. rustica* in size, habit, and its uniform minute pubescence throughout, but differing from that species, as from all other species of the group, by its coal-black, scale-like indusia, ciliate with whitish hairs.

DRYOPTERIS GERMANIANA (Fée) C. Chr.

(REVISION 311, No. 55 (excl. var.).)

CUBA: Upper slopes and summit of Gran Piedra, Oriente, altitude 900 to 1,200 meters, moist shaded slope under tree-ferns, *Maxon* 4059.

An interesting discovery, as the species was previously known only from Guadeloupe. The specimen agrees exactly with the type. It resembles some forms of *D. pachyrachis* included under *Jenmani*, but it has a scaly stem, many pairs of reduced pinnæ, and the upper surface pubescent.

DRYOPTERIS DOMINICENSIS C. Chr., sp. nov.

DOMINICA: Mt. Diablotin, *F. E. Lloyd* 876, type; U. S. National Herbarium, No. 429322.

Eudryopteris rhizomate (?). Stipitibus 3 mm. crassis, 8-10 cm. longis, superne late sulcatis, ubique squamis brunneis crispatis dense vestitis. Lamina ovato-lanceolata, 4-5 dm. longis, ca. 18 cm. latis, versus basin gradatim attenuata, versus apicem breviter acuminatum brevius attenuata, firmo-herbacea, obscure viridi, rachi grisea, pilis patentibus hirta et squamis brunneis crispatis (maxime in parte inferiore) squamosa, bipinnatifida. Pinnis ca. 20 utroque latere, inferioribus oppositis, 4-5 jugis sensim reductis, infimis 1 cm. longis et latis, superioribus alternis, sessilibus, maximis 8-10 cm. longis, 2 cm. latis, lineari-oblongis, versus apicem integrum breviter acuminatis, ad basin aerophoro magno acuto nigro instructis, supra ad costas late sulcatas ac inter venas pilis adpressis setosis, subtus ad costas costulasque pilis patentibus hirtis, ad alam 2 mm. vel ultra latam pinnatifidis. Laciniis approximatis, sinubus angustis acutis separatis, ca. 15 jugis, 4-5 cm. latis, patentibus vel paulum obliquis, obtusissimis, integris. Venis simplicibus, 6-7 jugis, distantibus. Soris parvis, medialibus; indusiis parvis, ciliatis, mox evanidis.

This new species stands next to *D. Germaniana,* but is considerably different in its scaly rachis, its differentiated pubescence, and its distinct, setose indusia. In the system adopted in my "Revision" the species must be placed between *D. Germaniana* and *D. Moritziana.*

DRYOPTERIS DEMERARANA (Baker) C. Chr.

Polypodium demeraranum Baker, Timehri 5:214. 1886; Trans. Linn. Soc. II. Bot. 2: 290. 1887.
Dryopteris demerarana C. Chr. Index Fil. 261. 1905.

British Guiana: Mount Roraima, old Cath, *im Thurn* 356; (type number).

A species of the group of *D. pachyrachis,* but having the leaf more abruptly reduced below, about as in a species of the group of *D. Sprengelii.*

Reduced pinnæ about 4-jugate, at distances of 4-5 cm., auriculiform. Stem at base with brown scales more than 1 cm. long, upwards like the rachis with a dense and coarse gray pubescence, intermixed with a few linear brown scales, especially along the rachis. Lower pinnæ subopposite, upper ones alternate, sessile, 10-12 cm. long by 2.5 cm. broad, thin, the upper side along the costæ densely setose, between the veins with fine, scattered, hamate hairs, the under side setose along the costæ and veins, almost glabrous between the veins. Segments slightly oblique, subacute or roundish at the apex, entire, 3.5-4 mm. broad, rather close, with subacute sinuses between; basal segments equal in size, or the upper one slightly reduced. Veins all simple. Sori exindusiate, near the edge. Sporangia glabrous.

In habit this species resembles *D. Leprieurii* (Hook.) Kuntze, but it can be distinguished by its reduced lower pinnæ, scaly rachis, and non-patent hairs. In the key to the species ("Revision," p. 268) it must be placed between no. 56, *D. Moritziana,* and no. 57, *D. corazonensis;* it is abundantly different from both.

DRYOPTERIS DIPLAZIOIDES (Desv.) Urban.

(REVISION 312, NO. 58.)

To this species I refer with some doubt a specimen from

GUATEMALA: Near the Finca Sepacuité, Alta Verapaz, *Cook and Griggs* 177.

DRYOPTERIS CONSIMILIS (Fée) C. Chr.

JAMAICA: Without locality, *Jenman.* Mt. Moses, *Harris* 1555. Mansfield, near Bath, 300 to 500 meters, moist shaded bank, *Maxon* 2370; at edge of woods, *Maxon* 1796 (= *Underwood* 2770); *Maxon* 1788 (= *Und.* 2765). Trail from Bath to Cuna Cuna Pass, 1,000 to 2,000 ft., on a wayside bank, *Maxon* 1723 (= *Und.* 2687). Near Tweedside, 2,000 ft., grassy bank in the open, *Maxon* 989. Vicinity of Hollymount, Mount Diabolo, about 750 meters, rocky ravine in humid forest, *Maxon* 2321.

DRYOPTERIS HETEROCLITA (Desv.) C. Chr.

Gymnogramme gracilis Hew. Mag. Nat. Hist. II. 2:457. 1838.

JAMAICA: Without locality, *Jenman.* Vicinity of Cinchona, 1,500 meters, shaded bank by trail, *Maxon* 1196 (= *Underwood* 2336). At the base of Blue Mountain Peak, 6,000 to 7,000 ft., *Maxon* 1453 (= *Und.* 2469). Cinchona Plantation, 5,000 ft., *Underwood* 167. New Haven Gap, 5,600 ft., *Clute* 205.

My treatment in the "Revision" of these two closely allied species is unsatisfactory. The specimens enumerated above show more clearly the differences between the two species, which I point out in the following table. Figures 37 and 38 of my "Revision" both illustrate *D. consimilis,* although the latter in the position of the sori resembles *D. heteroclita.*

D. consimilis	*D. heteroclita*
Leaf 5–6 dm. long.	Leaf 8–10 dm. long.
Pinnæ 8–10 cm. long by 1.5–2 cm. broad.	Pinnæ 12–15 cm. long by 2.5 cm. broad.
Whole plant clothed with a dense and coarse gray pubescence, the under side sometimes with a few yellow glands.	Whole plant furnished with fewer but longer and stiffer hairs, sometimes subglabrous on the under side and always without glands.
Veins immersed, not very distinct, 10–12 to a side.	Veins raised above stramineous like the costæ, 10–15 to a side.
Sori distinctly oblong or linear about medial.	Sori short, sometimes nearly round, distinctly supramedial.

DRYOPTERIS ATROVIRENS C. Chr.

(REVISION 316, NO. 61, FIG. 39.)

GUATEMALA: Trail between Sepacuité and Secanquim, Alta Verapaz, 1,000 meters, rocky bank in humid forest, *Maxon and Hay* 3281 (type number).

GROUP OF D. SPRENGELII

Tertiary veins close, 10-12 to a side, lamina in most species abruptly attenuate downwards, with several pairs of greatly reduced pinnæ, which appear as mere warts upon the stem. A distinct aërophore is often present at the base of the larger pinnæ. Most of the species belonging to this group are large, having leaves often more than 1 meter long.

DRYOPTERIS SPRENGELII (Kaulf.) Kuntze

(REVISION 318, NO. 65, FIG. 42.)

ST. THOMAS: Signal Hill, 1,400 ft., *Eggers* 32.

ST. KITTS: Molyneaux Estate, *Britton and Cowell* 312. Lambert Estate, *Britton and Cowell* 637.

DOMINICA: Soufrière, *Lloyd* 543.

ST. VINCENT: Mt. St. Andrews, 2,000 ft., in locis umbrosis inter herba, *Eggers* 6807. Chateau Belair, 1,000 ft., in sylvestribus umbrosis, *Eggers* 6843.

GRENADA: Without locality, *Murray and Elliott* 9; *Sherring.*

TOBAGO: In sylvestribus ad flumen Great Dog River, *Eggers* 5757.

TRINIDAD: *Fendler* 22.

PORTO RICO: Luquillo Mts., *Percy Wilson* 62; 255. Guayama Road, *Goll* 601. Quebrada Arriba, on rocky hillside, *Goll* 488. Road from Ponce to Adjuntas, *Underwood and Griggs* 764. Road from Utuado to Lares, *Underwood and Griggs* 108. San Juan, *Mr. and Mrs. A. A. Heller* 676. On the Adjuntas road, eight miles from Ponce, *Heller* 6137; 6346.

JAMAICA: Near Priestman's River, 75 to 300 meters, partially shaded moist bank, *Maxon* 2529; 2532. Swift River near Hope Bay, *Alex. Moore.*

The specimens enumerated above belong to typical *D. Sprengelii,* characterized by its almost hairless surfaces and rachis and its glandular under side. In the specimens from Jamaica, especially *Maxon* 2529, the upper side is, however, somewhat more hairy than in the plants from the smaller islands; thus, it is intermediate between the type and the Central American form. This has the upper side finely pubescent and the rachis somewhat hairy, as is the case in *D. Mercurii;* but it agrees very well with the type in habit. This form, perhaps worth a name of its own, is represented by the following specimens:

GUATEMALA: Cuyuta, Depart. Escuintla, 200 ft., *Donnell Smith* 2457 (the locality in my "Revision" erroneously referred to Mexico).
NICARAGUA: Volcan Mombacho, *C. F. Baker* 2449.
COSTA RICA: Plains of San Carlos, 100 meters, on bank by road, *Cook and Doyle* 99. Cuesta de la Vieja, 300 meters, on bank by road, *Cook and Doyle* 101. Juan Viñas, Reventazon Valley, 1,000 meters, on bank by roadside, *Cook and Doyle* 195. Rio Reventazon, Prov. Cartago, *Donnell Smith* 5088.

I now refer to this more hairy form J. R. Johnston's no. 190 from the island of Margarita, Venezuela, listed in my "Revision" under *D. Mercurii.*

DRYOPTERIS STRUTHIOPTEROIDES C. Chr., sp. nov.

GUATEMALA: Concepcion, Depart. Escuintla, 1,200 ft., *J. Donnell Smith* 2459, March, 1890, type; U. S. National Herbarium, No. 829,013. Mazatenango, Depart. Suchitepéquez, *W. A. Kellermann* 4701.

Eudryopteris rhizomate (?). Stipitibus rigidis, stramineis, basi squamis brunneis deciduis sparse instructis, vix 10 cm. longis. Lamina ovato-lanceolata, ad 6-7 dm. longa, medio ad 2.5 dm. lata, versus basin sensim attenuata, ad apicem serratum breviter acuminata, gramineo-viridi, firmo herbacea, rachi straminea glaberrima, bipinnatifida. Pinnis numerosis, valde approximatis, 1 cm. remotis, inferioribus 3-4 jugis sensim abbreviatis, imis auriculiformibus, lobatis, ca. 1 cm. longis, medialibus maximis, linearibus, 10-13 cm. longis, 1.5 cm. latis, sessilibus (aerophoro nullo), subhorizontalibus, oppositis, apicibus serratis longe acuminatis, supra ad costas stramineas sparse setosis, utrinque inter venas sparse et minute puberulis denique glabris, ad alam vix 1 mm. latam pinnatifidis. Laciniis numerosis, valde approximatis, sinubus angustissimis acutis separatis, parum obliquis, integris, acutis, marginibus planis, basalibus aequalibus. Venis 10-11 jugis, indivisis. Soris parvis, luteis, submarginalibus; indusiis minimis, hyalinis, glabris, mox deciduis.

This new species can only be compared to *D. panamensis* and *D. Sprengelii,* from both of which it differs in its remarkably closely-placed overlapping pinnæ and segments, the leaf resembling the sterile frond of *Matteuccia struthiopteris*—hence the specific name. It resembles large forms of *D. panamensis* in general habit, especially in the base of the lamina, but it is considerably different in its almost glabrious and eglandulose lamina, in its not very oblique segments, in its more numerous veins, and in having the sori placed very near to the margin. From *D. Sprengelii,* which it resembles in pubescence, size, and texture, it recedes by the absence of glanduliform abortive pinnæ and aërophore, by the position of the sori, by its fewer veins, etc. Still, I think it best to place the species next to *D. Sprengelii* in the "system," mainly because its veins are closer than in any species of the groups of *D. opposita* and *D. pachyrachis.*

DRYOPTERIS MERCURII (A. Br.) Hieron.

(REVISION NO. 66, FIG. 43.)

This is most probably a large, more hairy continental form of *D. Sprengelii,* in its typical form very characteristic, the pinnæ 2-2.5 dm. long, thin, with numerous segments separated by open roundish sinuses, the rachis and costæ beneath furnished with long patent hairs and the upper side more densely pubescent. But it will be, I believe, impossible to draw a sharp line between the smaller forms and the continental form of *D. Sprengelii* mentioned above. Thus, we have here a series of forms which grow larger from the Lesser Antilles to Central America, the increase in size being associated with an increase of pubescence, exactly as was the case in *D. opposita-D. panamensis.* Also, we find here the intermediate forms in Jamaica. Provisionally, I find it best to let *D. Mercurii,* like *D. panamensis,* stand as a species.

COSTA RICA: Santo Domingo de Golfo Dulce, *Tonduz* 10023 (=*Donnell Smith* 7215 B); *Tonduz* 9885 (=*D. S.* 7218). Haie à Turrialba, *Pittier* 4087*bis.* Forêts de Tsâki, Talamanca, 200 meters, *Tonduz* 9461.

A critical form is W. A. Kellerman's no. 4864 from Puerto Barrios, Guatemala; in pubescence exactly *D. Sprengelii,* in habit *D. Mercurii.*

DRYOPTERIS THOMSONII (Jenman) C. Chr.

(REVISION 320, NO. 67, as *D. Stuebelii*)

Polypodium Thomsonii Jenman, Bull. Bot. Dept. Jamaica II. 4: 130. 1897.
Dryopteris Thomsonii C. Chr. Ind. Fil. 298. 1905.
Dryopteris Stuebelii Hieron. Hedwigia 46: 340. *pl. 6. f. 13.* 1907.

This species is given as unknown in my "Revision." In the U. S. National Herbarium there are, besides a type specimen from Jenman, several specimens from Jamaica, and it is rather surprising to find that the species is exactly identical with *D. Stuebelii* Hieron. from Colombia. Thus we here come upon a new illustration of the close relationship existing between the fern-floras of Jamaica and the Andes.

I have only to add to the descriptions of Jenman and Hieronymus that the lamina narrows downwards very abruptly, as in *D. rudis,* with a few pairs of glanduliform warts, and that the stem is clothed throughout with thin, light brown scales. The species resembles in habit not a little *D. pterifolia,* but it is *inter alia* very distinct by its densely glandular under side and thin texture, and by its midribs and costules of the pinnæ being clothed beneath with short, crisped, stellate hairs.

JAMAICA: Near Vinegar Hill, 4,000 ft., *Harris* 7446; moist shaded bank, *Maxon* 1520. Vicinity of New Haven Gap, 1,650 meters, humid forest slope, *Maxon* 2693. At the base of Blue Mountain Peak, 6,000 ft., shaded edge of trail, *Maxon* 1442 (= *Underwood* 2465); *Maxon* 1442*a*.

DRYOPTERIS LIMBATA (Sw.) Kuntze

(REVISION 323, NO. 71.)

ST. KITTS: Belmont Estate, forest ravine, *Britton and Cowell* 397. Slopes of Mt. Misery, *Britton and Cowell* 560.

By its toothed segments, with the sori in the teeth, different from all allied species.

DRYOPTERIS SCALARIS (Christ) C. Chr.

(REVISION 323, NO. 72, FIG. 47.)

GUATEMALA: Vicinity of Secanquim, Alta Verapaz, 500 meters, partially shaded bank, *Maxon and Hay* 3193.

COSTA RICA: Vicinity of Santiago, on partially cleared slope, *Maxon* 122. Forêts de Tuís, 650 meters, *Tonduz* 11332. Waldeck, près Madre de Dios, 50 meters, *Pittier* 10260 (in my "Revision" referred to *D. Mercurii,* but probably belonging here).

DRYOPTERIS RUSBYI C. Chr., sp. nov.

BOLIVIA: Near Yungas, 4,000 ft., *H. H. Rusby* 429, type; U. S. National Herbarium, No. 828981.

Eudryopteris rhizomate lignoso, obliquo vel breviter repente. Stipitibus 0.5-1 cm. inter se remotis, ad pinnas infimas abortivas 10-15 cm. longis, rigidis, sulcatis, basi squamis paucis praeditis, griseo-stramineis, ubique brevissime puberulis. Lamina 6 dm. vel ultra longa, 12-20 cm. lata, lanceolata, versus basin abrupte attenuata, membranacea, bipinnatifida. Rachi grisea, dense et minute puberula. Pinnis oppositis, horizontalibus, sessilibus, majoribus aërophoro praeditis, infimis 5-6 jugis valde reductis, glanduliformibus, pinnis paris superioris 4 cm. longis reflexis, inframedialibus maximis, 7-9 cm. longis, ad 2 cm. latis, obtusis vel breviter acuminatis, apice integro vel serrato excepto ad alam 1.25 mm. latam pinnatifidis, utrinque ad costas costulasque dense setosis, supra inter venas minute pubescentibus, subtus glabriusculis. Laciniis 13-15 jugis, paulum obliquis, subobtusis vel subrotundatis, integris, 3 mm. latis, approximatis, sinubus angustis acutis separatis, basalibus reductis. Venis in laciniis majoribus 10-12 jugis, simplicibus, satis approximatis. Soris mediocribus fere medialibus, exindusiatis. Sporangiis glabris.

This new species I refer to the group of *D. Sprengelii,* as it most resembles species of this group in its very abruptly reduced lamina below and in its rather close veins. It will stand in this group between *D. lasiopteris* and *D. Christensenii,* being intermediate between these species in pubescence, but distinguished by its opposite, horizontal pinnæ with rather broad, subpatent and subobtuse segments. Its rachis is not so tomentose as in *D. lasiopteris* and *D. rudis;* still not with the microscopical pubescence of *D. Christensenii.* The species could also be considered a member of the group of *D. pachyrachis.* It will then stand near *D. atrorubens,* from which it differs by its closer veins and gray puberulous rachis.

Allied to this species is another specimen from Bolivia, *Miguel Bang* 2320, which probably belongs to an undescribed species, but the specimen is too incomplete for a description. It resembles *D. Rusbyi* in pubescence of the rachis, but while the upper side is almost glabrous, except along the costæ, the under side is rather densely hairy throughout. The acute segments have up to 15 pairs of veins. The sori, which are small and covered by a setose indusium, are placed within the margin. The collector's number 2320 is cited in my "Revision" under *D. oligocarpa,* but *this* specimen does not belong to that species.

DRYOPTERIS RUDIS (Kunze) C. Chr.

(REVISION 324, No. 73, FIG. 48.)

MEXICO: Sierra de Clavellines, State of Oaxaca, 9,000 ft., *Charles L. Smith* 2056. Cerro de San Felipe, 3,000 meters, *Gonzatti and González* 331. Wet mountain canyon above Cuernavaca, State of Morelos, 6,500 ft., *Pringle* 13773. Sierra Madre near Santa Teresa, Territorio de Tepic, *J. N. Rose* 2213.

GUATEMALA: San Rafael, Zacatepequez, 6,500 ft., *Donnell Smith* 2732; 2461.

COSTA RICA: Sabanilla de los Granados, 1,200 meters, *Alfaro* 16302. Vicinity of Coliblanco, about 1,950 meters, *Maxon* 267.

Polypodium ctenoides (Fée) Jenman from Jamaica I have supposed in my "Revision" to be this species, and the three specimens at hand (*Jenman; Hart* 343) confirm that opinion; I see no essential difference. *Maxon* 267 from Costa Rica is identical with the narrow-leaved form collected by Biolley (no. 67 in part) which in my "Revision" I referred to *D. lasiopteris* (Sod.) C. Chr. Also, I now consider this form to belong to the species of Sodiro, although this author describes *D. lasiopteris* as being indusiate, while our Costa Rican specimens are without indusia; but I cannot see any important difference between this form and ordinary *D. rudis*. It is almost glabrous above and has shorter pinnæ, while the most common form of *D. rudis* is setose throughout; probably *D. lasiopteris* (Sod.) C. Chr. must be reduced as a synonym of *D. rudis*.

Another synonym of *D. rudis* is *Aspidium subdecussatum* Christ,[1] as shown by the type specimen from Costa Rica, *Alfaro* 16556. It is glabrous between the veins upon both sides, and identical with the form which I have called *D. lasiopteris*.

D. rudis varies considerably in size and in density of pubescence. From *D. pterifolia* it can be distinguished by its acute segments and by its costæ being clothed beneath with antrorse (not patent) hairs.

A large variety, eventually a new species, is *Pringle* 8920, Mexico (State of Puebla, by brooks in pine forests, near Honey Station, 5,000 ft.). It has pinnæ 25 cm. long by 3.5 cm. broad.

Nephrodium tetragonum Presl[2] has been much misunderstood. It is, according to the type specimen in herb. Presl, not at all the same as *Nephrodium tetragonum* Hook (which is *Dryopteris pseudotetragona* Urban), but either *D. rudis* or a closely related species. The whole type specimen consists only of the upper half of a single leaf, and is therefore rather indeterminable.

DRYOPTERIS HEIMERI C. Chr.

I have recently described[3] this Brazilian representative of *D. rudis*. The diagnosis and comments are here reprinted without change.

"*Eudryopteris* e turma *D. rudis* (Kze) C. Chr. rhizomate (erecto?) dense radicante. Stipitibus ad pinnas infimas abortivas c. 15 cm longis, fusco-stramineis, quadrangularibus, ubique brevissime hirtis, ad basin squamis nigro-brunneis ovato-acuminatis marginibus sparsim ciliatis subdense vestitis. Lamina lanceolata, ad 8 dm longa, medio 17—18 cm lata, ad apicem pinnati-

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[1] *Aspidium subdecussatum* Christ, Bull. Herb. Boiss. II. 4:960. 1904; *Dryopteris subdecussata* C. Chr. Ind. Fil. 295. 1905.

[2] Rel. Haenk. 1:35. 1825.

[3] Fedd., Repertarium 6: 380, 381. 1909.

fidum sensim attenuata, versus basin abrupte reducta, supra obscure viridi, nitida, subtus pallidiore, submembranacea vel firmo-herbacea, bipinnatifida; rachi trisulcata breviter hispido-pilosa. Pinnis infimis 2—3-jugis tuberculiformibus, c. 8 cm inter se remotis, sequentibus 2—3-jugis auriculiformibus 4—5 cm inter se remotis, medialibus maximis, 10 cm longis, 2 cm latis, sessilibus aërophoro tuberculiformi instructis, a basi versus apicem breviter acuminatum sensim attenuatis, supra ad costa venasque sparsim et brevisime puberulis, subtus ad costas costulasque pilis fuscis brevibus dense setulosis ac ad costas paleis nonnullis nigro-brunneis minutis instructis, inter venas utrinque subglabra, ad alam 1 mm latam pinnatifidis. Laciniis approximatis, marginibus planis fere parallelis recte patentibus, obtusis, basalibus pinnarum inferiorum reductis. Venis simplicibus, 12—14-jugis, pellucidis, supra parum prominulis. Soris minimis, exindusiatis, paulo ultra mediam venulae partem sitis. Sporangiis paucis, 2—3 setis robustis instructis.

"Hab. Brasilia, São Paulo, Campinas oppidum, leg. A. Heiner no. 540, 9. 9. 1905 (typus in Herbario Regnelliano, Stockholm).

"Species nova distincta, a speciebus brasiliensibus adhuc detectis abunde diversa sed speciebus andinis nonnullis *(D. rudi, D. Engelii)* magis affinis. Magnitudine, pubescentia, textura, reductione laminae *D. rudi* C. Chr. similis, a qua specie valde recedit: sporangiis setosis, laciniis patentibus obtusis (nec falcatis nec acutis), stipitibus ad basin subdense paleaceis, costis subtus sparsim squamosis, pilis rachis brevioribus, pagina utraque inter venas subglabra, aliisque notis."

DRYOPTERIS PITTIERI C. Chr., sp. nov.

COLOMBIA: Paramo de Buena Vista, Huila Group, Central Cordillera, upper forest zone, 3,100 meters, *H. Pittier* 1200, January, 1906, type; U. S. National Herbarium, No. 531395.

Eudryopteris rhizomate (?). Stipitibus (?). Lamina 1 m. vel ultra longa, 2-2.5 dm. lata, dure coriacea, rachi rigida griseo-straminea pilis brunneis crispis laxe dispositis dense hirta, bipinnatifida. Pinnis sessilibus, horizontalibus, oppositis, basi aërophoro instructis, 3 cm. inter se remotis, 12-14 cm. longis infra medium 2.25-2.5 cm. latis, utrinque attenuatis, supra costis sparse strigosis exceptis glaberrimis, infra ad costas costulasque pilis crispis brunneis subdense pilosis et ad partem inferiorem costarum squamis nonnullis angustis brunneis ciliatis vestitis, apice breviter caudato-acuminato excepto ad alam vix 1 mm. latam pinnatifidis. Laciniis numerosis, subpatentibus vel saepe subfalcatis, remotis (sinubus rotundis latis), integris, obtusis, marginibus ubique revolutis, basalibus perparvis. Venis simplicibus, ad 20 jugis, supra distinctis. Soris submedialibus, brunneis, exindusiatis. Sporangiis glabris.

The species here described as new is founded upon an imperfect specimen without rhizome and stipe. Probably the leaf is narrowed downwards as in *D. rudis* and other allied species. Although the leaf very much resembles that of *D. Engelii* Hieron. in size, general habit, and very coriaceous texture, it is, however, that of a new and very distinct species of high andine habit, distinguished by the glabrous upper surface, the scales along the lower part of the costæ beneath, and by the crisped, lax pubescence of the rachis and of the costæ and costules beneath.

DRYOPTERIS LANIPES C. Chr., sp. nov.

GUATEMALA: Pinula, Depart. Guatemala, 4,300 ft., *J. Donnell Smith* 2462, April, 1889, type; U. S. National Herbarium, No. 828979.

Eudryopteris rhizomate obliquo-erecto, 1 cm. crasso. Stipitibus fasciculatis, ad auriculas infimas ad 12 cm. longis, stramineis, pilis mollibus luteo-albidis patentibus ad 5 mm. longis densissime vestitis. Lamina lanceolata, 5-6 dm. longa, medio 15 cm. lata, ad basin subabrupte valde reducta, ad apicem serratum vel integrum breviter acuminata, subcoriacea vel papyracea, luteo-viridi, rachi straminea maxime ad basin pilis mollibus patentibus luteo-albidis dense vestita, bipinnatifida. Pinnis oppositis vel subalternis, sessilibus, inferioribus 3-4 jugis gradatim abbreviatis, infra has 3-4 jugis subito valde reductis auriculiformibus ca. 1 mm. longis et latis, medialibus maximis 8 cm. longis, 1.5 cm. latis, subfalcatis, utrinque glaberrimis vel subtus ad costas pilis longis nonnullis deciduis instructis, apice integro breviter acuminata excepto pinnatifidis, superioribus serratis vel integris. Laciniis approximatis, sinubus rotundis angustis separatis, integris, parum obliquis, acutis, 2.5 mm. latis, basalibus aequalibus vel posteriore paulo longiore. Venis distinctis, approximatis, ca. 10 jugis, simplicibus. Soris margini approximatis, parvis; indusiis deciduis, glabris. Sporangiis glabris.

This new species is different from all known species by the peculiar lanose pubescence of the stem and lower part of the rachis. It is evidently a member of the *Sprengelii* group, although it is rather small and has few veins, which, however, are closely placed. In color it is not unlike typical *D. cheilanthoides* from Brazil. Remarkable also is the reduction of the lamina. Below the 3 or 4 pairs of gradually reduced pinnæ is a similar number of suddenly reduced very small auricles, not glanduliform warts, as in certain species of the *Sprengelii* group. Further must be mentioned the nearly entire upper pinnæ. The position of the species in my "system" must be before no. 76, *D. strigifera.*

To this species belongs, I have no doubt, as a forma *minor,* Donnell Smith's no. 2463, also from Guatemala (Department of Guatemala, 4800 ft.). It is quite identical in pubescence, but smaller (20 cm. by 6 cm.), with a very short stem and only 3 or 4 indistinct veins.

DRYOPTERIS PTERIFOLIA (Mett.) Kuntze

(REVISION 327, NO. 78, FIG. 49.)

GUATEMALA: Pansamalá, Depart. Alta Verapaz, 3,800 ft., *von Tuerckheim* (*J. Donnell Smith* 971); *Donnell Smith* 1551. Trail from Senahú to Actalá, Alta Verapaz, rocky bank at border of forest, *Maxon and Hay* 3311. Coban, 1350 meters, *von Tuerckheim* II. 2181.
BOLIVIA: Yungas, 6,000 ft., *Rusby* 1885, *sine num.*

A large species with pinnæ up to 25 cm. long by 4 cm. broad, the costæ and costules clothed sparsely beneath with stiff, patent hairs. In my "Revision" I considered *Nephrodium retrorsum* Sodiro the most developed form of this species. It is, however, rather a variety with pendent pinnæ; none of the specimens listed above, although very large, show this peculiarity. The species is apparently exindusiate, and the sori show a tendency to elongation; the receptacles are setose.

In my "Revision" I have supposed that *Alsophila pilosa* Mart. and Gal. belongs to *D. rudis*, and not to *D. pterifolia*. The Guatemalan specimens listed above seem, however, to agree completely with the plate of Martens and Galeotti, and most probably Professor Hieronymus was right in regarding *A. pilosa* as a synonym of *D. pterifolia*.

This Central American form is a very large plant, and it may be doubted whether it is conspecific with true *D. pterifolia*, which was described from scanty material from Bolivia. Still, the Bolivian specimen listed above is to me not specifically distinct from the Central American form, although considerably smaller and more soft-hairy.

A further synonym of *D. pterifolia* is *Aspidium gleichenioides* Christ.[1] I omitted this form in my "Revision" because Dr. Christ described the lamina as "*basi vix attenuata*." However, an examination of the type specimen from Costa Rica, *Tonduz* 1935, shows at once that it belongs to the group of *D. opposita* and not to the group of *D. patens*, as Christ supposed, and, further, that it can scarcely be separated from *D. pterifolia*. The hairs of the costæ and costulæ beneath are somewhat more autrorse than in common *D. pterifolia*, but it agrees otherwise.

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[1]*Aspidium gleichenioides* Christ, Bull. Herb. Boiss. II. 4: 960. 1904; *Dryopteris gleichenioides* C. Chr. Ind. Fil. 268. 1905.

DRYOPTERIS CHEILANTHOIDES (Kunze) C. Chr.

(REVISION 329. NO. 82, FIG. 51.)

JAMAICA: Without locality, *Jenman; Hart.* Near Hardware Gap, 4,000 ft., moist bank, *Maxon* 1104 (= *Underwood* 2220).
GUATEMALA: San Rafael, Zacatepequez, 6,500 ft., *Donnell Smith* 2560.

I have now no doubt that the Jamaican specimens belong here; they agree in habit and other characters exactly with the type from Brazil, but recede a little by their small, fugacious indusia. The Guatemalan specimen has, on the contrary, very large indusia, but its pinnæ are more hairy along the costæ beneath than in the type. It seems to be without glands, thus belonging to my variety *eglandulosa*. An excellent mark for this species is the lower basal segment, which in the well-developed pinnæ is considerably longer than the other ones. Synonyms of this species are: *Nephrodium Sprengelii* var. *persicinum Jenman* (Journ. Bot. 17: 261. 1879) and *Lastrea grossa* Presl (Epim. Bot. 41. 1851).

NOTES

The Cypræa notata Revived

The first "new species" described by Dr. Theodore Gill was a cowry named by him *Cypræa notata*. It was described in 1858 in the Annals of the Lyceum of Natural History of New York (vol. v, p. 255-257, pl. 9, figs. 1-3); it had been found among other cowries said to have come from Singapore. Although rather a striking and handsome species, it was overlooked or regarded as a mere variety of some other species till 1907. Then it was revived and recognized as a perfectly distinct species by J. G. Hidalgo in his monograph of the genus Cypræa ("Monografia de las especies vivientes del género Cypræa"), published in Madrid. Hidalgo refers to the same species the *Cypræa macula* of Adams, described in 1867, and the *C. interpunctata* of Brazier, indicated in 1895. He takes the same view of its relationship as Gill did. Specimens have been found in a number of places ranging from Arabia (Aden) to New South Wales (Port Jackson) and Polynesia (Funafuti). It is, however, a rare species, and there are only two specimens in the United States National Museum, one of which has long been labeled *Cypræa notata* and the other *C. macula;* neither is a typical representative of the species.—Theodore Gill.

Establishment of the Langley Medal

At the annual meeting of the Board of Regents in December, 1908, there was established a medal to be known as the Langley Medal, in recognition of Mr. Langley's contributions to aerial navigation, and to be awarded by the Institution from time to time for specially meritorious investigations in connection with the science of aerodromics and its application to aviation. Following precedent, the Secretary later appointed a Committee of Award, composed of the following-named gentlemen of recognized attainments in the science of aerodromics: Mr. Octave Chanute, of Chicago, Chairman; Dr. Alexander Graham Bell; Major George O. Squier, U. S. A.; Mr. John A. Brashear, of Allegheny, Pennsylvania, and Mr. James Means, formerly editor of the "Aeronautical Annual," Boston, Massachusetts.

Award of the Langley Medal

At a meeting of the Board of Regents on February 10, 1909, the Langley Medal was awarded to Wilbur and Orville Wright by the adopton of the following resolution:

"*Resolved,* That the Langley Medal be awarded to Wilbur and Orville Wright for advancing the science of aerodromics in its application to aviation by their successful investigations and demonstrations of the practicability of mechanical flight by man."

This was not only the first award of the Langley Medal, but was the first official recognition in America of the achievements of the Wright brothers.

Congresses and Celebrations

Darwin Celebration.—At the commemoration by the University of Cambridge, England, on June 22 to June 24, of the centenary of Charles Darwin's birth (February 12, 1809) and the fiftieth anniversary of the publication of the "Origin of Species" (November 24, 1859), Secretary Walcott represented the Institution. While in Cambridge, Doctor Walcott was honored by the conferring upon him of the degree of Doctor of Science, in recognition of his investigations of the early geological formations.

Pan-American Scientific Congress.—At the first Pan-American Scientific Congress, held in Santiago, Chile, December 25, 1908, to January 5, 1909, Mr. William H. Holmes, Chief of the Bureau of American Ethnology, who represented the Institution, read a paper on "The Peopling of America." The Congress decided to hold the second Pan-American Scientific Congress in Washington, D. C., in 1912.

Archeological Congress.—At the Second International Archeological Congress, held in Cairo, Egypt, at the Latin Easter, 1909, upon suggestion of the Institution, Mr. Albert M. Lythgoe, of the Metropolitan Museum of Art, New York, and Prof. Paul V. C. Baur, of Yale University, were designated by the Department of State as representatives of the United States.

University of Geneva Celebration.—Dr. James Mark Baldwin, Professor of Philosophy and Psychology in Johns Hopkins University, Baltimore, was designated to represent the Smithsonian Institution at the three hundred and fiftieth anniversary of the foundation of the University of Geneva, held in Geneva, Switzerland, July 7 to 10, 1909.

ANNIVERSARY OF UNIVERSITY OF LEIPZIG.—Dr. William H. Welch, of Johns Hopkins University, has been appointed delegate on the part of the Institution to the celebration in Leipzig, from July 28 to 30, 1909, of the five hundredth anniversary of the founding of the University of Leipzig.

GRANTS

A grant of a considerable sum was recently made from the Hodgkins Fund for the erection during this summer, on the summit of Mount Whitney, California (14,500 feet), of a stone and steel structure to be used by investigators in the study of astrophysics or in the prosecution of any other researches for which high altitudes and clear atmosphere are desired.

An allotment was approved for the erection on Mount Wilson, California, of a shelter for the Smithsonian observers of the Astrophysical Observatory during the summer months, when conditions for solar radiation measurements are peculiarly favorable.

An appropriation from the Hodgkins Fund is being devoted to the construction of several copper-disk pyrheliometers, these instruments to be lent to observers in different parts of the world for the purpose of establishing an international scale of pyrheliometry.

A considerable grant has also been made by the Smithsonian Institution on behalf of Professor J. P. Iddings, of the United States Geological Survey, for the collection in Manchuria of Cambrian fossils and rocks, and in Japan, Java, and neighboring countries of volcanic rocks.

PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

CONTINUED FROM LIST IN QUARTERLY ISSUE, VOL. V, PART 2

No.	Title.	Series.	Price.
1858	GILL, THEODORE. Contributions to the Life Histories of Fishes. Vol. I, 1904–1907. (Reprints from Smiths. Misc. Coll., Ann. Rep. Smiths. Inst. and Proc. U. S. Nat. Mus.) 1909	Sp.	
1859	Classified List of Smithsonian Publications Available for Distribution, March, 1909. 1909	Sp.	
1860	Smithsonian Miscellaneous Collections. *Quarterly Issue*, Vol. 5, Part 3 (containing Nos. 1861–1868). 1909	M.C. 52	.50
1861	GILL, THEODORE. The Archer-fish and Its Feats. (*Quarterly Issue*). 1909	M.C. 52	
1862	ARNOLD, JULEAN H. The Peoples of Formosa. (*Quarterly Issue*). 1909	M.C. 52	
1863	FULCHER, GORDON SCOTT. Our Present Knowledge of Canal Rays: A Detailed Bibliography. (*Quarterly Issue*). 1909	M.C. 52	
1864	TRUE, FREDERICK W. Observations on Living White Whales (*Delphinapterus Leucas*); with a note on the dentition of *Delphinapterus* and *Stenodelphis*. (*Quarterly Issue*). 1909	M.C. 52	
1865	HALE, GEORGE E. Hamilton Lecture: Some Recent Contributions to Our Knowledge of the Sun. (*Quarterly Issue*). 1909	M.C. 52	
1866	DALL, WILLIAM H. Some New South American Land Shells. (*Quarterly Issue*). 1909	M.C. 52	
1867	CHRISTENSEN, CARL. American Ferns of the Group of *Dryopteris Opposita* contained in the U. S. National Museum. (*Quarterly Issue*). 1909	M.C. 52	
1868	Notes to *Quarterly Issue*, Vol. 5, Part 3. 1909	M.C. 52	
1869	(In preparation).		
1870	(In preparation).		
1871	BECKER, GEORGE F., and VAN ORSTRAND, C. E. Smithsonian Mathematical Tables—Hyperbolic Functions. 1909	Sp.	4.00

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PREHISTORIC RUINS OF THE GILA VALLEY

By J. WALTER FEWKES

WITH FIVE PLATES

At the close of the author's field work at Casa Grande, Arizona, in the spring of 1908, he received a grant from the Secretary of the Smithsonian Institution for comparative studies of the same type in the Gila Valley and its tributaries. The following pages contain a report of this work, including some additional data collected in former years. The present investigation is limited especially to that type of mounds supposed to indicate Great Houses like Casa Grande, the type of buildings characteristic of southern Arizona. As the particular object of the study is to determine the geographical extension of ruins of this kind, many buildings, like cliff dwellings and cavate rooms, common on the northern tributaries of the Salt, as the Verde and Tonto rivers, are not considered.[1]

The Casa Grande type of buildings is practically found only in the plains bordering the Gila, Salt, and Santa Cruz rivers, where we have every reason to suppose this specialized form of structure first arose and later reached its highest development. Although it is probable that this type, somewhat modified, occurs in the Tonto and San Pedro valleys, it has not yet been recognized along the Verde and does not occur, so far as exploration has thus far gone, in the highlands in which the Salt and Gila rivers originate. It was of course impossible, considering the vast extent of desert in which these ruins are situated and the short time at the disposal of the author, to visit all of the ruins in these regions. Although the present report cannot be regarded as exhaustive, yet it is believed

[1] The forms and general archeological features of the Casas Grandes of Chihuahua appear to be identical with those of Casa Grande in Arizona, but as the pottery objects are wholly different in the two regions, it would appear that there were important cultural differences.

to embrace the more important clusters of the Casa Grande type in the valleys under consideration. Small mounds[1] with fragments of pottery or broken metates indicative of habitations are scattered over the plain in every place in the desert where irrigation was possible. Their number and distribution indicate a considerable population, often settled at some distance from the great dwellings, but generally near remnants of the prehistoric irrigation ditches that one constantly encounters in these regions.

The level plains bordering the Gila River and its tributaries were inhabited in prehistoric times by an agricultural people having a homogeneous culture. The prehistoric inhabitants built houses of two types: the one large, often several stories high, with massive walls, and the other, of more fragile character, serving for their dwellings. The material with which the latter were built and the manner in which they were constructed were not sufficiently durable to resist the elements, and the walls have fallen, augmenting the height of the debris accumulated at their foundations. Sand blown by winds has drifted over the ruins, covering the rooms and forming mounds over them, from which, in a few cases, there still project, a few feet high, irregular fragments of the original walls.

When the Gila Valley was first visited by the Spanish explorers the projecting walls of these buildings were more plainly visible than at present and their true character and architecture were more apparent. It was at that time easier to recognize the characteristic type of structure of the buildings to which they belonged, for the walls are now almost completely buried. The massive walled buildings in these plains were early called Casas Grandes, or Great Houses,[2] one of the best of which, the historic Casa Grande, still preserves the ancient type. A knowledge of these houses, derived from laying bare the walls by excavations, shows that in their form and construction they are characteristic. They differ radically from cliff dwellings, pueblos, or those other prehistoric constructions in our Southwest,[3] with which, however, they have certain affinities.

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[1] Many artificial mounds in the Gila Valley show no indication of walls. Among these may be mentioned those formed of refuse or trash heaps and accumulations of earth incidentally thrown up in digging reservoirs or irrigation ditches. The sites of "mescal pits" or depressions in the earth where mescal was formerly roasted are indicated by earth much darker than that of the surrounding plain.

[2] The words "Casas Grandes" and Great Houses are used as synonyms of compounds.

[3] The four types of prehistoric dwellings in the Southwest may be known as: (1) cavate habitations; (2) cliff dwellings; (3) pueblos; (4) compounds. The essential difference between (1) and (2) is that the former are dug out

The architectural features of these prehistoric buildings of the Gila plains is well shown in the historic Casa Grande, which may be designated, for purposes of study, a "type ruin." Its walls have now been excavated and are well preserved, showing the best example of other Casas Grandes scattered over the valley of the Gila and its largest tributary, the Salt River. The predominating feature of this Gila type of ruin is a rectangular inclosure bounded by a massive wall oriented about north and south and inclosing buildings, large and small, courts, and plazas. From the universal existence of a protective surrounding wall, the author has designated this type of prehistoric ruin a "compound" to distinguish it from other prehistoric ruins of the Southwest above mentioned, with which it has little in common.

Although the more striking mounds of this valley are formed of the debris of these great houses, or Casas Grandes, there is good evidence that the prehistoric inhabitants built synchronously with these other less conspicuous dwellings, which are not unlike the ancestral dwellings of the Pima, Sobypuri,[1] and Papago. These dwellings were rectangular in form. Their walls were supported by upright logs, between which were woven matting or possibly branches of the cactus called *ocatilla,* the whole frame being covered with adobe. The floors of such houses were made of mud firmly trodden down, while the fireplace was a simple depression near the middle of the floor, generally in front of a doorway opening in the longest side. We may suppose that the roof was also constructed of mud laid on boughs or split logs, the interstices being filled with mud.

A typical prehistoric settlement of the Gila may be supposed to have been composed of buildings constructed of massive walls one or more stories high and smaller huts or jacales (Aztec, *xa,* earth; *calli,* houses), the upright walls of which were supported by logs. Both types of houses occur in the rectangular area that has been

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of the cliff, while the latter have taken advantage of natural caverns. The two types grade into each other, and no strict line of demarkation separates one from the other. The essential feature of the compound is the surrounding wall, which is sometimes morphologically represented in aboriginal buildings known as pueblos.

[1] The walls of houses of rancherias of the Sobypuri in the San Pedro are spoken of by Father Kino as made of "palos" (sticks) and "petates" (matting), the chinks being filled in with clay or mud. No reference is made in his account of buildings in this valley with massive walls, although the "capilla" at Victoria may have been a special house made of stone and set aside for ceremonial purposes.

called a compound inclosed by a massive wall over breast high for protection.[1]

In some instances nothing remains of the larger buildings, in others there is no indication of those with more fragile walls, but in both cases the surrounding wall is present and constructed of clay or stone, whichever material was most convenient for the builder. The two kinds of rooms would seem to indicate a dual use,[2] or that the rooms with massive walls were constructed for a purpose different from those with fragile walls supported by logs. The former may be supposed to have been used for ceremonials, councils, protection from foes, or for granaries, while the latter served simply as habitations.

If the number of walled compounds in the Gila Valley is any indication of its former population, it is apparent, from their number, that many people inhabited this part of southern Arizona in prehistoric times. As bearing on this point, attention may also be called to the fact that the ancient aboriginal population was more or less scattered and not confined to these great compounds, or even to their immediate vicinity, for there is abundant reason to suppose that they had many dwellings on farms situated between them and dotting what is now a desert. The prehistoric population of the Gila Valley may have risen into the thousands, and it is not too much to say that the number of Indians in the valley at the advent of the Spaniards could not have been more than a tithe of what it was in prehistoric times.

For convenience in the presentation of the subject, the prehistoric compounds of the Gila Valley have been grouped geographically as follows: 1, Compounds on the Gila; 2, Compounds in the Santa Cruz Valley; 3, Compounds in the Salt River Valley.

The first of the above groups includes those mounds of Great Houses scattered all the way from the upper Gila,[3] or the valley

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[1] Refuse heaps and other artificial mounds without walls are almost always found just outside the surrounding walls of the compounds.

[2] Cushing, who apparently found the same "thin-walled" buildings, ascribed them to an "ultra urban" population, and Bandelier (Final Report) suggests that they were late Pima constructions. There seems no good reason to doubt that they were dwellings as old as the massive-walled structures and constructed by the same race.

[3] Mr. F. H. Cushing writes, "Preliminary Notes," p. 184: "Contemplating the numerous structures in no fewer than thirteen cities, scattered throughout a single valley not exceeding seven hundred and fifty square miles, * * * we are impressed not only by the prodigious industrial energy of their builders and makers, but also by the unavoidable conclusion that they harbored populations far denser and more numerous than heretofore had been deemed (by scientists at large) possible, in reference to any group of ancient North American remains."

1.—Ruin A

2.—Ruin B

CLIFF DWELLINGS NEAR ROOSEVELT DAM, SALT RIVER

called Pueblo Viejo, to the so-called Gila Crossing; the compounds of the Salt River are strung along this river from near Mesa to the junction of the Salt and Gila, while the Great Houses of the Santa Cruz extend from the old missions at Tubac and Tumacacori, in southern Arizona, past the mission, San Xavier del Bac, to the isolated peak Picacho and the point where this river is lost in the sands of the desert. Mounds marking the former sites of these Great Houses occur on both sides of the rivers mentioned near to or remote from their banks.

There are evidences that these Casas Grandes were most numerous in regions of the Gila Valley, where at the present day the white population is the densest.[1] In other words, large settlements of Americans now occupy some of the same sites that the aborigines chose for the construction of their compounds. This occupation by a later race has led in some instances, as at Tucson, the oldest white settlement in Arizona, to the almost complete destruction of all evidences of these Great Houses of the aborigines. The same is true of the settlements near Phœnix and Mesa, where we note the same reduction in size and rapid disappearance of the ancient mounds. On the other hand, the desert south of the Gila, at Casa Grande, or the plains of the Santa Cruz between Red Rock and the "mouth"[2] of the river, show mounds indicative of former Casas Grandes more scattered, smaller in size, and fewer in number.

It appears that the valley of the Salt River in the neighborhood of Phœnix, Tempe, and Mesa was the most densely populated region of this whole drainage area and apparently contained the oldest settlements. These facts may be ascribed to the ease with which the plains in this region could be irrigated as compared with other parts of the valley, or may have been due to the presence of more fertile land in those localities.

The mounds in the valley above mentioned are known to the Pima Indians as the old houses (vaaki) and are associated with certain chiefs, called *civans,* whose names vary with localities. The following ruins and corresponding chiefs, recorded by Dr. Frank Russell in his monograph[3] on the Pima Indians, may be mentioned:

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[1] In the upper Salt we find several other types of ruins, the most striking of which are the two large cliff dwellings (pl. XXXVIII, figs. 1, 2) a few miles from Roosevelt Dam.

[2] *Atcin,* Pima word for mouth of the river.

[3] 26th Annual Report of the Bureau of American Ethnology.

According to the legends published by Dr. Russell the Great Houses were formerly inhabited by the Vulture or Red people, the A'kol, A'pap, and A'pŭki.

Casa Grande,	Sĭa′-al Tcu-vtakĭ, Morning Blue.
Santan,	Kĭa′-atak, Handle.
Ruin four miles northwest of Santan,	Tcuf′haowo-o, Dipper.
Sweetwater,	Ta′-a, Flying.
Casa Blanca,	Tco′-otcuk Ta′tai, Black Sinew.
Gila Crossing Ruin,	Tcu′narsat, Lizard.
Mesa (name?),	A′-an Hi′tŭpăkĭ, Feather Breathing.
Tempe (name?),	Vi′ĭk I′alt Ma′kai, Soft Feathers Rolling.

The author has found that different Indians apply other names to the above ruins, but although their nomenclature of individual mounds varies, all refer a name of a chief to each of the larger clusters.

The geographical center of the culture area, characterized by Great Houses inclosed in compounds, as indicated by the largest number and purest architectural forms, lies near Phœnix, Tempe, and Mesa.[1] The San Pedro, Santa Cruz, upper Gila, and Salt and the northern tributaries of the Salt are frontiers of this area, the culture being considerably modified by local environment.

For convenience in treatment, the mounds or ruins in the region under consideration will be classified as follows: I, Middle Gila Valley Compounds; II, Santa Cruz Valley Compounds; III, Salt Valley Compounds; and, IV, Ruins on the San Pedro.

I. Middle Gila Valley Compounds

The more prominent of the Great House mounds of the Gila are the following: 1, Ruin 15 miles east of Florence; 2, Ruin 3 miles east of Florence; 3, Ruin near Florence; 4, Escalante ruin; 5, Tcurikvaaki (Ruin near Adamsville); 6, Ruin 5 miles east of Casa Grande; 7, Casa Grande; 8, Ruin on right bank of Gila opposite Blackwater; 9, Santan; 10, Ruin 4 miles west of Santan; 11, Snake ruin; 12, Sweet Water; 13, Casa Blanca; 14, Ruins at Gila Crossing. The following ruins have been associated with names of chiefs (*civans*) who inhabited them: 7, Casa Grande: *Sialim tcutuk* (Green or Blue); 11, Taa (Flying); 13, Tcuk tatai (Black Sinew); 14, Tcunarsat (Lizard).

These people were conquered by Elder Brother in the following order: (1) Casa Grande; (2) an extensive "pueblo" at Santan, the pueblo of chief Tcuf′-haowo-o; (3) Sweetwater, ruled by Ta′-a; (4) Casa Blanca, pueblo of Tco′-otcûk Ta′tai; (5) Vultures pueblo; (6) Tcu′narsat's pueblo at Gila Crossing; (7) that of A′an Hi′tŭpăkĭ at Mesa; and (8) Vi′ĭk I′alt Ma′kai, at Tempe.

[1] The Septenary arrangement of these Great Houses and compounds to which Mr. F. H. Cushing, *op. cit.*, ascribed considerable importance is not evident.

The architectural features characteristic of the Great Houses in the middle Gila appear also in the ruins in the upper Gila, or the so-called Pueblo Viejo, Old Pueblo, in which are situated the towns San José, Solomonsville, Safford, and Pima, considered in a previous report[1] on the ruins of that region.

There are many localities in this region of the Gila Valley where there are fine examples of ancient pictographs, among which may be mentioned those cut on cliffs near Sacaton and on the lava hills north of the river. About six miles east of Florence there are pictured rocks that are particularly interesting.

I.—Ruin 15 Miles East of Florence[2]

This ruin (fig. 65) has the rectangular shape characteristic of a compound, and its surrounding wall measures approximately 232 by 120 feet. It is situated a few miles north of the old road from Florence to Old Fort Grant. Not far from this ruin there can still be seen two old reservoirs, called by the Pimas "*vashki*" and by the Americans "Indian tanks." One of these contained water at the time of the author's visit; the bank[3] of the other tank was washed out and cut in two, so that it resembled two mounds and is so designated by the cow-men who have stock in this region. One of these "*vashki*" or "Indian tanks," (fig. 66) is identical in shape with the problematically "oval mound" at Casa Grande, suggesting a similarity in use.

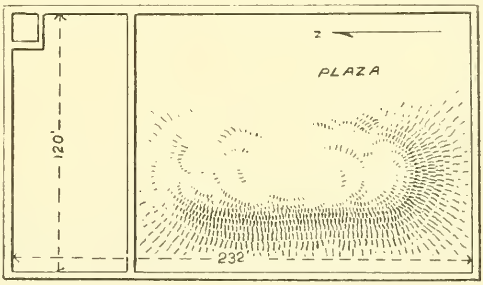


Fig. 65.—Compound 15 miles east of Florence

[1] 22d Annual Report of the Bureau of American Ethnology. The compound as a distinct type of Southwestern ruin was not recognized in this report. It is recognizable at the Epley Mound, which is the central citadel of a compound near Solomonsville.

[2] Florence, the capital of Pinal County, is the most conveniently placed city from which to visit most of the Gila compounds in the eastern region, and Sacaton, the Pima agency, is the best point of departure for those visiting ruins on the Pima reservation.

[3] There are no walls built around the depressions, but they are surrounded by a bank of earth thrown out of the depression. This fact was determined by digging a cross-section of the bank of the "oval mound" at Casa Grande.

Another so-called "Indian tank," situated in a valley six miles from the two reservoirs mentioned above, was used by Sr. Paisano for watering his stock when the author visited the place. It contained considerable water at that time (March), and from its geographical position is supposed to be the reservoir in the valley west of the Tortilla Mountains, which is designated as a "tank" on the United States engineers' map of 1879. Everything indicates that this is undoubtedly an old Indian reservoir.

2.—Ruin 3 Miles East of Florence

This ruin, having the form of a low mound, is situated not far from the main irrigation ditch of Florence and about three miles

Fig. 66.—Ancient Reservoir

east of that town. Although the compound form is not easily detected in this mound, there is no doubt that it belongs to the characteristic ruins of the Gila-Salt Valley. The absence of smaller mounds in its neighborhood indicates that this settlement was never of great size or importance. In the immediate neighborhood of the modern irrigation ditch that now furnishes Florence with water were found several sections of a much older, perhaps prehistoric, ditch that once irrigated the fields cultivated by the aborigines near the settlement.

3.—Ruin Near Florence

This mound is of considerable size and is situated a short walk from the town, on the south side, near a settlement of Papagos. It is referred to in the author's account[1] of excavations made at Casa Grande in 1906–07, where a plan of the compound is published.

The author visited the large modern reservoir south of Florence and searched carefully for a "ruin" which is designated on several maps, but failed to find it. A small mound was discovered near the bank of the reservoir, but larger "buildings" which were reported by several Americans did not materialize.[2] There are mounds in the broad stretch of desert between the reservoir and the prehistoric buildings at Picacho which several reliable men whose stock "run" in this region have described in detail, but the author was unable to locate them with any certainty.

4.—Escalante Ruin

It is recorded that when Father Kino's party, in 1694, followed down the left bank of the Gila, Sargent Escalante and some comrades swam this river to visit a ruin the walls of which they had observed on the opposite bank. All that now remains of this "tower" is supposed to be the mound situated about a mile west of Posten's Butte, which is nearly opposite Florence and about the same distance from the right bank of the river.

Mr. H. C. Hodge thus refers to a ruin not far from Florence:

> "Four miles to the west of Florence, on the line of the canal, are the ruins of another old town, the outlines of some of the buildings being easily traced. One of them is 120 feet long, and 80 feet wide. It was surrounded by a wall of concrete and stone, portions of which now remain; and this wall was 130 feet long on two sides of the building and 225 feet long on the other two sides, forming a kind of court-yard enclosing the buildings. This court-yard was filled in on the south and east sides with earth to the depth of four feet."[3]

Possibly the ruin here referred to is that which the author has called the Escalante ruin, or it may be Tcurikvaaki.

Although the standing wall that once attracted Escalante's attention as a tower has now fallen, a high mound marking the position of a massive walled building or "citadel" and the low ridge, indi-

[1] Smithsonian Miscellaneous Collections. Quarterly Issue, Vol. IV, p. 3, 1907.

[2] One or more were possibly destroyed when the reservoir was constructed.

[3] Arizona as it is, or the Coming Country, 1877, p. 182.

cating the surrounding wall of a compound (fig. 67), can still be traced. Rough measurements of the last-mentioned wall show that its dimensions were about 210 feet by 120 feet. The ruin is situated not far from the railroad from Mesa City to Florence. In the springtime it can be readily seen from a distance as a mound of earth looming above the cacti and mesquites. The walls of this ruin were partially constructed of stones, none of which now project to any considerable height above the surface of the ground.

Apparently the Escalante compound had, in addition to a centrally placed building, a cluster of rooms in its northwest corner. There are also other mounds near it, indicating rooms in the neighborhood, although some of these show no signs of walls and were evidently piles of debris or rubbish heaps.

This settlement was supplied with water by one of the best-preserved ancient irrigating ditches the writer has seen in the Gila-Salt Valley. This ditch follows the Gila from a point several miles higher up the river and extends to the neighborhood of the Escalante ruin, where it is lost in "laterals" or minor subdivisions. At a point near Posten's Butte, the southern side of which it skirts, the banks of this prehistoric ditch are head high and can be traced for many hundred feet without difficulty. The writer has been informed by an old Mexican, who lives in Florence, that when a boy he saw old stumps of logs in this ditch at the point where the banks are highest and he believed that these stumps were remnants of a prehistoric gate.

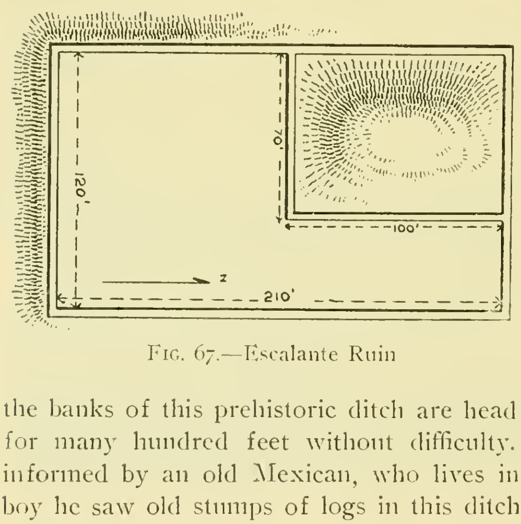


FIG. 67.—Escalante Ruin

In the following quotation Mr. H. C. Hodge[1] refers to a prehistoric irrigation ditch on the north side of the Gila near Posten's Butte:

"About two miles west of Florence, on the north side of the river, between the homes of Mr. Stiles and Mr. Long, is a stretch of hard, stony land, through which another of the large irrigating canals was cut, and where for several hundred yards one can ride on horseback in the canal, which is yet so deep one cannot look over its banks on either side when sitting on his horse."

[1] Arizona as it is, or the Coming Country, 1877, p. 182.

5.—Tcurik Vaaki

There is a large ruin a short distance south of the abandoned American village, Adamsville, called also Sanford's Mill, which is one of the largest and most instructive in the valley. The Pima name for Adamsville is *tcürik,* the Turk's head cactus, which would seem an appropriate name for the neighboring ruin. It consists of a cluster of mounds (fig. 68), among which rises a large central elevation that may be identified as the citadel of a compound. In addition, there is a clan house with four well-preserved walls above ground and an oval depression surrounded by a bank of earth which may have been a *vashki* or ancient reservoir. The most conspicuous of these mounds is the citadel, which looms high above the plain and is visible for a considerable distance, but the walls[1] that are best preserved are those of the clan house a few hundred feet away.

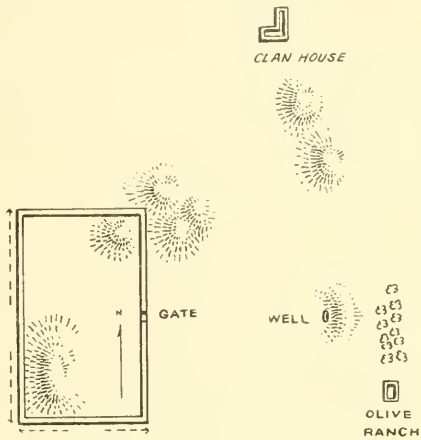


Fig. 68.—Tcurik vaaki

6.—Ruin 5 Miles East of Casa Grande

This ruin is conspicuous for a considerable distance, its largest mound or citadel being clearly visible from the last-mentioned mound. It lies about half way between *Tcurik vaaki* and Casa Grande and was apparently once a settlement of considerable size. It is still pointed out by the Pimas, who retain the name Uturituk[2] for this place.

Two sections of the surrounding wall of this compound still project several feet above ground on the east side, indicating that it was similar to the surrounding wall of the Casa Grande compound.

There are prehistoric mounds on the north bank of the Gila about opposite Blackwater, not far from a modern Pima settlement con-

[1] These are figured in the author's account of the excavations of Casa Grande in 1907-1908.

[2] The author has heard the ruin Casa Grande called Uturituk, probably a confusion of names of the ancient and more modern settlement.

taining several houses. The largest of those, which may be called conspicuous, is situated a few feet from a house belonging to the mother of Juan Enos, a Pima workman employed by the author in his work at Casa Grande. No walls of buildings stand out of the ground, but the general character of the mounds show that in form the ruins were compounds like those on the south bank of the river. There are many pictographs on the lava hills north of this mound, which resemble those shown in the accompanying illustrations (pl. XXXIX).

7.—Casa Grande

The general character and architectural features of the Casa Grande cluster of mounds will be described elsewhere[1] and will therefore not be here considered.

A lagoon mentioned in early writings as Cumani or Laguna was probably situated not far from where the Santa Cruz in times of flood empties into the Gila. The mouth of the river is near Sacaton Flats, known to the Pimas as Huring, "place of the standing cactus," and is mentioned by Fathers Font, Garces, and other early visitors. The name Cumani is adopted from their writings.

8.—Ruin Opposite Blackwater

The Pima village called Blackwater, near Casa Grande, is comparatively modern, its inhabitants being descendants of certain families which moved there from Casa Blanca a few years ago. Previously, however, or at the time Casa Grande was first visited by the Spaniards, there was a Pima settlement near its site, called Uturituk or the place at the angle or corner.[2] Although the exact site of Uturituk is now washed away, the banks of the river at that point having been much modified by the changes in its current from the approximate position.

9.—Santan Ruin

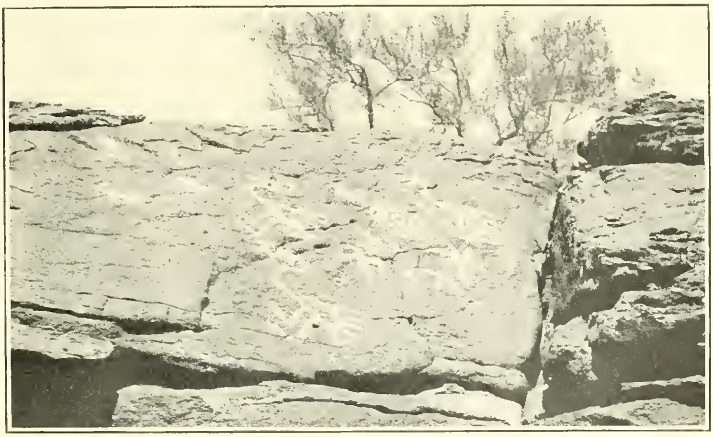
There are mounds at Santan, on the north side of the Gila, opposite Sacaton.[3] These mounds resemble those of Casa Grande and

[1] A view of the largest compound is shown in the author's preliminary report on Casa Grande for 1907-1908.

[2] Referring to the island in the Gila near this place. Dr. Russell calls Casa Grande, Tcóoltûk, Pima word for "corner," which is believed to be a part of the *sivan* or chief's name, Sialtcutuk, Morning Blue, or Green.

[3] Good views of the Santan Ruin, the ruin west of Santan, and that at Sweetwater are given by Dr. Russell in 26th Ann. Rept. Bur. Amer. Eth., pl. IV, *a*, *b*, and *c*.

a



b

c

PICTOGRAPHS FROM GILA-SALT VALLEY

preserve traces of the same compound architecture or buildings with a surrounding wall. They show signs of sporadic digging by amateurs, but have never been systematically excavated.

10.—Ruin 4 Miles West of Santan

This ruin, like that at Santan, is situated on the north side of the Gila and is a large mound surrounded by a rectangular wall. It apparently belongs to the compound type.

11.—Snake Ruin

Snake Ruin, north of the Gila, was not visited by the author. From reports it is believed to be a compound.

12.—Sweet Water Ruin

There is a low mound surrounded by a wall to the left of the road from Sacaton to Casa Blanca which shows the compound type. A plan of this compound has been published in a preliminary report on Casa Grande.

13.—Casa Blanca Ruin

The mounds at Casa Blanca are among the largest in the Gila Valley and the compound wall of one of them is most extensive. In the middle of the last century, according to a contemporary writer, the walls of this building projected above the ground, but today they are level with the surface of the mound, though they can be readily traced. The mounds in the neighborhood indicate that this was formerly a settlement of importance and large size.[1] A considerable number of Pima Indians, possibly descendants of the ancients, now inhabit a cluster of houses west of the main mounds.

14.—Ruin at Gila Crossing[2]

The mounds situated a short distance from Gila Crossing are extensive, but have not been studied by the author. From descriptions by those who have visited them, it appears that one or more

[1] Smithsonian Miscellaneous Collections, Quarterly Issue, Vol. IV, 1907. This was a *vaaki* of considerable size, having one or more compounds, clan houses, burial mounds, and a large circular or oval well or reservoir with low banks. The indications are that its size was greater than that of the Casa Grande group of buildings.

[2] This compound is called by some of the Pimas *Tcunarsat vaaki*, or Lizard Old House. Many folk tales are current among Pimas and Papagos concerning it.

has the true compound form or type identical with the Casa Grande and Florence region.

It is desirable to explore the mounds reported from Gila Bend, which are supposed to be old habitations of the ancestors of the Maricopas.

II. Santa Cruz River Compounds

The mounds indicating Casas Grandes along the Santa Cruz have the same general characters as those of the Gila and Salt rivers. The typical compound architecture characteristic of the plains along the Gila almost universally prevails in this region.

The Santa Cruz is not a constant stream, but in portions of its course may be called a subterranean river, the water literally flowing as a subway sometimes at a considerable depth. Near the Gila it is generally just below the surface, but its presence above ground is indicated by alkali lagoons, as at "Cumani," not far from Sacaton Flats. There are several mounds of large size along the valley of this river marking the sites of former Casas Grandes. Among these may be mentioned the Picacho settlement and those in the vicinity of Tucson, the most ancient Spanish settlement in Arizona. Numerous large ruins south of Casa Grande railroad station, near the road to the Vekol and other mines, belong to this same drainage area.

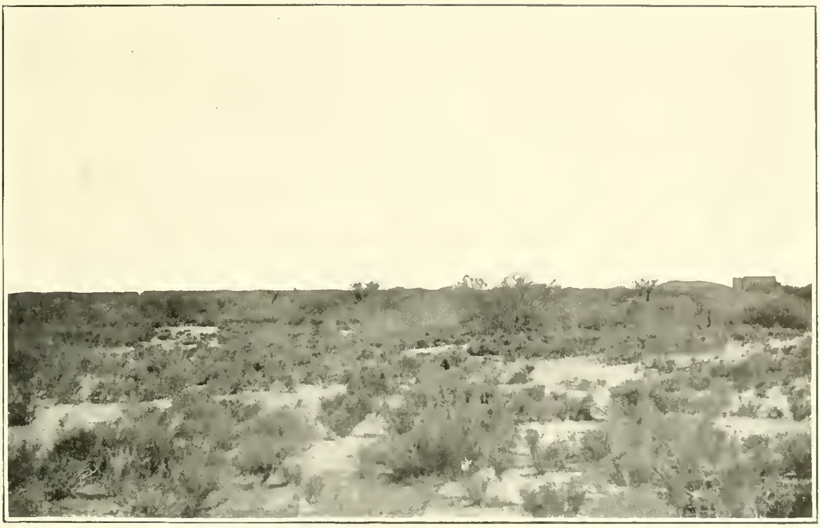
The Casas Grandes of the Santa Cruz will be considered under the following headings: 1, Ruins near Tucson; 2, Chakayuma; 3, Aquituno; 4, Quitoac; 5, Ruins near Kwahadt Indian Villages.

1.—Ruins Near Tucson

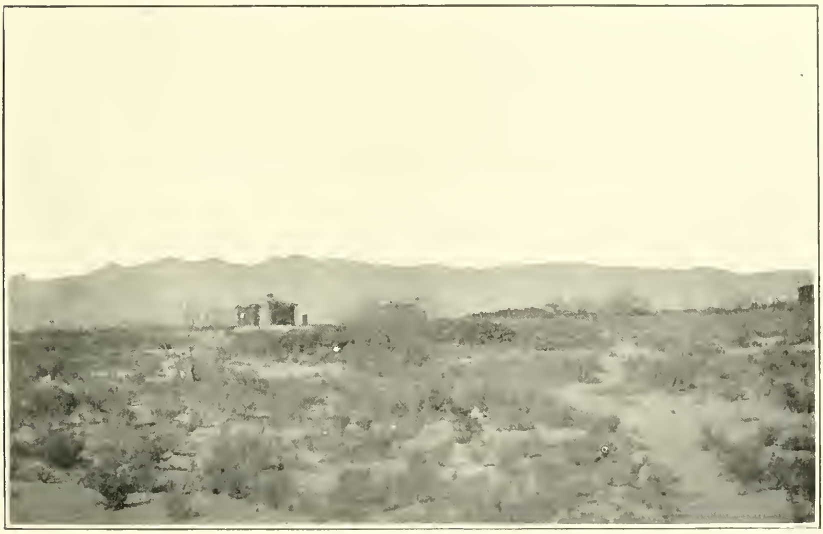
The valley of the Santa Cruz from the city of Tucson south appears to have been the most densely populated in prehistoric times. In this part of the valley the stream rose to the surface, and the supply of water was probably more constant here than farther down the river, where it was less available for agricultural purposes.

The author failed to find in the immediate neighborhood of Tucson any large mounds, such as occur in the deserts near Casa Grande or in the midst of the cultivated fields at Mesa and Phœnix, but near the city there are mounds bearing evidences of several old Indian rancherias or *vaaki*.[1] These, however, have been considerably reduced in size and so worn down that in most instances they

[1] The term *bac* in San Xavier del Bac, Tubac, and other names of settlements or sites may be a contraction of *vaaki*, old house or old ruined house.



a



b

RUIN AT EL RANCHO DEL TUCSON

are inconspicuous. The land in this neighborhood has been cultivated for several generations, the valley at this point being one of the earliest settled portions of Arizona.

About a mile south of the site of the former presidio of Tucson there are remains of old mounds (pl XL, figs. *a, b*), out of which, according to Hon. Samuel Hughes, who settled in Tucson in 1853, there formerly rose cajon or caliche walls. One of these mounds was of considerable size, suggesting the central building of a compound. The author has been informed by several persons that formerly low massive walls projected out of this mound, which statement, if true, would indicate that this was actually a compound. It is about the center of a group. In the immediate neighborhood there is a cluster of Papago huts, the place being known to old residents as El Rancho del Tucson.[1]

The first mission at Tucson was called by the oldest inhabitants Casa de los Padres, and was established at another Indian settlement on what is now the Grosetta Ranch, about three miles down the Santa Cruz from Tucson. The rancheria Santa Catalina was not far from this neighborhood. Here and at various other points on the Rillito, up the Santa Cruz north and northwest of the old Rancho del Tucson, there are low mounds on which are still found scattered fragments of Indian pottery indicating ancient aboriginal rancherias. It is, however, extremely difficult to distinguish historic from prehistoric sites of dwellings, both of which are found in numbers near Tucson, in the valleys of the Rillito and Santa Cruz.

The elevated land west of the city of Tucson called Tumanoac or Lizard Hill, has on its sides and near its summit walls, trincheras, or lines[2] of fortifications constructed of blocks of lava, near which are many boulders bearing pictographs, thus indicating the former presence of the aborigines.

Some of the best pictographs in this region, the general character of which appears in the accompanying plate[3] (pl. XLI), are clustered on the cliffs about 5 miles west of Tucson.

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[1] Several writers assert that the Pima word Tucson means black water, but other informants declare that it means black foothills; *took*, black; *son*, foothills, referring to the laval flows of the Tucson Mountains.

[2] Similar lines of stones set upright are also found in the valley. These could hardly be called trincheras. Their interpretation is doubtful.

[3] From a photograph by Dr. MacDougal, Director of the Carnegie Desert Laboratory, to whom the author is indebted for an opportunity of visiting this locality.

On the north side of the Santa Cruz Valley, in the Tortilla Mountains opposite Tucson, there are several ruins, some of which have walls standing high out of the ground.[1]

2.—Chakayuma

This ruin lies at the foot of the northwest point of the Tucson Mountains, about 18 miles from Tucson, opposite the station Rillito, on the Southern Pacific Railroad. The face of the mountain, called by Garces "Frenta Negra," bears many pictographs, and lines of trincheras, fortifications, are still visible on the summit. The settlement spreads over several acres, the houses consisting of low mounds, with indistinct evidences of walls and many fragments of pottery. The sites of these houses are generally marked by rows of stones set on edge. These stones in some cases formerly supported and protected the bases of the walls, which were held upright by logs now much decayed. Shallow excavations at this place revealed the face of the wall in which these upright stones had been set and a hard clay floor, upon which was generally found a layer of charcoal. Evidently the stones served the same purpose as the logs found at Casa Grande, the remainder of the walls and the roof being constructed of perishable material, possibly brush or ocatilla cactus.

Several good vases, one of them in the collection of the University of Arizona, at Tucson, have been excavated at this ruin, which seems rich in specimens and offers unusual advantages for further study.

3.—Aquituno Ruin (Akutciny, Russell)

There are several mounds, indicating ancient Casas Grandes, not far from the desert butte, Picacho, that were not visited by the author.

The site of *Cutcia vaaki* (Kistcoit, Russell), frequently mentioned by the early Spanish priests, has not yet been definitely made out, but was possibly east of Picacho, and maybe the mounds at Aquituno are remains of this settlement.

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[1] A site near Tucson mentioned in "Garces' Diary" as Laguna still bears the same name. Professor Blake, of the University of Arizona, has shown the author ground plans of ruins in the Tortillas and Mr. Brown reports stone ruins with high walls.

PICTOGRAPHS ON CLIFF NEAR TUCSON

4.—Quitoac Ruin[1]

Another cluster of mounds in the neighborhood of Picacho,[2] also not visited by the author, appears from reports to be the remains of a considerable prehistoric settlement. In the time of the Spanish fathers there were apparently several Pima rancherias in this locality, which was a constant halting place in early visitations.

5.—Ruins Near Kwahadt Indian Villages

South of the railroad station called Casa Grande, on the Southern Pacific Railroad, there are Indian villages inhabited by Kwahadts, Papagos, and Pimas.[3] Near one of these settlements there is a cluster of mounds, one or two of which are large, indicating buildings of compounds like those at Casa Grande and elsewhere along the Gila and Salt rivers.

The largest cluster of these mounds has been described to me as situated on the road from the "Jack Rabbit Mine" to the "Reward Mine," near an Indian village about 6 miles south of the former. The informant said that while the general appearance of the mounds resembled those of Casa Grande, there were no extensive walls above ground.

III.—Salt River Compounds

The majority of ancient mounds of the Salt River Valley lie in the neighborhood of Phœnix, Tempe, and Mesa City. Although house walls are now generally hidden, their exposed tops, when traced, show the same compound structure as those of the Gila between Florence and Casa Blanca. Seven such compounds exist in the neighborhood of Phœnix, as shown in Mr. Patrick's map,[4]

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[1] *Kihu*, carrying basket; *toac*, mountain.

[2] Called by the Pimas Taátûkam (Russell) Tacom, which appears in Spanish writers as Ttacca, Taceo, or Quitcak. Dr. Russell mentions the following ruins near Picacho: 1, "Small pueblo ruin" northeast of the mountain, 15 miles from the river; 2, East of the mountain "Kistcoit Vatcik," Table Tank; north, Mo'ok' Vatcik, Sharp Tank; west, A'alt Vap'tck, Small Tanks; northwest of Akûtciny, small pueblo ruins.

[3] The region extending south from the Southern Pacific Railroad to the Mexican boundary is ethnologically a most interesting one, pleading for visits of both ethnologists and archæologists.

[4] The best published map we have of the distribution of aboriginal ruins and irrigation ditches in this region is by Mr. Patrick, of Phœnix, Arizona, to whom the author is indebted for many kindnesses.

and it is probable that there were formerly others unrecorded, which have in the course of time been leveled to the surface of the cultivated fields. There are also other signs of former settlements of smaller size, many smaller mounds, and banks of irrigation ditches and canals lined with rows of stones, indicating lateral branches.

In general appearance the prehistoric mounds of the Salt River Valley resemble those of the Gila, but the ground plans of a few of them are larger than any of the Gila Casas Grandes. None of them show walls standing above ground, a fact indicating great age.

The Salt River Valley ruins are commonly regarded by the Pimas as older than those along the Gila and Santa Cruz. The legends of these Indians declare that the culture of their builders was somewhat more advanced and older than that of the Gila, but that the compounds of these two regions were inhabited simultaneously. It is said that there was a constant communication between them, and that the relations were not always friendly. An examination of the ruins of the two regions indicates that those of the Salt are more ancient than those of the Gila and the Santa Cruz.

The Salt River Valley compounds may be divided into three groups: A, Phœnix Ruins; B, Tempe Ruins; C, Mesa City Ruins.

A.—PHŒNIX RUINS

The ruins and prehistoric irrigation ditches in the neighborhood of Phœnix have been studied by Mr. Patrick, who as surveyor has for many years professionally visited almost every part of this valley. The city itself is built on the site of one or more prehistoric settlements, which have long ago disappeared, its very name being derived from its relation to other more ancient settlements of the region.

The ruins near Phœnix here considered may be grouped as follows: 1, Patrick Compound; 2, Kalfus Mounds; 3, Heard Mounds.

1.—Patrick Compound

This cluster of mounds lies on the left of the road from Phœnix to Tempe, about half the distance of the Great Tempe Mound from the former city. In its neighborhood there are now many houses, the leveling of the ground for which has greatly changed the aspect of the place since the author's visit in 1892, but outlines of walls and ditches can even now be traced.

2.—Kalfus Mounds

West of Phœnix there are two large mounds that may be called the Kalfus Mounds, both of which, especially the smaller, are being rapidly destroyed. A road has been cut through one of these and the material is being rapidly carted away for use elsewhere.[1]

The larger of the two ruins west of Phœnix has the compound shape, its surrounding wall measuring 500 by 260 feet, the orientation being about north and south. This surrounding wall incloses two large mounds (fig. 69) in addition to one or two smaller elevations, which are evidently remains of rooms. The material of one of the Kalfus mounds is almost pure adobe, but there are no stones in the walls. The larger Kalfus mound was constructed on a slight

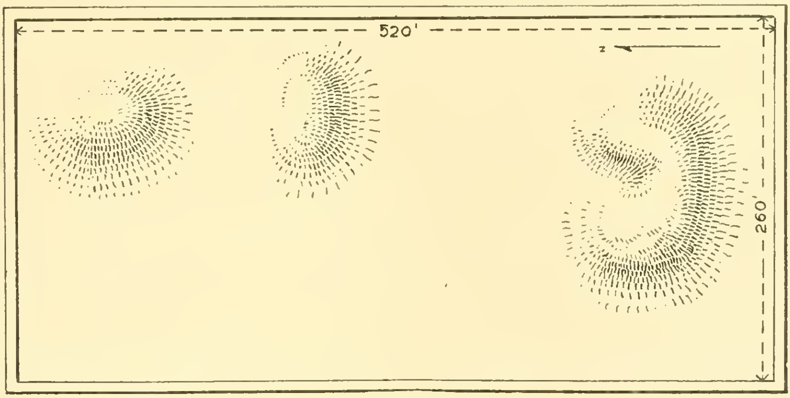

Fig. 69.—Kalfus Mound

natural elevation; the smaller of the compounds measures 275 by 210 feet.

3.—Heard Mounds[2]

One of the ruins south of the Salt River, opposite Phœnix, called Ruin E by Mr. Patrick, has been considerably leveled by plowing. It consists of a cluster of mounds, including one with an oval form which is much mutilated.[2]

It is very difficult to trace the surrounding wall of this ruin or to determine whether it was a compound, but another large mound on the same side of the river is surrounded by a rectangular wall, the west side of which is about 200 feet and the south 150 feet long.

[1] This "caleche" is much sought for by Americans, as it makes a very firm road-bed.

[2] The author was guided to these ruins by Mr. Heard, owner of the property on which they stand.

B.—TEMPE RUINS.

The several ruins near Tempe have the same general compound structure as those in the Gila Valley, namely, mounds inclosed in surrounding walls.[1] It would appear that the largest compounds exist in this region, where there are some of the best preserved prehistoric irrigation ditches in Arizona.

There are several descriptions of the Tempe ruins that might be quoted. Mr. J. H. Bartlett's account is as follows:[2]

"On reaching the great pile, I found it to be the remains of an adobe edifice from two hundred to two hundred and twenty-five feet in length, by from sixty to eighty feet wide, its two sides facing the cardinal points. Portions of the wall were visible only in two places, one near the summit, at the south end, where, from the height of the pile it must have originally been three or four stories high; and the other at the northern extremity, on the western side. These remains just projected above the mass of rubbish and crumbled walls. The rest formed rounded heaps of various heights and dimensions, worn into deep gullies by the rain, the whole presenting a striking resemblance to the mound which marks the site of ancient Babylon.

"The higher walls seen in the sketch probably belonged to an inner portion of the building. Near this is a conical hill, formed, doubtless, by the crumbling away of the higher portion or tower. Near the wall, which projects from the lower portion, at the northern end, are two large masses of this wall which have fallen. The adobe is still very hard, so much so that I could not break it with the heel of my boot. Several broken metates, or corn-grinders, lie about the pile. I picked up a stone pestle and some small sea shells. Along the eastern side are the remains of a long wall, extending beyond the building, now but a rounded heap, which seemed to have formed an enclosure. On the western side is an excavation about four feet deep, and extending from sixty to eighty feet from the main heap, and along its entire length, from which I suppose the mud and gravel to have been taken to make the adobe. To the northeast, about a distance of two or three hundred feet, are the ruins of a circular enclosure. This was not large enough for a canal; nor could it have been a well, as it is too near the margin of the plateau where the canal ran, which would always furnish a supply of water. At the south, two hundred yards distant, are the remains of a small building with a portion of the wall still standing.

"From the summit of the principal heap, which is elevated from twenty to twenty-five feet above the plain, there may be seen in all directions similar heaps; and about a mile to the east, I noticed a long range of these ruins north and south, which the Indians said were of a similar character to that on

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[1] From this region and Mesa City have been obtained some of the finest collections of prehistoric objects found in this valley. Among these may be mentioned the complete series collected by the Hemenway Expedition at Los Muertos and that of Dr. J. S. Miller, obtained from various points in the valley.

[2] Personal Narrative of Explorations and Incidents, 1854, p. 245.

which we stood. In every direction the plain was strewn with broken pottery, of which I gathered up some specimens to show the quality, as well as the style of ornamentation."

Mr. H. C. Hodge[1] thus speaks of the Tempe ruins:

"Six miles east from Phœnix, and two miles from the Hellings mill, now owned by Major C. H. Vail, are the ruins of a large town, near the center of which is one very large building, 275 feet long and 130 feet wide. The debris of this building forms a mound which rises thirty feet above the surrounding plain. The walls are standing about ten feet in height and are fully six feet thick. There seem to have been several cross-walls, and the whole was surrounded by an outer wall, which on the south side was thirty feet from the main wall; on the east, sixty feet; on the north, one hundred feet; and on the west side sixty feet.

"On the north and at the northwest corner were two wings, perhaps guard or watch houses. On the south of the outer wall was a moat, that could be flooded with water from a large reservoir fifty yards to the south. Several other large reservoirs are at different points in and around the main town, which was over two miles in extent.

"A large irrigating canal runs to the south of the large building, which was from twenty-five to fifty feet wide. This canal took the water from the Salt River eight miles above, and can be easily traced for twenty miles or more below. * * * The largest of the old irrigating canals visited and examined by the author is some twenty-five miles above Phœnix, on the south side of the Salt River, near the point where the river emerges from the mountains. This one, for eight miles after leaving the river, is fully fifty feet wide. For this distance it runs in a southwest course through hard, stony ground, and enters on a vast stretch of mesa or table-land, which extends south and southwest from thirty to sixty miles, having an elevation above the river of nearly one hundred feet.

"At about eight miles from where this great canal leaves the river, it is divided into three branches, each twenty-five feet wide, one of which runs in an east of a south course, one nearly south, and the third southwest, the three probably carrying water sufficient to irrigate the whole of the immense plateau before mentioned. Two miles west of where the main canal branches are the ruins of a large town, which extends along the mesa for many miles.

"Near the center of this town are the ruins of the largest building yet discovered. Its ground measurement is 350 feet by 150 feet, with outer walls, moats, embankments, and reservoirs outside the main walls, and ruins of smaller buildings in all directions.

"On the line of the branch canals, distant many miles from this one, are other ruins of towns similar to the others described. Below the great canal and the large ruin described, extending through what is called the Tempe settlement, are other irrigating canals of nearly equal size to the others, and which were taken out of the river many miles below the large one mentioned, and along there are also the ruins of great houses and towns."

Father Sedelmair, according to the last authority, described a ruin 36 miles below the Casa Grande, on the same side of the Gila.

[1] Arizona as it is, or the Coming Country, 1877.

The following quotation[1] evidently refers to the Tempe mound:

"Several mounds were found on the Salt River measuring from 80 feet wide to 120 feet long. One of these is plainly discernible, as our illustration shows, from the stage road at La Tempe. On the other side of the river two mounds larger in size are to be seen, one near Hayden's mill and the other close to East Phœnix. Mr. Bartlett, as well as other explorers, calls attention to the fact that the pieces of pottery so widely scattered show that the vessels were all painted or glazed white inside, an art which the Pima and other Indians do not possess. The La Tempe mound was measured by him, and found to be from 200 to 225 feet long by from 60 to 80 wide. This would give a much larger edifice than the Casa Grande. It is true to the cardinal points of the compass—a peculiarity common to all these ruins and mounds. Father Sedelmair also describes the La Tempe mound, and gave an account, too, of the three-storied building or ruin there which he found at the junction of the Gila and Salt rivers."

1.—Great Tempe Mound

The largest of all the mounds is the Great Tempe mound,[2] on the left of the main Phœnix-Tempe road, about 4 miles from the

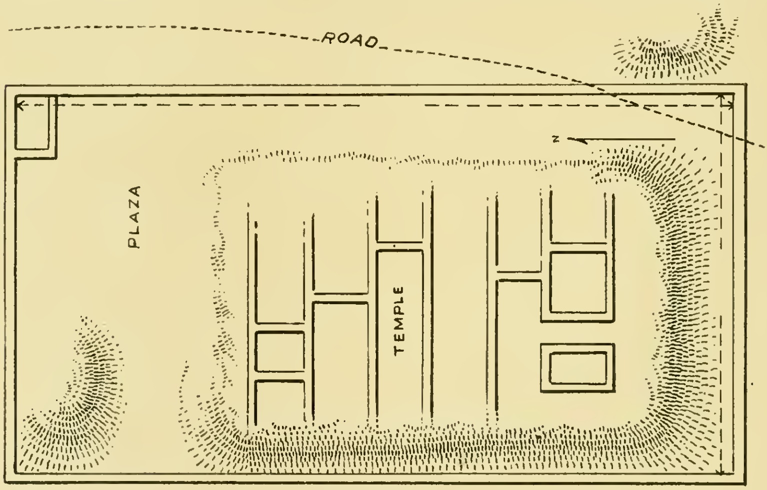

Fig. 70.—Great Tempe Mound

former city. This is probably seen by more white people in the course of a year than any other ruin in Arizona. It is conspicuous from the railroad and is a marked object in all the surrounding country. The main mounds with their walls form one of several clusters, covering more than 40 acres, evidently formerly one of the largest settlements in the Gila-Salt Valley.

[1] Hinton's Handbook to Arizona, pp. 411-412.

[2] This is possibly the ruin called by Dr. Russell by the name of the chief, S'o'am Nyu'i vaaki.

The largest compound (fig. 70) is oriented north and south, the wall surrounding it being approximately 353 by 246 feet in dimensions. The north wall and the northeast and northwest angles of the compound are entire, and were the earth removed would show unbroken corners. The whole west wall from the northwest to the southwest corner is likewise in fair condition, but the southwest angle, the southwest wall, and the southeast angle are more or less broken, the latter having been washed away by the "Cross-cut" canal. The road following this canal cuts across the southeast side and the Phœnix-Tempe road has more or less obscured or destroyed the south wall.

The large central mound of this compound has been somewhat mutilated.[1] It is from 15 to 18 feet high and shows walls of many rooms, some of them constructed of stone laid in adobe with smooth surfaces. This mound was evidently once covered with fragile walled buildings like those on Compound B of the Casa Grande group, but at present the supports have decayed and the walls are covered by fallen debris.

There are several other smaller mounds in this group, among which may be mentioned a circular depression or reservoir, *vaski*, 1,400 feet north of this compound. About 2,230 feet north of it there is a cluster of mounds, one of them in part excavated many years ago by Mr. F. H. Cushing.[2]

Of the several other mounds in this vicinity the largest has the form of a compound and is situated about 600 feet west of the first. This compound has the general form of the type, but it has no central mounds indicating large buildings. Apparently its rooms were fragile walled habitations and it closely resembles Compound C of the Casa Grande group.

2.—Carroll Compound

This compound, situated about a mile and a half west of Tempe, was not visited in 1907, but was examined by the author in 1892. The massive walled building is considerably worn down and reduced almost to the level of the surrounding plain.

[1] Excavations into the east side of this mound were made several years ago by the Arizona Antiquarian Society. The idea that the rooms of this mound were subterranean is erroneous, and the indications are that there were floors one above another as at Compound B, in the Casa Grande group, one room being built on the debris that had accumulated after the lower had been deserted.

[2] From the many small mounds in this vicinity this cluster of rooms was called Los Pueblitos by Mr. F. H. Cushing, who first opened them.

C.—MESA CITY RUINS

1.—Stewart Compound

The largest ruin near Mesa, situated about two miles and a half north of the post-office, is one of the largest ruins in the Salt River Valley. It is now occupied by Mr. S. O. Stewart and called the "Aztec Poultry Farm." His house and outbuildings stand in the northeast corner of the compound.

This compound is one of the largest and the best-defined in the Salt River Valley, measuring 430 by 250 feet. Its orientation is practically north and south, the majority of the mounds being on the left side. The surrounding wall can still be traced by the slight

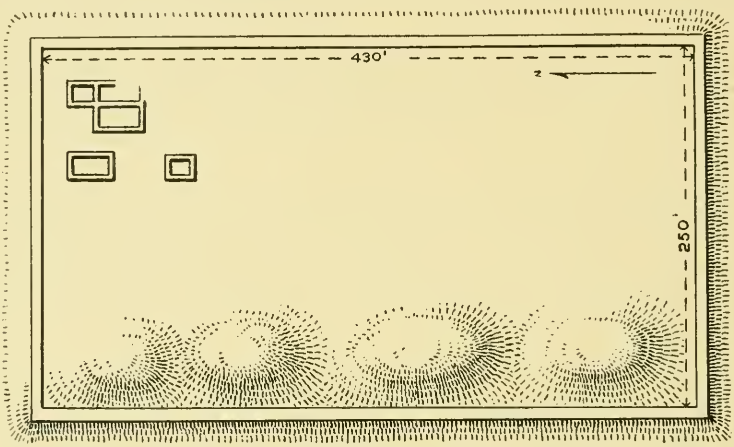

Fig. 71.—Stewart Compound

swell in the surface of the earth. Several rooms that have been excavated exhibit smooth, well-polished walls.

There is a circular mound with depressed interior and raised bank, reminding one of a similar "well"[1] (*vaskki*) at Casa Grande, situated a short distance from the compound.

2.—Los Muertos

The mounds called by Mr. F. H. Cushing "Los Muertos," are those in the Salt River Valley where much work was done by the

[1] Mr. Cushing gives an account of oval structures or "sun temples" having a distinct resemblance to the hollow mound at Casa Grande. According to him, these "sun temples" had smooth floors with fireplaces, banquettes, and evidences of ceremonial use. Remnants of the upright logs that formerly supported a roof and method of construction of the roof are described by Cushing.

Hemenway Southwestern Expedition.[1] The remains are now in the midst of cultivated fields; many formerly conspicuous are invisible, having been reduced to the surrounding level. These mounds are of great interest as the site of the first archæological field work in this valley.

3.—Draines's Compound

Although the compound situated on Mr. Draines's farm is now almost wholly destroyed, its great mound rises as a white or ash-colored elevation in the midst of the cultivated fields, and is conspicuous for some distance, being easily seen from the railroad train. A ditch divides the mound into two parts.

There are many instructive pictographs (pl. XXXIX, figs. *a*, *b*, and *c*) not far from the Salt River.

IV.—Ruins on the San Pedro.

The San Pedro River, the largest tributary of the Gila on the south, is in fact the only one of size which rises in Mexico and flows approximately north with highlands on both sides. It is supposed that the trail taken by Coronado in 1540 on his trip to Cibola (Zuni) followed the San Pedro Valley, through which we know Father Kino passed in 1694. Although this was the only known route from Mexico to the unknown north in the 17th century, it was abandoned by the Spaniards in favor of the valley of the Santa Cruz in the following century.

A study of the ruins on the San Pedro leads one to believe that the ancient structures in this region had certain features of the Gila compounds. It is evident that they had stone walls built for protection, inclosing areas in which were erected the fragile walled domiciles of the people. Within this inclosure were also other buildings with massive walls corresponding to the houses in the compounds of Casa Grande.

The San Pedro Valley was inhabited in 1694 by the Sobypuri, agricultural Indians of Pima stock, and from the scanty records

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[1] Preliminary Notes on the Origin, Working Hypothesis and Primary Researches of the Hemenway Southwestern Archæological Expedition. Congrès International des Americanistes, 7th session, Berlin, 1888.

It will be seen by a comparison of the author's interpretation of the Casa Grande ruins with those given in this pioneer work that they differ in some particulars. The oval structures at Los Muertos called sun temples were not recognized at Casa Grande or the other ruins here considered. The author interprets the fragile walled buildings as the same as the thin-walled rooms described by Mr. Cushing.

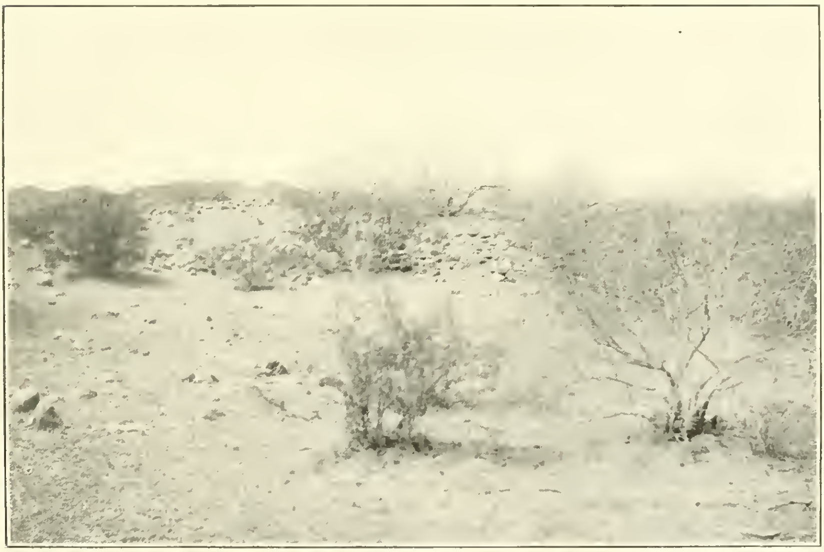
that have come down to us it appears that they lived in rancherias and cultivated farms, the whole valley being artificially irrigated. Their chief, named Coro, accompanied Kino down the river past these rancherias, the names of which he mentions. In 1694 the contest between Sobypuri and Apaches had begun, but the former still held possession of the valley. Later, however, the Sobypuri having been forced from their homes, the tribes along the San Pedro Valley became hostile to Europeans, and the valley ceased to be a line of communication between Mexico and the Gila. For over 150 years following this expedition the trail to the north from Mexico passed along the Santa Cruz River by way of Tucson and through the gap at Picacho into the deserts of the Gila.

An examination of the configuration of the San Pedro Valley from a point 15 miles south of Monmouth to the junction of the river with the Gila has led me to believe that Padre Kino, after following the San Pedro many miles, left it opposite where old Fort Grant now stands, and marched west until he came to the Gila, not far from the present site of Florence. The place where he turned away from the river was probably the rancheria called Victoria del Ojio, not far from the ruin at the mouth of the Arivaipa, which empties into the San Pedro, but in his diary he says that on the 16th of November, "after mass," he followed down the river 6 leagues until he came to the junction with the Gila. We cannot definitely say whether the rancherias mentioned by Kino stood on the same site as the ruins now found in the valley, but it is believed they did. He speaks of the houses as being made of "palos" or "petates," or a kind of jacal structure, which we have reason to suppose housed the common people at the Casa Grande ruins. Probably the buildings with stone walls found in the San Pedro were structurally the same as those the author has called massive walled rooms at Casa Grande and served for citadels, granaries, or ceremonial buildings[1] rather than habitations for the people.

The existence of ruins along the San Pedro has been known for several years, but their character and the kinship of their former inhabitants have been a matter of speculation. A more exact knowledge of these ruins being desirable, the writer included them in his comparative studies and made a brief visit to the lower course of the river in April, 1908, when he examined several of the more

[1] Kino speaks of one building as a "capilla," chapel, as if it were different from others, but whether it was a massive walled house or not does not appear evident from his brief mention.

1



2

RUIN OPPOSITE OLD FORT GRANT

important ruins in this part of this valley, entering it from the junction with the Gila.

Prehistoric mounds of considerable size were first encountered in the immediate neighborhood of Dudleyville, at the mouth of the San Pedro. One of the most striking evidences of the former presence of Indians at that point are the pictographs, possibly of Apache origin, in a cave not far from the road on the left bank of the river. Ruins are found at intervals as far up the river as the exploration was continued.

1.—Ruin Opposite Old Fort Grant

Old Fort Grant is situated a short distance north of the mouth of the Arivaipa Canyon, on the east side of the San Pedro. Directly opposite the fort to the south, on the low hills, there are remains of walls, rows of foundation walls, and piles of stones, indicating the site of a considerable settlement (pl. XLII, figs. 1, 2). Although here and there a rock formation of red color occurs in this neighborhood, neither the walls nor the soil are red, so that environment adds little to support the theory that here was situated the red house (Chachilticalli)[1] of Castaneda. The rectangular arrangement of rows of stones characteristic of compounds is indicated in this ruin. The east wall (fig. 72) of this rectangle measures not far from 250 feet. In the inclosure there is a large central mound composed of stones, the altitude of which is from 10 to 15 feet.

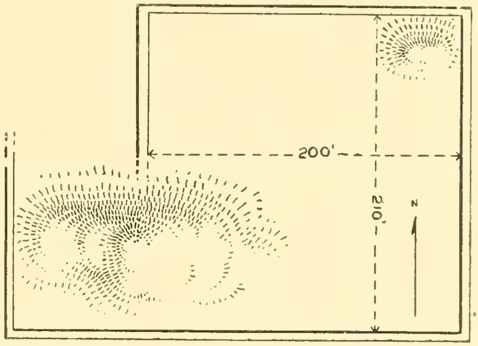


Fig. 72.—Ruin opposite Old Fort Grant

On a neighboring mesa, situated a few hundred feet south of that on which the compound lies, there are many piles of small stones suggesting a cemetery.

The author believes that the ruin near the mouth of the Arivaipa

[1] It has been suggested that the building called by Castaneda Chachilticalli, or Red House, was situated near Old Fort Grant, but neither the rock in place, earth, nor stones that compose the walls examined by the author in that neighborhood have a red color.

may have been the last rancheria on the San Pedro mentioned by Kino in 1694 and called by him Victoria del Ojio. The chief of this settlement was named Humari. It consisted of 70 houses, the walls of which were made of sticks and matting and contained 380 persons. One of these houses was capacious enough to hold all the soldiers in the expedition.

2.—Ruin Opposite Monmouth

Just across the San Pedro, opposite Monmouth, there is an interesting ruin, the stone walls of which are situated on an elevation overlooking the river.

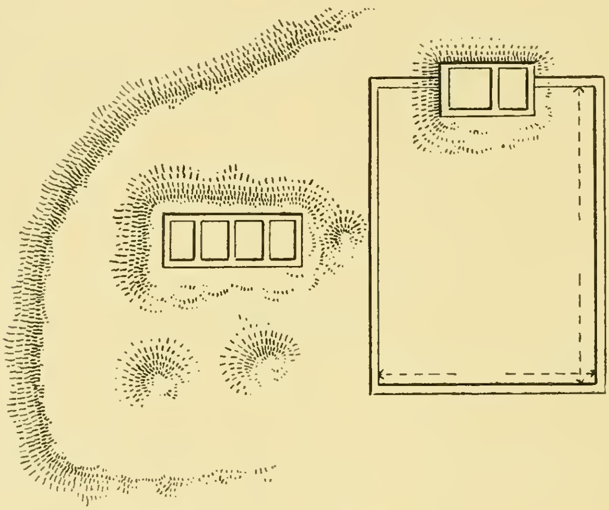


Fig. 73.—Ruin opposite Monmouth

This ruin consists of a central building, the subterranean rooms of which, excavated by Mr. Childs, have a surrounding wall (fig. 73) inclosing a rectangular area measuring about 275 feet on the north and 178 on the west sides. The wall of this inclosure cannot be followed throughout, as there is a continuation of the wall beyond the rectangle on the south side. On the east side there are several rooms, the form and dimensions of which were not traced with any accuracy. This settlement may have been Kino's Tutoida,[1] said to have been situated 18 miles south of the mouth of the Arivaipa.

[1] The rancheria at this point was composed of 20 houses and 100 souls, according to Kino's diary.

3.—Seven Mile Ruin

This ruin is situated 7 miles from Monmouth, on the left bank of the river. One takes the road on the east side of the river to Clark's ranch, then crosses it to the bluffs on the side. These bluffs have been very much eroded since the site was inhabited and many of the walls have been washed out, revealing many specimens of minor antiquities.

The surface of the ground is covered in places with fragments of pottery. There are no high mounds, but the rooms are indicated by the tops of their walls projecting out of the sand. These rooms seem to have been arranged in blocks.

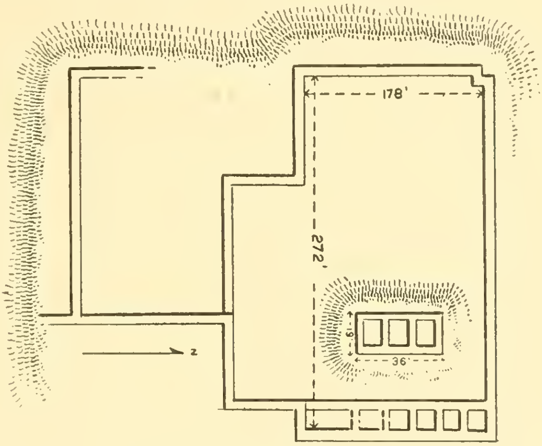


Fig. 74.—Fifteen-Mile Ruin

4.—Ruin Near Clark's Ranch

This ruin is remarkable in having indications of circular rooms that remind one of kivas or subterranean "pit dwellings." These resemble reservoirs or wells, their true nature being as yet unknown.

5.—Fifteen Mile Ruin

This ruin (fig. 74) is situated 15 miles up the river from Monmouth, on the opposite side of the road from a small ranch house. Not far from it there is a natural rock formation of red color that might be mistaken for a house perched on topof a much-eroded mesa. It is suggested that this building may have been at or near the site of Kino's rancheria Arivaipa, which was not more than 27 miles from the mouth of the Arivaipa Canyon.

Specimens from San Pedro Ruins

The only collection of small antiquities from the ruins along the San Pedro examined by the author are those owned by Mr. E. O. Childs, at Monmouth, who has kindly allowed the author to examine and publish an account of them. The prehistoric inhabitants of this valley cremated[1] their dead, a vessel with calcined human bones having been found by the author near one of the houses at the ruin 15 miles above Monmouth, where the majority of objects were obtained.

The most remarkable specimen in the collection (fig. 75, *a, b*) is the figure made of black stone resembling lava and representing a quadruped with curved horns like those of a mountain sheep. The most unusual feature of the specimen is a circular depression in the back, notched on the rim, as shown in the figure.[2]

Several clay effigy figures (fig. 75, *c, f, h*), among which are the two-figured, have been found in the San Pedro ruins. An arrow polisher and a circular stone disk recalls similar objects found in the ruins on the Gila. Perhaps the most exceptional piece of pottery consisted of a double neck of a vase, *d*, of which the bowl is missing. The pottery is a dark brown ware, smooth on the surface and decorated. The people of the San Pedro had flat shovels made of slate, not unlike those from Casa Grande, and made use of perforated stones, *g*, and ornaments, *e*, recalling those commonly excavated in the Salt River Valley ruins. The culture of the people, as shown by the small collections of known objects, did not greatly differ from that of the rest of the Gila, but environmental conditions did not lead to the erection of Casas Grandes like those near Phœnix and Tempe.

Conclusions

From the points where the Gila River and its two tributaries, the Salt and Santa Cruz, emerge from the mountains, their broad valleys become level or rolling and slightly elevated, forming low mesas. These valleys are practically deserts, on which the rainfall is not

[1] Two methods of disposal of the dead—one, house burial; the other, cremation—existed among the inhabitants of the Great Houses of the Gila-Salt region. This might mean that two distinct peoples occupied this valley or that the builders of the Casas Grandes were composite in stock. Possibly it might be interpreted as an indication that one of the components was akin to tribes near the mouth of the Gila, where cremation is still practised.

[2] There is a similar stone idol in the museum of the University of Arizona, at Tucson.

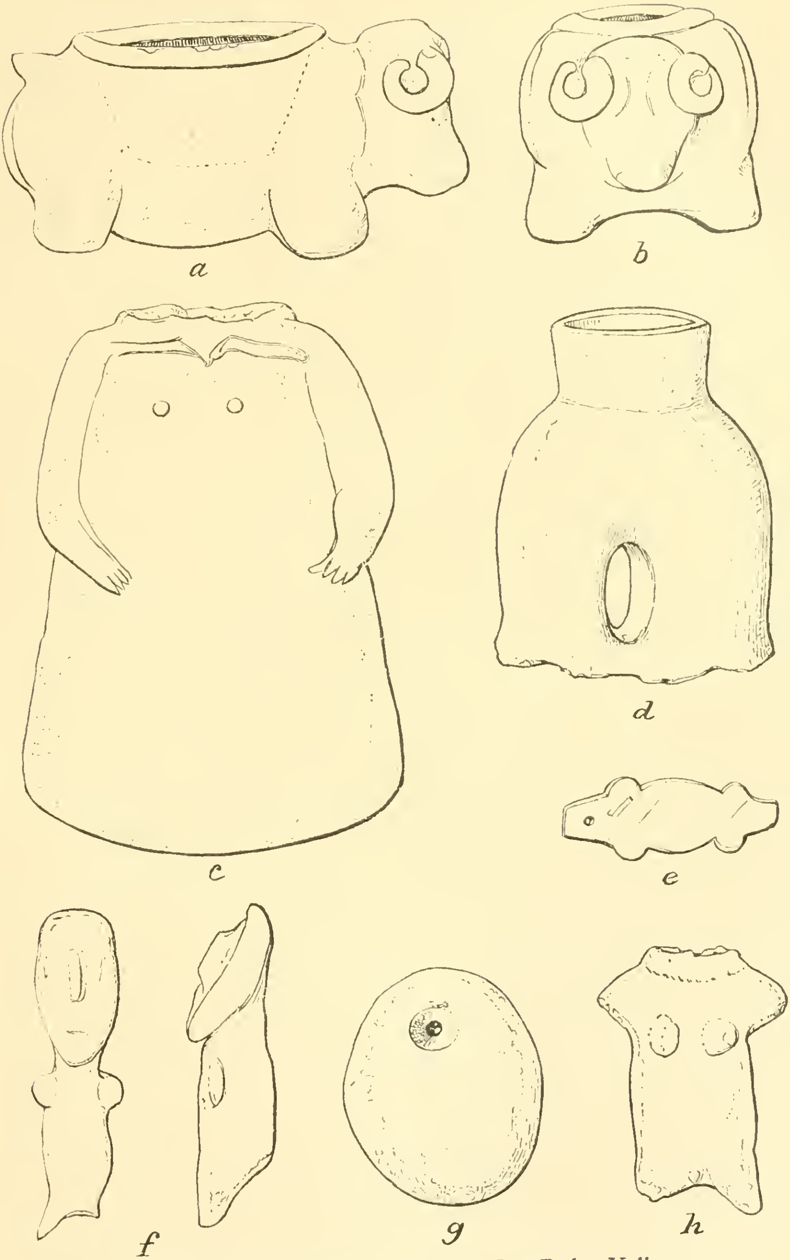


FIG. 75.—Prehistoric objects from San Pedro Valley

regular enough for successful agriculture without irrigation. They present a good field for the evolution of a sedentary, agricultural stage of human culture dependent on artificial irrigation. The extent of the aboriginal ditches that can be traced for miles show that the prehistoric inhabitants had discovered and applied a more extensive system of irrigation than any of their contemporaries who dwelt in other sections of what is now the United States. Here was developed a highly organized autochthonous stage of social life which we have good evidence to believe was of great antiquity.[1] The indications are that it was from this center that there radiated a form of culture which influenced the whole area now embraced in the territories of New Mexico and Arizona and the southern parts of Utah and Colorado.

In order successfully to bring an area of the size of the Gila and Salt River valleys under cultivation, the construction of large irrigation ditches was necessary, but these great canals could not be dug by individuals, and were possible only through cooperation of many workers. There must have been an intelligent leader to carry this work to completion. This cooperation of many under one head meant a high social organization. The natural result would be a sociological condition higher than any that existed among bands of hunters, fishermen, or even agriculturists depending on natural rainfalls.

A people accustomed to building irrigation canals naturally became accustomed to cooperation and combined to construct other public works, as houses for defense, for ceremony, or for storage purposes. Hence there occur with these extensive irrigation ditches great houses, and wherever the population was the densest, there are great buildings and canals, the most numerous and largest.[2] Such Casas Grandes as the Gila compounds are to be expected among people in this high social condition resulting from cooperation.

There seems no valid objection to the theory that these settlements were built by ancestors of the present house-building Indians of the Southwest. It can hardly be supposed that the builders of these Casas Grandes disappeared from their native land without descendants, even if they lost the habit of constructing massive houses and

[1] A somewhat similar culture arose independently in the valley of the Casas Grandes in Chihuahua, which in certain arts, as ceramics, reached a higher stage of development, perhaps being unmolested for a longer period.

[2] The existence of artificial reservoirs, or *vashki*, in the deserts, miles from any compound, implies an aboriginal population in their neighborhood living in huts, or jacales, the walls of which can no longer be traced.

compounds. The ancient mode of life and difference in their style of building from that of Pueblos and Pimas are adduced to support the theory that the latter are not descendants of the inhabitants of the Casas Grandes. It is held that when the ancients left their houses they migrated into other lands, where we should now look for their descendants. This supposed disappearance of the ancients was a favorite theory with some early writers, like Clavijero, who identified the ancients of the Gila Valley as Aztecs and regarded these buildings as marking one of the halting places of the Mexicans in their southern migrations. Some authors have gone so far as to regard the Gila Valley as a cradle of Aztec culture.[1]

Other writers have held that the descendants of the original peoples migrated into the northern mountains and later built the cliff houses and pueblos of northern Arizona and New Mexico. It is probable that certain clans were driven away from their homes and forced into other regions by the changed conditions as inroads of hostiles. This theory is in fact supported by legends still told by the Hopi and other pueblo people. It is logical to suppose that other clans of prehistoric builders remained in the valley and continued to live in houses similar to those their ancestors inhabited, even after they had lost the custom of building the massive walled structures that distinguish the ancient phase of their culture. The survivors of those who remained are the modern Pimas Kwahadts and Papagos, whose legends distinctly state that the ancients (*hohokam*) built Casa Grande.

The abandonment of the custom of building Casas Grandes dates back to prehistoric times, and none of the great buildings in the Gila were constructed subsequent to the arrival of the Spaniards. Casa Grande was a ruin when Kino discovered it, and the great buildings along the Salt River appeared to have been abandoned before Casa Grande was deserted, for old Pima legends state that the Great Houses of the Salt River were the oldest in the valley. The war between nomads and the house-builders of the Gila, who overthrew the Casas Grandes, had practically ceased before the advent of the Spaniards, although in 1694 the Sobypuri along the San Pedro were holding back the Apaches,[2] a hostile encroachment from the east.

[1] No doubt some of the people did migrate southward, but the acceptance of this conclusion does not mean that they later became Aztecs. There is little in common between objects found in the valley of Mexico and that of the Gila.

[2] There is nothing to show that these people overthrew the inhabitants of the Casas Grandes, and it is much more likely that the earliest foes of the people of the Great Houses came from the west, from the Gulf of California.

A few years later the Sobypuri were forced westward and the Pimas, who were probably the offspring of an earlier union of hostiles and the house-builders they conquered, retreated to Casa Blanca and Sacaton, leaving the Apaches to raid the whole of the eastern part of the Gila Valley, including the San Pedro.

The author would state in conclusion that he believes the abandonment of the Casas Grandes was brought about by an invasion of nomads from farther down the river, in prehistoric times. The aborigines who inhabited the valley of the Gila when the Spaniards first entered it were a mixed race, with blood of conquered and conqueror. These people—Pimas, Papagos, and others—practically inhabited fragile walled houses built in two forms—some rectangular, others circular—the former of which were practically the same as those of their ancestors who built the Casas Grandes. The circular dwellings may have been introduced by the alien prehistoric hostiles from the west. As the Great Houses on the Salt and Santa Cruz seem to have been destroyed before those on the Gila, the conclusion would be that the prehistoric enemies came from the west and south. The advent of the Apaches and their struggles with the mixed race that replaced the builders of the Casas Grandes is a subsequent practically historical event.

DESCRIPTION OF A NEW FROG FROM THE PHILIPPINE ISLANDS

By LEONHARD STEJNEGER

Curator, Division of Reptiles and Batrachians, U. S. National Museum

Having received through the courtesy of Mr. Thomas Barbour a topotype of Duméril and Bibron's *Rana macrodon* from Java, a suspicion entertained by me for several years has received confirmation, namely, that the species occurring in the Philippine Islands, and commonly recorded as *Rana macrodon*, in reality is a well-differentiated form. I therefore propose to separate it under a distinctive name.

RANA MAGNA, new species

Diagnosis.—First finger longer than second; a distinct dermal flap along outer edge of fifth toe and metatarsal; no outer metatarsal tubercle; tympanum one-half diameter of eye, or less, its distance from eye larger than or equaling its own diameter; vomerine teeth in two oblique series between and behind the choanæ, their distance from the choanæ nearly equaling the diameter of the latter; upper surface smooth, with numerous small pointed tubercles on sacrum and upper surface of tibia.

Habitat.—Philippine Islands.

Type-specimen.—Cat. No. 35231, U. S. N. M.; Mount Apo, Mindanao, between Todaya and camp, 4,000 to 6,000 feet altitude; Dr. E. A. Mearns, collector.

Description of type-specimen.—Vomerine teeth in two oblique series between and behind the choanæ, their distance from the choanæ nearly equaling the diameter of the latter; two bony "teeth," 6 mm. long, near the anterior end of lower jaw fitting into deep holes in the upper; head large, broad, its width at tympanum greater than distance from tip of snout to posterior rim of tympanum; snout short, rounded; canthus rostralis well-defined, angular; nostril just below canthus; distance between nostrils but slightly less than their distance from eye, greater than their distance from lip and greater than width of upper eyelid; interorbital space somewhat wider than upper eyelid; lores concave; tympanum very distinct, its diameter slightly less than one-half the diameter of the eye, and distant from the latter by nearly twice its own diameter; first finger longer than second; toes fully webbed; fifth metatarsal and toe externally margined with a dermal flap 2 mm. wide; digits terminated by well-developed knobs; subarticular tubercles well developed; inner metatarsal tubercle long and narrow, rather weak; no outer metatarsal tubercle; a distinct tarsal fold; heel of extended hind leg reaches between eye and nostril; heels not overlapping; skin loose, smooth, with numerous minute, pointed tubercles on sacrum and on the upper aspect of tibia, particularly towards the heel; a few blunt tubercles on the posterior part of upper eyelid; on the sides indications of blunt tubercles; a strong cutaneous fold from posterior corner of eye to above and behind tympanum; a distinct fold across the posterior part of the interorbital space. Color (in alcohol) above very dark chocolate brown, with faint indications of darker blotches which form obscure cross-bars on the hind legs; hind aspect of femur blackish with whitish marblings; underside pale, with dense brownish vermiculations on the legs and coarser and paler ones on abdomen, becoming very faint and indistinct on chest and throat; underside of hind feet and tarsus dark chocolate brown, with pale subarticular tubercles, tarsal fold and terminal digital knobs; a blackish band from nostril to eye and blackish blotches on upper and lower lips.

Dimensions.

	mm.
Total length from snout to vent	113.
Snout to eye	21.
Snout to posterior border of tympanum	44.
Nostril to eye	7.
Distance between nostrils	10.5
Interorbital width	10.5
Width of upper eyelid	8.5
Diameter of eye	12.
Diameter of tympanum	5.5
Width of head at tympanum	45.
Fore leg	56.
Tibia	56.

Remarks.—A large series of old, adolescent, and young specimens from Mindanao, Basilan, Mindoro, and Luzon bear out the characters assigned to this new form. The younger specimens have a narrower head, longer and more pointed snout, and narrower interorbital space. It is therefore necessary, when comparing them with related species, always to select specimens of exactly the corresponding age. It is well to remember that the same size does not necessarily indicate the same age.

Rana magna is most nearly related to *Rana macrodon,* which was originally described from Java, and has since been found in many of the other Malayan islands as well as on the mainland. It is a smaller species, however, and if we compare Philippine adult specimens with specimens of the same size from Java and Sumatra, the difference is indeed striking, because the latter, being so much younger, have a correspondingly longer snout and narrower interorbital space; but the differences are less striking if we compare the very largest western specimens with the oldest Philippine specimens—for instance, the type—though they are numerous enough and obvious enough to demonstrate the distinctness of the latter. The most important difference and the one which can be traced through all stages is that in the size and location of the vomerine teeth series. In *R. macrodon* these originate close to the inner anterior border of the choanæ and extend very obliquely backwards, while in *R. magna* they are separated from the choanæ by a space almost as wide as the latter; their position is less oblique, sometimes almost transverse, and the series are also appreciably shorter. In addition, the tympanum is considerably smaller, apparently never exceeding one-half the diameter of the eye. The nostrils are also located more apart than in *R. macrodon,* besides many minor and less easily appreciated differences.

A NEW GENUS OF FOSSIL CETACEANS FROM SANTA CRUZ TERRITORY, PATAGONIA; AND DESCRIPTION OF A MANDIBLE AND VERTEBRÆ OF PROSQUALODON

By FREDERICK W. TRUE

Head Curator of Biology, U. S. National Museum

With Three Plates

Some months ago Prof. W. B. Scott, of Princeton University, placed in my hands for study two specimens of fossil cetaceans from Patagonia, one of which proves to belong to an undescribed genus; the other represents the genus *Prosqualodon,* and affords new information regarding the mandible, teeth, and vertebræ.

The first of these specimens (No. 15459) comprises two large and two small fragments of a skull of a fossil toothed whale, collected by the late J. B. Hatcher, April 24, 1899, in the Patagonian Beds at Darwin Station, Santa Cruz Territory, Patagonia. Upon examination it proves to be an undescribed form, allied to *Inia,* but much larger. In order to bring it to the attention of cetologists I propose to describe it under the name of

PROINIA PATAGONICA, new genus and species

The specimen consists only of the cranium, from which the rostrum has been broken off immediately in front of the blowholes. It has been strongly compressed vertically, so that the basioccipital and supraoccipital are nearly in the same plane. The blowholes have also been forced backward and upward. All the under parts of the skull anterior to the basioccipital, together with the earbones, jugals, and the right zygomatic process are lacking. The remaining parts are in a good state of preservation, but the surface and contours have been considerably modified by excessive chiseling.

The skull resembles *Inia* more closely than it does any other recent or fossil form with which I am acquainted, but is much larger. The most salient points of resemblance are the strongly elevated vertex, consisting of the large, rectangular anterior median processes of the frontal; the relatively narrow orbital plates of the frontal; the anterior position of the orbit; the quite large temporal fossæ, bounded above by strong ridges, and internally by the convex surfaces of the parietals and squamosals.

The similarity to *Inia* in the foregoing characters is close enough to make it quite certain that the form is really allied to that genus, but the skull presents differences of sufficient importance, in my opinion, to justify its separation under a distinct generic name. These differences are as follows: The free margins of the orbital plates of the frontal, instead of being nearly parallel, as in *Inia,* diverge strongly anteriorly. The greater part of the surface of the plates is, furthermore, nearly horizontal, but is strongly curved downward anteriorly, and the external free margin is not bent upward. The temporal fossæ appear not to have extended to or beyond the line of the occipital condyles, as they do in *Inia,* and the region of the exoccipitals is broad and flat, rather than narrow and concave, as in *Inia.* The zygomatic process is oval and convex externally, as in many of the Delphinidæ, rather than rectangular and concave externally, as in *Inia.*

The most anterior portion of the skull which has been preserved consists of the orbital plates of the frontal. These are smooth superiorly, and might be considered to consist of the maxillary and frontal plates consolidated, but the smoothness is, I think, due in part to excessive chiseling, and the structure, as shown in section at the broken edges, seems to support this view. The greater part of the surface is flat, but posteriorly it becomes concave, and anteriorly convex and curved downward. The plates diverge strongly, and the right one is broken off a little in front of the postorbital process. This process is short and rather blunt, and is directed downward. Its form is, therefore, quite unlike that of *Inia.* The orbit, which is situated well forward, appears to have been relatively quite large. The free margin of the orbit is thin.

The median processes of the frontal at the vertex are very large and strongly elevated, and are squared and smooth superiorly. They resemble the nasals of the Right whales. The external surfaces are vertical. The nasals and premaxillæ are lacking.

The shape of the maxillary plates can not be determined, but was probably the same as in *Inia,* the postero-internal angle being bent up so as to rest against the vertical sides of the median frontal processes.

The position of the blowholes has been altered by vertical compression, so that they stand above the level of the orbital plates of the frontal. They are small, relatively, and are separated from each other by a wide interval, which appears to indicate that the superior portion of the septum has been broken off. Anteriorly, the end of the large elliptical mass of the mesethmoid is seen.

On the under surface of the frontal plates the most conspicuous feature is the optic canal, which is deep proximally, and runs at an angle of 45° with the longitudinal axis of the skull. It dies away distally, before reaching the free margin of the orbit.

The larger fragment of the skull consists of the occipital, squamosal, and parietal bones. The basioccipital[1] is somewhat fractured, and the inferior surface has been abraded and more or less altered by chiseling. It is broad and nearly flat medially, and appears not to have had the transverse ridge which is so noticeable in *Inia*. The lateral free margins are thick.

Nearly all of the median portion of the supraoccipital is lacking, but the general surface appears to have been nearly plane, with the lateral margins nearly parallel and the anterior margin forming an obtuse angle. The occipital crest is low and broad, with sloping sides, rather than thin and erect, as in *Inia*. It appears not to have been greatly thickened anteriorly, as it is in *Inia*. Posteriorly it dies away altogether, so that there is no barrier between the squamosal and occipital. This conformation is due to the small extension of the temporal fossæ posteriorly, as compared with *Inia* and many of the Delphinidæ. The exoccipitals are oblong, broad, nearly flat, and but little inclined backward. They resemble the same parts in *Balænoptera* and other whalebone whales, rather than in *Inia*. The occipital condyles are rather narrow, and do not project much from the surface of the occipital bone.

The squamous portion of the temporal is oblong and slightly concave below, and is separated from the zygomatic process by a very shallow groove. The latter process is short and convex externally, and appears to have been moderately acute anteriorly, but the apex is broken off on the left side, while on the right the whole process is lacking. The free margin of the zygomatic process is thin, and the postgenoid is well developed, thin, and directed downward. The interval between it and the exoccipital is small relatively. The temporal fossa gets its great breadth chiefly from the breadth and inclined position of the parietal bone, and very little from the lateral extension of the zygomatic process, the root of which is very short.

The glenoid surface is broad and only moderately concave, and is rendered uneven by several low, rounded, transverse ridges. The inferior mastoid surface is broad and concave. The periotic region, unlike that of *Inia,* is quite smooth, but the position of the various vacuities and foramina cannot be determined.

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[1] I am not sure that a portion of the basisphenoid is not attached to this.

Dimensions of the type-skull of Proinia patagonica

	mm.
Breadth between the orbits (est.)	292
Length from posterior margin of the frontal in the median line to anterior end of the mesethmoid	121
Length of the nasal process of the frontal	52
Breadth of the two nasal processes	86
Greatest breadth of the orbital process of the frontal	57
Least breadth between the blowholes	36
Greatest breadth across zygomatic processes (est.)	350
Length from surface of occipital condyles to anterior end of basi-occipital	91
Breadth across occipital condyles	112
Least distance between condyles	9
Greatest breadth of right condyle	35
Height of the same	67
Greatest breadth of basioccipital	159
Distance from occipital condyle to post-glenoid process of zygomatic	122
Breadth between exoccipitals (est.)	250
Length of zygomatic process (apex lacking)	80
Breadth of glenoid surface	37
Breadth of temporal fossa	90
Length of temporal fossa (est.)	218
Distance from superior margin of occipital condyles to vertex	140
Least distance between temporal fossæ (est.)	113

Cervical Vertebra

This skull is accompanied by a cervical vertebra (fig. 76), collected at San Julian by Mr. Hatcher two days before the former. There seems little room for doubt that this vertebra belongs to the same species as the skull. The neural canal has almost the same width as that of the foramen magnum.

The vertebra resembles the third cervical of *Inia* in general appearance, but differs from it in size and thickness, and in various details. The centrum is somewhat more than one-half as long as broad; the neural canal is as broad as the centrum and is about one-half as high as it is broad, while in *Inia* it is much higher than broad and much less broad than the centrum. The neural spine is somewhat broken, but was evidently very small when complete. On account of the length of the centrum and of the top of the neural arch, the anterior and posterior zygapophyses are widely separated, instead of overlapping, as they do in *Inia*. The zygapophyses themselves are oval, or nearly circular, and quite flat. The anterior pair are directed upward and inward, and the posterior downward and outward. The transverse process is very broad, and is pierced by the vertebrarterial foramen, which is elliptical and very large, and was complete originally. The base of the portion of the process below the foramen is thick and nearly horizontal, while the terminal portion is expanded and rather thin, and is nearly vertical, but a little inclined forward below. The portion above the foramen is slender and nearly cylindrical. The process as a whole resembles that of *Inia,* but in that genus the vertebrarterial foramen is incomplete.

The centrum of the vertebra of *Proinia* has a median ridge superiorly and inferiorly, while the sides opposite the vertebraterial foramina are deeply concave. The anterior epiphysis is slightly convex and the posterior one a little concave. Both are anchylosed to the centrum and are thin.

FIG. 76.—Third cervical vertebra of *Proinia patagonica,* new species. Anterior surface. One-half nat. size.

The dimensions of the vertebra are as follows: Length of centrum, 31 mm.; breadth of centrum, 51; depth of centrum, 46; greatest breadth of vertebra across transverse processes, 108 (?); greatest height from inferior margin of centrum to tip of neural spine, 85; height of neural canal, 30; breadth of the same, 51; length of neural arch in the median line above, 18; distance between tips of anterior and posterior zygapophyses on either side, 50; length of anterior zygapophysis, 15; breadth of the same, 14; length of posterior zygapophysis, 19; breadth of the same, 15; height of vertebrarterial foramen, 24; breadth of the same, 17.

Without more complete material, it appears to me unwise to attempt many generalizations as to the origin and relationships of the form here described. It is much larger than *Inia,* and that it is quite distinct will, I think, be conceded; as also that it is rather closely related to the latter genus, warranting its assignment to the family Iniidæ. I am unable to see that it throws any considerable light on the origin of this family, although it is in some respects less specialized than *Inia.* As compared with the latter, generalized characters are observable in the thin walls, large size, and only moderately anterior position of the orbit; the larger extension of the frontals at the vertex; short postorbital process; moderately large temporal fossæ, and perhaps the flat basioccipital and the meniscoid zygomatic processes; also in the length of the cervical vertebræ.

If Professor Abel's views[1] regarding the origin of the Iniidæ be correct, *Proinia* should show a much closer approximation to *Squalodon* than does *Inia*. I do not see that such is the case. The only characters which might be construed as showing a leaning toward *Squalodon* are, perhaps, the shape of the zygomatic processes and of the median processes of the frontals, and the rather flat basioccipital region. *Squalodon* is in many respects a specialized form, and, in my opinion, hardly to be considered as belonging on the main stem of development. Of known forms, I should prefer to take the point of departure from *Agorophius*, but *Proinia* appears to show no closer resemblance to that genus than it does to *Squalodon*.

It has to be considered also, as is indicated below, that *Proinia* occurs with *Prosqualodon*, a near relative of *Squalodon*, in the Patagonian beds. It can hardly be supposed that *Proinia* has been derived from this form, which appears to be contemporary. The squalodont type and the inioid type appear to have been thoroughly differentiated and well established in the early Miocene, and we must look back further for the progenitors of the latter, as we certainly must for those of the former.

Other Accompanying Vertebræ

A series of five thoracic vertebræ and a caudal vertebra, No. 15439, collected at Darwin Station by Mr. Hatcher, April 22, 1899, might from a superficial examination be considered as possibly belonging with the skull and cervical vertebra of *Proinia*. It is my opinion, however, that they are rather too small, and they do not exhibit any tangible inioid characters. Most of the epiphyses are detached, showing that the individual was comparatively young; two of them, which are very thin, have been preserved separately. The anterior metapophyses are much elevated above the centra, horizontal, flattened, and continued backward on the sides of the neural arch as a sharp ridge. The neural spines were broad antero-posteriorly, and, except in the caudal, appear to have been strongly inclined backward. The transverse processes are preserved on one or both sides of two of the thoracics. In one case they are flat, broad antero-posteriorly, linear, and not expanded at the extremity. In another thoracic they appear to have been somewhat expanded at the extremity, at least anteriorly.

All the vertebræ have sharp, thin median inferior carinæ on the centra. The latter are shorter than broad, and somewhat pentagonal

[1] Mém. Mus. Roy. Hist. Nat. Belgique, 3, 1905, pp. 41 and 123.

in outline anteriorly and posteriorly, but the upper margin is more or less rounded. The two sides of the centra below the transverse processes are quite concave, but without distinct channels.

The foregoing combination of characters appears to me to indicate a relation to some of the North American forms which have been assigned to the nominal genus *Priscodelphinus,* such as *P. hawkinsi, harlani,* etc.

The dimensions of the vertebræ are as follows:

Dimensions of five thoracic vertebræ, No. 15439

	1.	2.	3.	4.	5.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
Length of centrum	39	40	40	40	45
Height of anterior face of centrum	45	45	47	......	49
Breadth of anterior face of centrum	52	52	54	54	55
Height of posterior face of centrum	42.5	46	......	45	47
Breadth of posterior face of centrum	50.5	52	54	54	57
Height to anterior extremity of metapophysis	71	74	......	73	74(?)
Projection of metapophyses anteriorly beyond margin of neural arch	13+	23	......	21	......
Breadth of neural arch at base, antero-posteriorly	29	29	30	31	27
Breadth of neural canal anteriorly	26.5	22	20	......	16
Breadth of neural canal posteriorly	26	24	20	23.5	18
Antero-posterior breadth of neural spine in a horizontal line immediately above zygapophyses	48	47	......	......	34
Breadth of transverse process at base	34	33	35	32	35
Breadth of transverse process at extremity	28(?)	26	......	......	......

PROSQUALODON AUSTRALIS Lydekker

Prosqualodon australis Lydekker, Anal. Mus. de la Plata, Pal. Argentina, vol. 2, art. 2, p. 8, pl. 4, Apr., 1894; Proc. Zool. Soc. London, 1899, p. 919, figs. 1, 2.

The material turned over to me for study by Professor Scott includes portions of the skeleton of this species, comprising (1) a portion of the right half of a mandible with two teeth in position; (2) a portion of a left ramus; (3) eight separate teeth; (4) a nearly perfect atlas and two thoracic vertebræ; (5) two pieces of ribs; (6) a tympanic bone; (7) a periotic bone. These were collected from the Patagonian beds at San Julian, April 22, 1899, by J. B. Hatcher.

A detailed comparison of these remains with Doctor Lydekker's figures and description leaves no doubt in my mind that they represent *Prosqualodon australis.* The right ramus of the mandible is nearly complete posteriorly, the coronoid process being perfect and the condyle nearly so, while only a small portion of the angle is lacking. The jaw contains five alveoli, in two of which—the penultimate one and the next but one anterior to it—the teeth are still in position. The fragment of the left ramus is very imperfect, only a small portion of the inferior border being complete and no alveoli present. Of the separate teeth, one appears to be a right lower molar, and probably belongs between the two which are in place in the mandible; three others are single-rooted teeth from the anterior end of the mandible on the right side, and the remaining four appear to belong to the upper jaw. Of the latter, two are single-rooted, one has indications of three roots, and is probably a premolar, and the last is a short tooth with two fused roots—possibly a last molar.

Mandible

The dimensions of the jaw, compared with those of the same part in the type specimen, as indicated by Doctor Lydekker's figures, are as follows:

Dimensions of two mandibles of Prosqualodon australis

	15441. San Julian, Patagonia.	Type of *P. australis*.
	mm.	*mm.*
Total length of the fragment containing 5 posterior alveoli	445	420 (?)
Distance from condyle to posterior alveolus	290	297
Height of jaw at coronoid process	217[1]	....
Distance from highest part of coronoid process to inferior margin of condyle	204	225 (?)
Depth of jaw at posterior alveolus	95	78[2]
Length of last four alveoli taken together	124	120
Length of penultimate tooth at alveolus	30	30
Breadth of penultimate tooth at alveolus	18	....
Least distance externally between crown and alveolus of penultimate tooth	17	9
Length of crown at base	21	21
Thickness of crown at base	14	....

[1] Angle defective. [2] Border defective below (?).

The correspondence in size and proportions between the two specimens is evidently very close, the chief difference, apparently, being that the teeth protrude more from the alveoli in the San Julian jaw.

In the latter specimen the apex of the coronoid process is obtuse and is directed backward. The superior margin of the jaw near the apex of this process is 15 mm. broad and is inclined outward. Anteriorly it becomes more everted, narrower, and more rounded, but broadens out again as it approaches the posterior alveolus, and is nearly horizontal. The internal surface below the apex of the coronoid process is concave.

The condyle is oval, small, and projects outward strongly. Originally it was about 50 mm. deep and 35 mm. broad. The orifice of the inferior dental canal is situated about 180 mm. anterior to the condyle and appears to have been relatively small. Opposite the penultimate tooth the jaw is 33 mm. broad.

The alveoli are shallow, the penultimate one being about 19 mm. deep. The septa between the molars are not more than one or two millimeters thick, but appear to have reached the level of the superior margin of the jaw when complete. The teeth themselves were very close to each other, if not actually in contact.

Teeth

All the teeth are closed at the roots, and, with one exception, have a large part of the crown worn away, indicating (as do the vertebræ) that the individual was adult or old. The dimensions of the several teeth preserved are given below. The separate teeth are referred to by the numbers of the figures on plate XLIV.

Dimensions of teeth of Prosqualodon australis

	Lower molariform teeth.					Lower single-rooted teeth.			Upper molariform teeth.		Upper single-rooted teeth.	
	Posterior alveolus.	Penultimate tooth.	Ante-penultimate alveolus.	Fourth tooth.	Fifth alveolus.	Fig. 5.	Fig. 6.	Fig. 7.	Fig. 3.	Fig. 4.	Fig. 1.	Fig. 2.
Total length	....	58[2]	....	....	....	62[2]	81[2]	74[2]	72[3]	43	82[4]	97[2]
Length of root	....	43	....	....	....	51	74	63	51	29	82	85
Greatest antero-posterior diameter of root	30[1]	28	30[1]	29	25[1]	18	20	22	26	27	17	17
Greatest transverse diameter of root	11[1]	18	19[1]	15	10[1]	15	18	18	20	15	16	17
Antero-posterior diameter of crown at base	....	22	....	25	....	....	15	18	22	16	..	....
Transverse diameter of crown at base	....	15	....	14	....	13	15	15	13	12	....	....

[1] Alveolus.
[2] Crown worn.
[3] Three-rooted, crown somewhat worn.
[4] Crown lacking.

The two lower molars which are in position, and the separate one, are all very similar in form and size. The crowns are worn on top, and also posteriorly, except the penultimate molar, which is much abraded anteriorly. All three teeth present a form similar to that of the tooth figured by Doctor Lydekker in 1899, but the two branches of the root are not so widely divergent. They are nearly parallel and curve backward inferiorly. In the separate molar (pl. XLIV, fig. 8) the anterior branch of the root is bent upward like a fish-hook at the lower end and the tip lies on the outer side of the posterior branch. The two branches are united nearly to the tip by a portion which is thinner than themselves. On the outer side, between the two branches, is a low, rounded eminence, like a rudimentary third root.

The molars present a distinct neck, above which is an equally distinct cingulum, having the appearance of an appressed band, with the upper free margin developed in the form of small denticles. The cingulum is most prominent and highest internally and posteriorly. The crown is deeply wrinkled, the ridges being numerous, vertical, and covered with rounded tubercles. The inferior molars which are in position have one or two prominent denticles each on the posterior edge of the crown, near its base, and others were probably present higher up. The separate molar has a similar denticle on the anterior edge.

The three single-rooted teeth, which appear to me to belong to the lower jaw, resemble one another in form, the roots being fusiform and more or less curved backward. The crowns of two of them (pl. XLIV, figs. 6 and 7) are worn away obliquely, but that of the third (pl. XLIV, fig. 5) has the upper surface horizontal. In all three teeth the crowns are rugose, but rather less so than in the molars. In one (pl. XLIV, fig. 7) the root shows a deep longitudinal groove internally, indicating an incipient division into two branches. The crowns are lowest posteriorly.

Of the upper single-rooted teeth, one (pl. XLIV, fig. 1) consists only of the root, which is conical and nearly straight. The second (pl. XLIV, fig. 2) is strongly curved and resembles the lower single-rooted teeth. The crown is entirely worn away anteriorly.

Of the two upper molariform teeth in this series, the larger (pl. XLIV, fig. 3), probably a right premolar, resembles the lower molars in general form. The two branches of the root are nearly parallel and but slightly curved. The lower closed ends overlap each other. On the inner side, between the two branches of the root, is a third branch, directed inward nearly at right angles with the two others, and extending about 7 mm. beyond their inner surface. This third branch is shorter than the two principal ones. The crown is compressed and conical, but worn away at the apex, and also anteriorly. It is rugose, like the lower molars, and presents bases of two large denticles on the posterior edge.

The smaller upper molariform tooth (pl. XLIV, fig. 4) is different from any of the others in form. It is probably the last left upper molar, or possibly a premolar. The root is triangular, broadest at the base, very uneven, somewhat curved inward, convex externally, and marked internally by a narrow longitudinal groove, representing an incipient division into two branches. The neck is strongly marked and very smooth. The crown, which is nearly complete, is thick, conical, and very rugose. Beside the ordinary rugosities, there are on the posterior edge the remains of five denticles, arranged in two rows, and marking the boundaries of an elliptical area, which terminated near the apex of the crown. This peculiarity is of much interest, as a similar arrangement of denticles is found in various genera belonging to families allied to the Squalodontidæ. On the anterior edge of the tooth are the bases of two similar denticles in a single row.

Tympanic Bulla

The right tympanic bulla and periotic bone, which accompany the jaw, appear at first sight too small to have belonged to the same individual as the latter, but on comparing them with Lortet's figure of *Squalodon bariensis,* a species of about the same size as *Prosqualodon australis,* I find that the bulla of the Patagonian specimen is quite as large, or even larger. It bears a superficial resemblance in form to that of *Schizodelphis,* but this is chiefly because the anterior portion is broken off, leaving a sharp point. Originally the bulla was probably nearly as broad anteriorly as posteriorly, and presented, therefore, much the same shape as that of *Squalodon.*

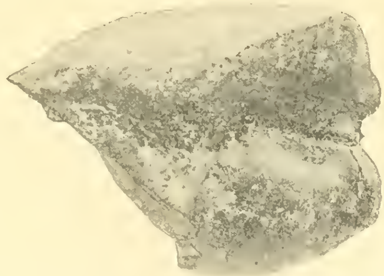


Fig. 77.—Tympanic bone of *Prosqualodon australis* Lydekk. Inferior surface. Nat. size.

The bulla (fig. 77) is everywhere quite rugose. Viewed from the inner side, the inferior outline is nearly straight, and the posterior outline almost at right angles with it. The outer lip is very high posteriorly. The inner lip is also high, and is peculiar in that it is divided longitudinally below the middle by a distinct groove, resembling the median inferior groove. Viewed from above, the great breadth of the bulla, its rectangular outline, and the breadth of the Eustachian canal are especially noticeable. The upper border of the inner lip is only slightly emarginate. A principal feature of the under surface of the bulla is the great breadth of the groove between the two lips, or lobes. It is quite deep as well as broad, and extends to the anterior end of the bulla (as far as preserved), dividing it into two nearly equal portions. The two lobes are nearly equal in size and downward extension, differing greatly in the latter respect from such forms as *Mesoplodon, Berardius,* etc. The posterior end of the outer lobe, or lip, is well rounded, but that of the inner lobe is strongly compressed, presenting a prominent thin ridge, directed obliquely upward and outward. The interior of the bulla, as in *Schizodelphis,* presents two pits separated by a rounded, transverse ridge. The posterior pit, or concavity, is much the deeper.

The dimensions of the bulla are as follows: Greatest length (as preserved), 50 mm.; greatest breadth, 36; greatest height, 30; transverse breadth of the involuted portion of the inner lip, 20.

Periotic Bone

The right periotic bone (fig. 78), which is the one preserved, is small and of a peculiar form, unlike that of any living toothed whale with which I am acquainted, but somewhat resembling that of *Berardius* and other ziphioid genera. The bone is a little abraded, but not so much as to materially alter its original form. Viewed from within, the anterior petrous body is separated from the remainder of the bone by a deep emargination below, and is oval in outline, and moderately bent downward. The convex portion of the periotic containing the cochlea is small, and the internal *porus acusticus* oval and oblique. The superior outline of the main mass of the bone when viewed from the inner side is nearly straight, but that of the anterior petrous body is inclined downward at an angle of 45°. The process for the articulation of the tympanic, which is seen on the under side of the bone, is small, and its inner margin overhangs the short, curved canal for the facial nerve.

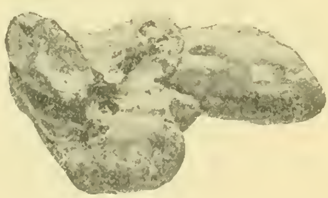


Fig. 78.—Periotic bone of *Prosqualodon australis* Lydekk. Inferior surface. Nat. size.

The dimensions of the periotic are as follows: Greatest length, 42 mm.; greatest breadth at posterior end, 27; length of anterior petrous portion, 18; depth of the same, 11.

Vertebræ

As already stated, an atlas and two thoracic vertebræ accompany the mandible, and, from their size, complete ossification, and color, appear to have belonged to the same individual. (Pl. XLV.)

The atlas resembles that of *Eurhinodelphis*. The articular facets for the occipital condyles are large, broad, deep, and but little inclined outward. They are separated below by a space of about 17 mm. The foramen above these facets on either side is complete, and of large diameter, and is situated nearly in the middle of the length (antero-posteriorly) of the neural arch. The arch is comparatively narrow, thin anteriorly, but with a broad, concave surface posteriorly in the median line above. The spine is rudimentary. The posterior articular facets are large, nearly circular, flat, and project strongly from the body of the vertebra. Below in the median line there is a broad, shallow concavity, indicating that the odontoid process of the axis was large and prominent. There is also a large median rugosity on the postero-inferior surface of the vertebra, which represents the remains of a strong process which extended below the body of the axis. On either side of the vertebra are two short, thick transverse processes superimposed, as in *Eurhinodelphis*.

The two thoracic vertebræ are from near the posterior end of the series, and probably belong near one another. The body of the more nearly complete one, seen from the front, is broadly cordate in outline. The inferior outline, seen from the side, is deeply concave. The epiphyses appear to be thin. The transverse processes are short, thick, directed outward, and somewhat expanded at the extremity. Their upper surface is nearly in line with that of the body of the vertebra. The metapophyses are prominent, rather thin, and rectangular. The anterior zygapophyses are large and only slightly concave, and are placed obliquely. The posterior zygapophyses are oval in form, and directed obliquely downward and outward. The neural spine is somewhat incomplete, but was originally inclined backward more or less. It is broad antero-posteriorly, with a thin anterior edge, and quite thick posterior edge.

The second thoracic vertebra (pl. XLV, figs. 5 and 6) is quite imperfect, lacking the whole of the neural arch and spine and one of the transverse processes. The remaining process is similar in form to those of the vertebra just described, but longer, both transversely and antero-posteriorly, with a long and deeply concave articular facet at the extremity. There is no facet on the body of the vertebra for the articulation of the head of a rib. The body itself resembles that of the vertebra previously described in form and size, but the epiphyses are elliptical, rather than cordate.

The dimensions of the vertebræ are as follows:

Dimensions of three vertebræ of Prosqualodon australis.

	Atlas.	Thoracic vertebra *a*.	Thoracic vertebra *b*.
	mm.	*mm.*	*mm.*
Greatest length of centrum	67	75	77
Greatest depth of centrum	....	68	69
Greatest breadth of centrum	129[1]	90	87
Breadth, including transverse processes	155	155	184(?).
Length of transverse process	20[2]	29	39
Least breadth of transverse process antero-posteriorly	18	36	52
Greatest diameter of transverse process at extremity	17	45	51
Breadth of neural canal	51	42	31
Height of neural canal anteriorly	67	36	....
Breadth of neural spine antero-posteriorly at base	....	57	....

[1] Across posterior articular facets. The breadth across the anterior facets is the same.
[2] The superior one, from anterior base.

The jaw and teeth above described confirm many of Doctor Lydekker's statements regarding *Prosqualodon australis,* and especially its size, the small number of teeth as compared with *Squalodon,* and the peculiar form of these organs. The size of the skull figured by Doctor Lydekker in 1899[1] is not given, but assuming that it was about as large as the type skull, it seems likely that the number of two-rooted molariform teeth did not exceed ten in the lower jaw. The Patagonian material here described affords us the information that the anterior teeth were single-rooted, as might, of course, have been expected.

The vertebræ are especially interesting on account of their resemblance to those of *Eurhinodelphis,* a genus which Professor Abel derives from the Squalodontidæ. It is to be observed, however, that the atlas of *Squalodon* figured by Van Beneden[2] is quite different in form from that of *Prosqualodon.* The former is much more

[1] Proc. Zool. Soc. London, 1899, p. 919, figs. 1, 2.
[2] Recherches sur les Squalodons, 1865, pp. 45, 46, pl. 3, fig. 2.

like that of *Physeter,* or of a whalebone whale, especially as regards the transverse processes, of which there is but a single broad and thick one situated very high up on either side. According to Van Beneden, it was found in the shell-marl of Salles, while the type-beak of *Squalodon,* with which it was associated, was found at Liognan. Johann Müller also mentioned this atlas in 1849, remarking that Grateloup had written to him that it probably belonged to *Squalodon.*[1] If this association be correct, which seems somewhat doubtful, the atlas and (by inference) the axis of *Squalodon* are very different from those of *Prosqualodon.* Additional information regarding the vertebræ of the different species of *Squalodon* is very much to be desired.

[1] Die Zeuglodonten von Nord Amerika, 1849, p. 29.

EXPLANATION OF PLATES

Plate XLIII

Fig. 1.—*Proinia patagonica,* new species. No. 15459, Princeton Univ. Coll. Type skull. Patagonian beds, Darwin Station, Santa Cruz Terr., Patagonia. Collected by J. B. Hatcher, April 24, 1899.

Superior surface. About ⅜ natural size.

Fig. 2.—*Prosqualodon australis* Lydekker. No. 15441, Princeton Univ. Coll. Portion of right ramus of mandible. Patagonian beds, San Julian, Santa Cruz Terr., Patagonia. Collected by J. B. Hatcher, April 22, 1899.

External surface. About ¼ natural size.

Plate XLIV

Teeth of *Prosqualodon australis* Lydekker. No. 15441.

Fig. 1.—Root of an upper incisor.
Fig. 2.—A right upper incisor. Inner surface.
Fig. 3.—A right upper premolar. Inner surface, showing three roots.
Fig. 4.—Left posterior upper molar? Outer surface.
Figs. 5 and 6.—Right lower incisors. Inner surface.
Fig. 7.—Right lower canine or premolar? Inner surface.
Fig. 8.—A right lower molar. Outer surface.

Natural size.

Plate XLV

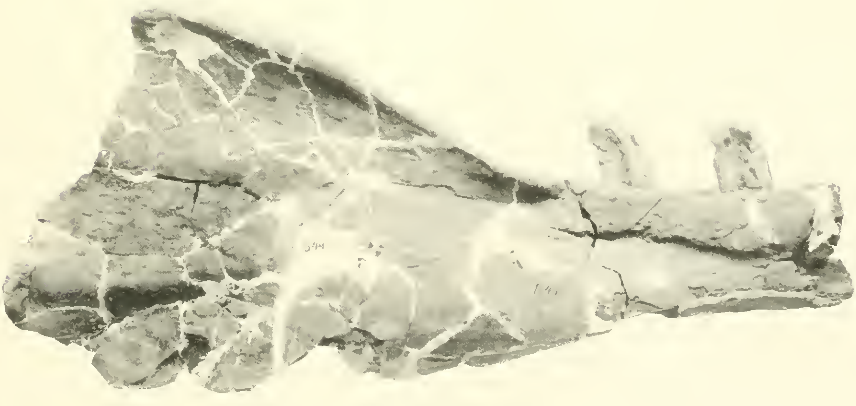
Vertebræ of *Prosqualodon australis* Lydekker. No. 15441.

Fig. 1.—Atlas. Anterior surface.
Fig. 2.—The same. Right side.
Fig. 3.—Thoracic vertebra. Anterior surface.
Fig. 4.—The same. Right side.
Fig. 5.—Another thoracic vertebra. Anterior surface.
Fig. 6.—The same. Right side.

One-half natural size.

1

TYPE SKULL OF PROINIA PATAGONICA, NEW SPECIES



2

MANDIBLE OF PROSQUALODON AUSTRALIS LYDEKK

TEETH OF PROSQUALODON AUSTRALIS LYDEKK

VERTEBRÆ OF PROSQUALODON AUSTRALIS LYDEKK

NOTES ON CERTAIN FEATURES OF THE LIFE HISTORY OF THE ALASKAN FRESHWATER SCULPIN

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Shortly after the publication of Doctor Gill's paper [1] on the habits of the freshwater Cottids of North America, there was received at the U. S. National Museum a small lot of Blobs collected at Loring, Alaska, by Mr. Fred Patching, superintendent of the Fortmann hatchery. These fish were interesting by reason of their stomach contents, a table of which is given on the last page of this article, and for the observations on their habits, an account of which is given in Mr. Patching's letter to Mr. E. L. Goldsborough, here copied in part:

"The Blob or Bullhead I consider very destructive to the Salmon eggs and in all probability to the fry in the earlier stages. I don't suppose they catch very many fuller grown Salmon, although the chances are that they manage to capture a few all the time, whenever they find them in schools or cornered up.

"I am sending you by express some specimens which may prove interesting; one showing the number of eggs a small Blob can eat and also the size of fry he can catch; the other showing that this fish is not particular when it is hungry, as it will eat even another of its kind. The two were washed ashore dead in just the position they are now. The eggs in the first mentioned specimen were probably some of the bait used in the trap (Silver ? Salmon eggs) and simply show the number a fish of that size can hold.

"Until we made traps I had no idea there were so many Bullheads in this stream [Helm Bay Stream]. One morning we caught 2,700 in three small traps, and in twenty-five days the total catch of Blobs was 31,000. If they only make way with one egg each a day the loss would soon be great.

"I have never kept any accurate account of the number of Blobs caught here nor made any careful examination of their stomachs, but have only observed enough to satisfy myself that they were enemies of the Salmon and should be destroyed whenever caught. I

[1] "The Millers-thumb and its habits." Theodore Gill. Smithsonian Miscellaneous Collections, Volume 52, (Quarterly Issue, Volume 5, Part 1), pages 101–116.

supposed others knew this, and also the fact that the Trout is destructive to the Salmon, but last winter I found in the 'Pacific Fisherman' statements from authorities on the question that Trout are not destructive to Salmon fry, though I had been supposing all the time that everybody knew the greatest enemy the Salmon had was the Trout.

"Last season we captured fourteen marked Salmon and the year before two, sixteen in all, exactly one per cent of the number you marked. I have in consequence to lay aside my theory that Salmon take anywhere from twelve to twenty years to mature. On account of the marked fish caught at Yes Bay, my other theory that hatchery fish would return to the stream in which they were liberated, is likewise not substantiated. No one seems to know how many marked Salmon were caught, but one man told me they certainly took as many as twenty-five in one day; so, according to that, by far the larger portion of our hatch went to Yes Bay. One peculiar thing I notice about the return of marked fish is that at Yes Bay in 1906 they caught more than in 1907, whereas here in 1906 we captured only two, as against fourteen in 1907."

The two specimens of Blobs mentioned by Mr. Patching were a *Cottus asper* about 16 cm. (6⅜ inches) long and one about 11–12 cm. (4½ inches) long, which it had tried to swallow. The other specimen, also *Cottus asper,* had in its stomach thirty to forty eggs and a young Salmon about 8.5 cm. (3½ inches) long. The Blob was the same size as the larger one mentioned above.

Late in 1908 Mr. Patching sent to the U. S. National Museum another small collection from the same locality. This included a small Salamander, a Stickleback (*Gasterosteus aculeatus*), a Blenny (*Pholis ornatus*), and fourteen specimens of *Cottus asper.* The Blobs appeared so plump and well fed that an examination of their stomach contents was made. All of them showed evidence of having taken food a short time before being caught and in most cases this food, which consisted of young Salmon (*Oncorhynchus*) and Salmon eggs, was hardly digested. In one case two or three young Salmon in the stomach of a Blob were almost entirely digested, only the head and vertebræ remaining, and in two other cases there were a few scraps remaining from a previous meal. It is evident either that these Blobs must have gone a long time without eating or that their digestive processes must be very rapid; otherwise there would have been a greater diversity of conditions in regard to the amount of digestive action which had taken place. The latter supposition is the more probable one, for these fish came from a river filled with young Salmon of the size of those they had eaten, and there is no reason to suppose that they would voluntarily wait until their stomachs were entirely empty unless from some special cause.

Blobs in general are bottom fish and prefer to remain hidden under stones, etc. It is just in similar places that young Salmon and Trout hide at certain hours of the day, usually when the sun is hottest; the Blobs can then get them with least difficulty. It is probable, therefore, that the stomach contents of each of these Blobs represents one day's feeding and that under proper conditions (when Salmon eggs or young Salmon are available) about the same amount would be eaten each day.

These fourteen Blobs had eaten thirty-nine Salmon and forty-six eggs, or an average of almost three Salmon and a little over three eggs for each fish. This is probably a good daily average for at least two months of each year, and if the Blobs are present in the river in such numbers as are indicated in Mr. Patching's letter, the consequent loss would be many thousand Salmon a year.

The greediness of some of the Blobs was certainly remarkable. One had eaten seven Salmon, five of which were about 5 cm. (2 inches) long and the other two about 7 cm. (nearly 3 inches) long. The last fish eaten was about 7 cm. long and had been swallowed tail first. As there was no room in the Blob's stomach for this one, only its tail was found there, while its head stretched up into the mouth of the Blob. The young Salmon eaten by the Blobs varied from about 5 centimeters (2 inches) to more than twice that length. One or two that were smaller seemed to be Trout (*Salmo* sp.). Nearly all the fish were in such condition that the genus to which they belong could be determined.

In all but one of the Blobs the presence of large numbers of Nematode parasites was noted. They were in the body cavity, either free or in cysts. Most of them were just leaving the cysts, but a few were entirely free. Two or three were found in the stomach or intestine and several more had penetrated the wall of the stomach. Others had started to burrow in the dorsal and ventral muscles and some were visible from the outside just under the skin of the belly. In their attempts to burrow to the outside they had penetrated all the visceral organs; one had even entered the head and seemed to be seeking an exit through the cranium. The cysts were found in the peritoneum, in the wall of the stomach, in the dorsal and ventral muscles and in the liver and kidney. None was found in the ovary or the testis. The males seemed to be less susceptible to the attacks of these worms than the females, but this may be due to the small number (three) of males available for study. One of the females had eighty-two worms in the body cavity. The parasites were turned over to Dr. C. W. Stiles for identification, but were too immature for even generic diagnosis. A few of the larger cysts were heavily pigmented, but the most lacked pigment.

Table of food and parasites of Cottus asper from Loring, Alaska.

No.	Length.	Sex.	Worms.	Salmon.	Eggs.	Other food.
	cm.					
1	19.5	Female.	82	3	1	Sticks (dried seaweed).
2	17.5	...do...	14	2	13	
3	17.0	...do...	22	3	....	
4	16.5	Male...	9	2	1	Fish scraps.
5	14.0	Female.	6	1	....	
6	16.0	...do...	53	3	....	
7	17.0	Male...	9	4	....	
8	17.0	Female.	28	7	....	
9	16.5	...do...	15	2	....	Fish scraps.
10	16.0	Male...	....	1	....	
11	18.5	Female.	41	2	8	Fish scraps
12	17.0	...do...	21	5	....	
13	16 5	...do...	1	....	23	
14	19.0	...do...	21	4	....	
Total	....	....	322	39	46	

There were eleven females and three males in the collection.

THE GEOLOGIC WORK OF MANGROVES IN SOUTHERN FLORIDA

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With Seven Plates

The importance of mangroves in building shallow submarine banks into land and increasing the area of land of very low relief has been observed and described in more or less detail by several geologists who have studied the Florida coast and keys and the West Indian islands. Professor Louis Agassiz, in his report on the "Florida Reefs," has given a charming account of the origin of the mangrove islands; Mr. Alexander Agassiz has also written about them in his "Three Cruises of the Blake"; and Mr. Robert T. Hill has described them in his "Geology and Physical Geography of Jamaica." Although the activity of mangroves as geologic agents is well known, no series of illustrations showing the development of the plants and the successive stages in their formation of islands has, to my knowledge, been published. While studying the geology of the Florida keys and the corals of the reefs and flats of the region, under the auspices of the Carnegie Institution of Washington, I have had an opportunity to take a number of photographs, and they, with the information obtained in connection with those investigations, form the basis of these illustrations and notes. My thanks are due Dr. Alfred G. Mayer, Director of the Marine Biological Laboratory of the Carnegie Institution, for the privilege of visiting nearly all of the Florida keys.

Mangroves (*Rhizophora mangle* Linn.) are small trees or large shrubs, from 10 to 20 feet tall, limited in their distribution to tropical or semi-tropical regions and confined to low lands, growing either in the water or so near the water that the soil in which their roots are imbedded is perpetually saturated. These conditions—a tropical or semi-tropical climate and low land margining the sea or extensive flats only slightly below the level of the ocean—are realized in southern Florida, and mangroves are there abundant. They border the rivers near the ocean, margin most of the higher keys, and form

FIG. 79.—Mangrove fruit and young shoots. The four smaller specimens on left are fruit. About one-sixth natural size.

FIG. 80.—Young Mangroves. About one-sixth natural size.

islands or keys on which mangroves are practically the only vegetation. It is estimated that perhaps between one-half and one-third of the total key area is occupied by these plants.

The mangroves, where they are fully developed, form dense mats of vegetation, with interlocking branches above and interlocking roots below. The roots constitute an interesting and geologically important feature of the plant. Besides the single root or tuft of rootlets given off from the basal end of the young plants, there are other roots originating above ground, at higher levels from the plant stem. These grow downward and imbed their lower ends in the soil, thus adding to the support of the plants. The roots arising in the manner just indicated multiply and form a root tangle above the ground. The various stages of root development are illustrated by text figures 79 and 80, and by plates XLVII, XLVIII, figure 2, and XLIX, figure I (the illustrations are cited in an order to indicate a developmental series). The tangles of roots are geologically important in catching and holding débris washed among them by currents and waves.

The three modes of occurrence of mangroves—along the river banks, around the margins of keys having their land surface above water level, and the purely mangrove keys—are illustrated by the plates. Plates XLVI and XLVII represent the banks of the Miami River and illustrate the river mangroves. Plate XLVIII illustrates the shore of the western side of the cape east of Bay Biscayne; plate XLIX, figure I, depicts Pigeon Key;[1] plate XLIX, figure 2, the Marquesas, and plate LII, figure I, the southern end of Old Rhodes Key—all keys margined by mangroves. Plate LII, figure 2, represents a mangrove-covered key between Key Largo and Old Rhodes Key.

It has already been stated that these plants may initiate the formation of islands or they may be active in increasing land areas. The process may now be sketched as follows:

The fruit of the mangrove is an elongate body, from six inches to a foot long, about half an inch thick, with a pointed distal, and an enlarged and heavy proximal end, the calyx still adhering to the latter. These cigar-shaped bodies drop into the water and are carried hither and thither by the waves and currents, to settle on any soft bottom where the water at low tide does not exceed about one foot in depth. They sprout and quickly take root. Text figures 79 and 80 represent a series of young mangroves, ranging from pods plucked from the trees to specimens with a considerable development of roots and several young branches.

[1] A small key north of the western end of Key Largo.

The manner in which they do their work in extending areas of land above water will be described first. Plate L, figure 1, shows a young mangrove growing in the water some feet away from shore, at Northwest Point, Virginia Key, Bay Biscayne. In many localities along the keys young mangroves may be seen with their terminal leaves protruding above the water at distances of only a few feet up to several hundred feet from the shore. An especially good example of this may be seen along the southern shore of the Marquesas. Plates XLVI, figure 2, and XLVII, figure 1, representing the Miami River, illustrate how the young mangroves extend into the water area. When they have grown sufficiently for the development of a tangle of roots, they catch and hold sediment and any floating débris, by the successive accumulation of such material ultimately bringing the level of the land above that of the water.

The process by which they build new land is as follows: Behind the keys, in the regions of slack water, deposition of sediment is taking place, forming banks of soft calcareous ooze. After these shoals have been built to within about a foot of the water-level (at low tide), young mangroves begin to catch and grow. Plate L, figure 2, represents a single young mangrove growing on a shoal north of Pigeon Key in water about one foot deep. Plate L, figure 3, represents two young plants from the same locality, held up by the boatman. Plate LI shows a further stage in the development of a mangrove key, the young plants being more numerous and larger in size. The plants become still more numerous, further increase in size, and ultimately form a mat of interlocking roots and branches resulting in keys such as those represented on plate LII. When the plants become thick they catch and retain sediment and ocean drift, and are a constructive agent in the formation of land.

After a time, whether it be a newly formed key or the margin of a land area, the mangroves, by the accumulation of sediment and drift, form land, and thus cut off their roots from the necessary supply of sea water, causing their own death. The land surface then acquires another vegetation. But the marginal fringe of mangroves persists to protect the young island from the erosive action of the ocean waves, and young mangroves spread seaward to add new land to that already formed.

Thus these plants are among the most important constructional geologic agents of southern Florida.

Fig. 1.--MIAMI RIVER BETWEEN MIAMI AND THE EDGE OF THE EVERGLADES

Fig. 2.--YOUNG MANGROVES ALONG NORTH BANK OF MIAMI RIVER MIAMI

Fig. 1.--MANGROVES ALONG SOUTH BANK OF MIAMI RIVER, MIAMI

Fig. 2.--ADULT MANGROVES ALONG NORTH BANK OF MIAMI RIVER MIAMI

Fig. 1.--MANGROVES AT NEW CUT, EASTERN SIDE OF BISCAYNE BAY, OPPOSITE MIAMI

Fig. 2.--MANGROVE ROOTS SAME LOCALITY

Fig. 1.--MANGROVE ROOTS AT PIGEON KEY

Fig. 2.--MANGROVES ALONG THE SOUTH SHORE OF THE MARQUESAS

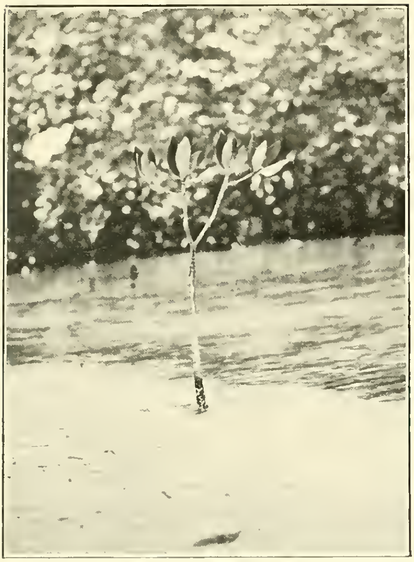


Fig. 1.--YOUNG MANGROVE ON SOUTHWEST SIDE OF BEAR CUT, NORTHWEST POINT, BAY BISCAYNE

Fig. 2.--YOUNG MANGROVE ON SHOAL TWO MILES NORTHEAST OF PIGEON KEY, WATER ABOUT ONE FOOT DEEP

Fig. 3.--TWO YOUNG MANGROVES FROM SHOAL ABOUT TWO MILES NORTH OF PIGEON KEY WATER ABOUT ONE FOOT DEEP

Fig. 1.--YOUNG MANGROVES ON SHOAL, UPPER END OF LONG ISLAND, WATER ABOUT ONE FOOT DEEP

Fig. 2.--YOUNG MANGROVES, OAR BY THEIR SIDE. NEAR VIEW SAME LOCALITY

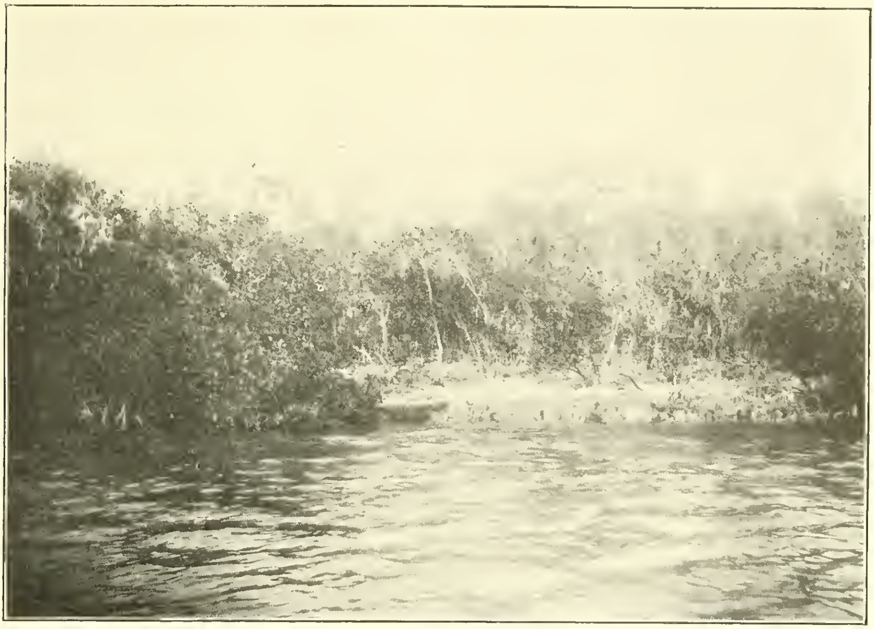


Fig. 1.--ELEVATED CORAL REEF ROCK AND VEGETATION AT SOUTHERN END OF OLD RHODES KEY, DETACHED KEY

Fig. 2.--MANGROVE KEY, BETWEEN LARGO AND OLD RHODES KEYS

CRYSTALLOGRAPHIC NOTES ON CALCITE

By J. E. POGUE

Assistant Curator, Division of Mineralogy, U. S. National Museum

With Two Plates

(1) Calcite from Joplin, Missouri

Although the Joplin calcites have been very completely described by Farrington,[1] two specimens in the U. S. National Museum present features of sufficient difference and interest to warrant a brief note.

The first of these, bearing the National Museum number 84435, and represented in its true proportions in plate LIII, figure 1, is composed of the scalenohedron *v* ($21\bar{3}1$), modified by the positive rhombohedron *r* ($10\bar{1}1$), and the rarer scalenohedrons *σ* ($51\bar{6}4$) and *C* ($61\bar{7}8$). This crystal is similar in appearance to one figured by Farrington,[2] but in the latter the modifying scalenohedrons are *w* ($31\bar{4}5$) and *n* ($41\bar{5}3$). The measurements upon which the identification of the forms are based, made by the contact goniometer, are as follows:

	Measured (contact).	Theoretical.
$v : r \ = 21\bar{3}1 : 10\bar{1}1 =$	29°	29° 2′
$r : r' = 10\bar{1}1 : \bar{1}101 =$	75°	74° 55′
$v : v' = 21\bar{3}1 : \bar{2}3\bar{1}1 =$	75°	75° 22′
$v : \sigma \ = 21\bar{3}1 : 51\bar{6}4 =$	17°–18°	17° 30′
$\sigma : \sigma' = 51\bar{6}4 : \bar{5}6\bar{1}4 =$	77°	77° 54′
$\sigma : \sigma^{v} = 51\bar{6}4 : 6\bar{1}\bar{5}4 =$	15°	14° 27′
$v : C^{v} = 21\bar{3}1 : 7\bar{1}\bar{6}8 =$	37°–38°	37° 47′
$C : C' = 61\bar{7}8 : \bar{6}7\bar{1}8 =$	60°	59° 47′
$C : C^{v} = 61\bar{7}8 : 7\bar{1}\bar{6}8 =$	10°	9° 32′

This type, represented by two specimens in the collection, is of a honey-yellow color and about 8 cm. in length. Numerous cleavage cracks intersect within the crystal and reflect the light as the crystal is revolved. The faces *r*, *σ*, and *C* are dull; *v*, bright. Three faces of the scalenohedron *v*, as shown in the drawing, are stippled with

[1] Publ. Field Columb. Mus., Geol. Ser., vol. 1 (1900), pp. 232–41.

[2] *Ibid.*, plate XXIX, fig. 1.

marcasite in a most interesting manner. This forms a sandpaper-like surface, which extends to within 4 mm. of the edges $v\,\sigma$, where an even line of demarkation separates the stippled part from the remaining bright portion of the faces. This line runs parallel to $v\,\sigma$ to within a few millimeters of the sharp edges, $v\,v'$ and $v^{iv}v^{v}$, and then bends down in a direction roughly parallel to the cleavage, intersecting the edges at a sharp angle. Also, from the same sharp edges occasional narrow bands, lacking the stippling, extend toward the blunt edges in a direction parallel to the cleavage. The three back faces, v^{ii}, v^{iii}, and v^{iv}, are entirely wanting in marcasite. This mineral is confined to the surface of the crystal and must have been deposited after the growth of the calcite was completed or nearly completed; yet it is entirely controlled in its distribution by the crystallographic relations of the host crystal.

The second crystal described bears the Museum number 84435, and is shown in its natural development in plate LIII, figure 2. This is made up of the scalenohedron v $(21\bar{3}1)$ and negative rhombohedron e $(01\bar{1}2)$, modified by the rhombohedron l $(04\bar{4}5)$ and the scalenohedron t $(21\bar{3}4)$, and is a combination of Farrington's[1] type 1, composed of v and t, and type 2, composed of v and e. By a parallel shifting of vv^{v} and corresponding edges, the alternate t faces are distorted into long, narrow planes, which, on account of their small inclination to e and the striations of the latter, are not prominent. The crystal is of a honey-yellow color and in numerous positions is brilliantly illuminated from within by light reflected from a network of cleavage cracks. The v faces are all peculiarly marked, as shown in the drawing.

The measurements, made by contact, are as follows:

	Measured (contact).	Theoretical.
$v : l = 21\bar{3}1 : 04\bar{4}5 =$	44°	44° 6′
$e : l = 01\bar{1}2 : 04\bar{4}5 =$	12°	12° 2′
$e : v = 01\bar{1}2 : 21\bar{3}1 =$	45°–52°	50° 36′
$v : t^{v} = 21\bar{3}1 : 3\bar{1}\bar{2}4 =$	47°	45° 31′

(2) Calcite with Moving Bubble, from Guanajuato, Mexico

A calcite twin from Guanajuato, Mexico, bearing the National Museum number 75672, is shown in its true size and development in plate LIV, figure 1. The form shows the scalenohedron v $(21\bar{3}1)$, terminated above by the negative rhombohedron e $(01\bar{1}2)$, which,

[1] Publ. Field Columb. Mus., Geol. Ser., vol. 1 (1900), pp. 233–34.

imperfectly developed at the lower end of the crystal, appears here by a mere rounding. The crystal is twinned parallel to the basal plane *c* (0001), following a common law for calcite. The feature of interest is a moving bubble, which has a free course over the area outlined by dots in the drawing. This space is roughly rectilinear in shape, about 16 x 6.5 mm. in size, and is situated 1 to 3 mm. beneath and parallel to the surface; its edge of greatest length is also approximately parallel to edge $\underline{vv'}$ of the crystal. The space is apparently located in a definite manner in regard to the orientation of the calcite.

Complex twins from the same locality have been described by Pirsson.[1]

(3) Calcite from Virgilina, Virginia

A small suite of calcite crystals have been found in the Virgilina copper district of Virginia by Dr. F. B. Laney, who kindly placed the material at the disposal of the writer. As no descriptions of calcite from this locality, so far as the writer knows, appear in the literature, a brief note is deemed desirable.

Crystallized calcite occurs at the High Hill Copper Mine, Halifax County, Virginia, about nine miles north of Virgilina. It is found in small cavities or vuggs, distributed at irregular intervals in a quartz vein 4 to 8 feet in width, which traverses a greenstone schist (probably a mashed andesitic tuff). The crystals are rare and are associated with crystalline quartz, cuprite, malachite, and one or more other copper minerals. The mine is 300 feet deep, but the depth from which the present specimens were obtained is not known. Massive calcite as a gangue is not common at this mine, though very prominent at the Blue Wing Mine in the same district.[2] The crystals range in size from 1 to 7 mm. in greatest length and occur in two distinct types.

Type 1, shown enlarged in plate LIV, figure 2, is rarer and smaller than type 2 (figs. 3 and 4). The former is very simple, being a combination of the positive rhombohedron *r* ($10\bar{1}1$) and the rare scalenohedron *G:* ($72\bar{9}5$).[3] This form was noted by Farrington and Tillotson[4] on calcite from Joplin, and by Palache[5] on calcite from the copper mines of Lake Superior, but has not otherwise been described on

[1] Amer. Journ. Sci., vol. 41 (1891), pp. 61–64.

[2] For these details of occurrence the writer is indebted to Dr. Laney.

[3] Goldschmidt's symbol. This form is not given in Dana's Mineralogy.

[4] Publ. Field Columb. Mus., Geol. Ser., vol. 3 (1908), p. 141.

[5] Zeitschr. für Kryst., vol. 24 (1895), p. 589; Mich. Geol. Survey, vol. 6, pt. 2 (1898), p. 168.

American calcite. *r* is dull and *G:* is fairly brilliant, though its signal is not well defined. The measurements upon which the identification is based are as follows:

	Measured.	Theoretical.
$G: : G:' = (72\bar{9}5) : (\bar{7}9\bar{2}5)$ =	78° 16′	78° 3′
$G: : G:^{v} = (72\bar{9}5) : (9\bar{2}\bar{7}5)$ =	21° 0′	20° 44′
$r : G: = (10\bar{1}1) : (72\bar{9}5)$ =	17° 8′	17° 36′

Type 2, an average crystal of which, enlarged, is shown in orthographic projection in plate LIV, figure 3, and in clinographic projection in figure 4, is the common type. It occurs very symmetrically developed and is composed of the scalenohedron *y* $(32\bar{5}1)$ and the negative rhombohedron *e* $(01\bar{1}2)$, modified by the positive rhombohedrons *r* $(10\bar{1}1)$ and *k* $(50\bar{5}2)$, and the rare scalenohedron *G:* $(72\bar{9}5)$. *e* is deeply striated parallel to *rr′*; *r*, *k*, and *G:* are dull, and *y* only slightly lustrous. The crystals were measured by the reflection goniometer, but as direct reflections could not be obtained, the measurements were made by bringing the faces into parallel alignment with the vertical cross-hair. This method gave readings only slightly more accurate than those obtained by contact on larger crystals, but such were sufficient to identify the forms. The identification of *G:* was strengthened by its more accurate determination on type 1. The faces of the scalenohedron *y* have a tendency toward rounding, so that the edges between the upper and lower faces are not always well developed; hence the crystals have a barrel-shaped appearance.

The specimens described have been placed in the National Museum collections under the number 86574.

EXPLANATION OF PLATES

PLATE LIII, Fig. 1.—Joplin calcite, showing peculiar stippling of marcasite. Natural size. Nat. Mus. No. 84435.

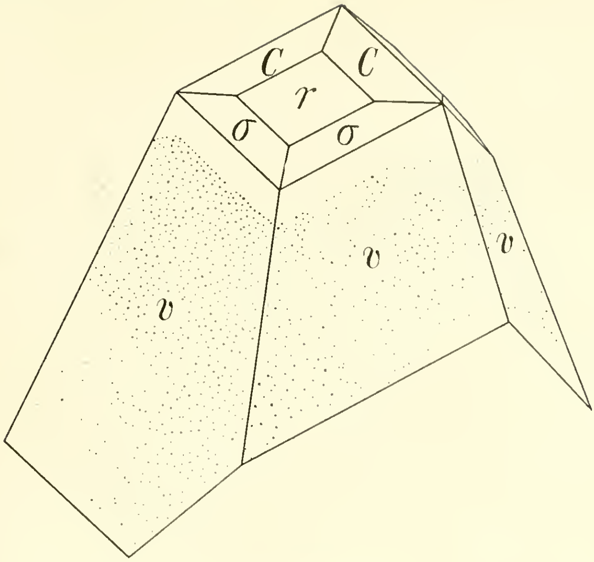
Fig. 2.—Joplin calcite, combination of *v*, *c*, and *t*. Natural size. Nat. Mus. No. 84435.

PLATE LIV, Fig. 1—Calcite twin, Guanajuato, Mexico. Path of moving bubble outlined by dots. Natural size. Nat. Mus. No. 75672.

Fig. 2.—Crystal of type 1, Virgilina calcite. Enlarged. Nat. Mus. No. 86574.

Fig. 3.—Crystal of type 2, Virgilina calcite. Orthographic projection. Enlarged. Nat. Mus. No. 86574.

Fig. 4.—Crystal of type 2, Virgilina calcite. Clinographic projection. Enlarged. Nat. Mus. No. 86574.



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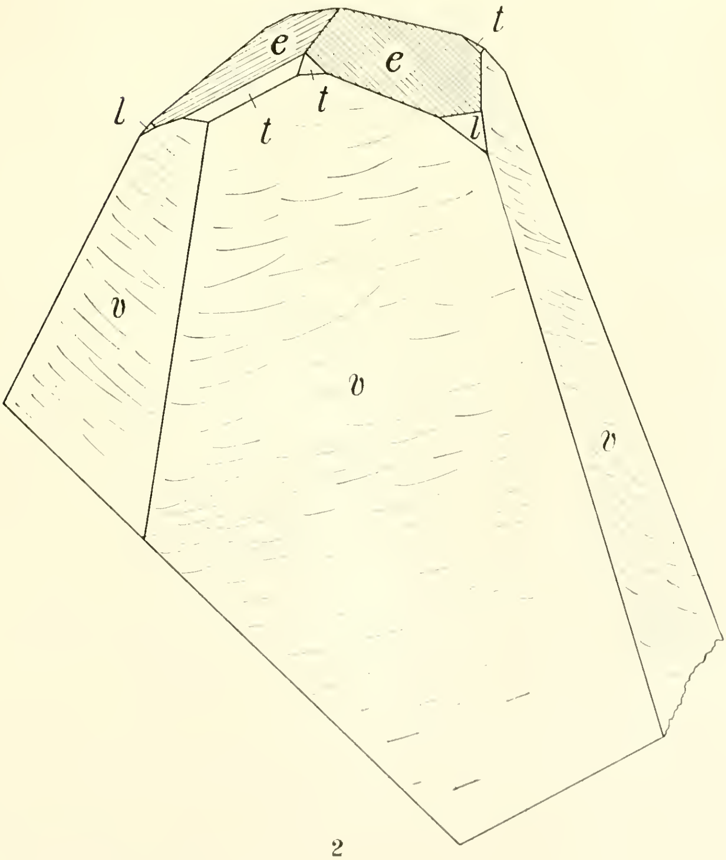

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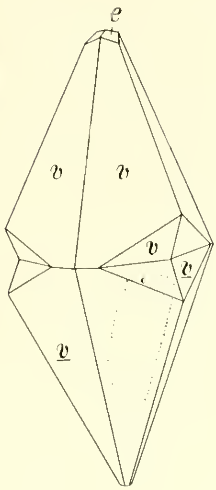

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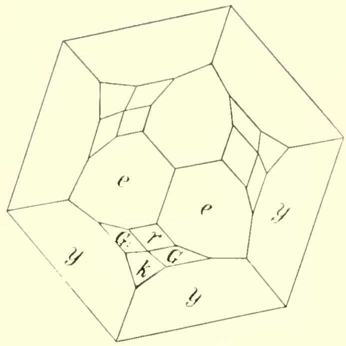

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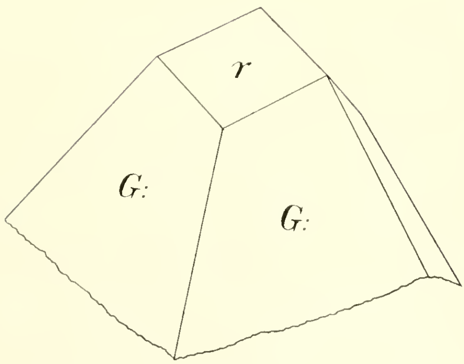

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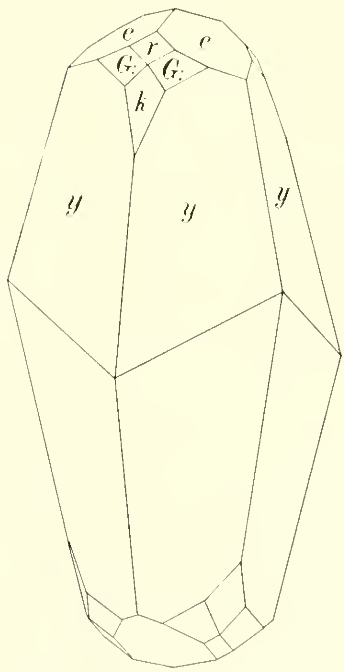

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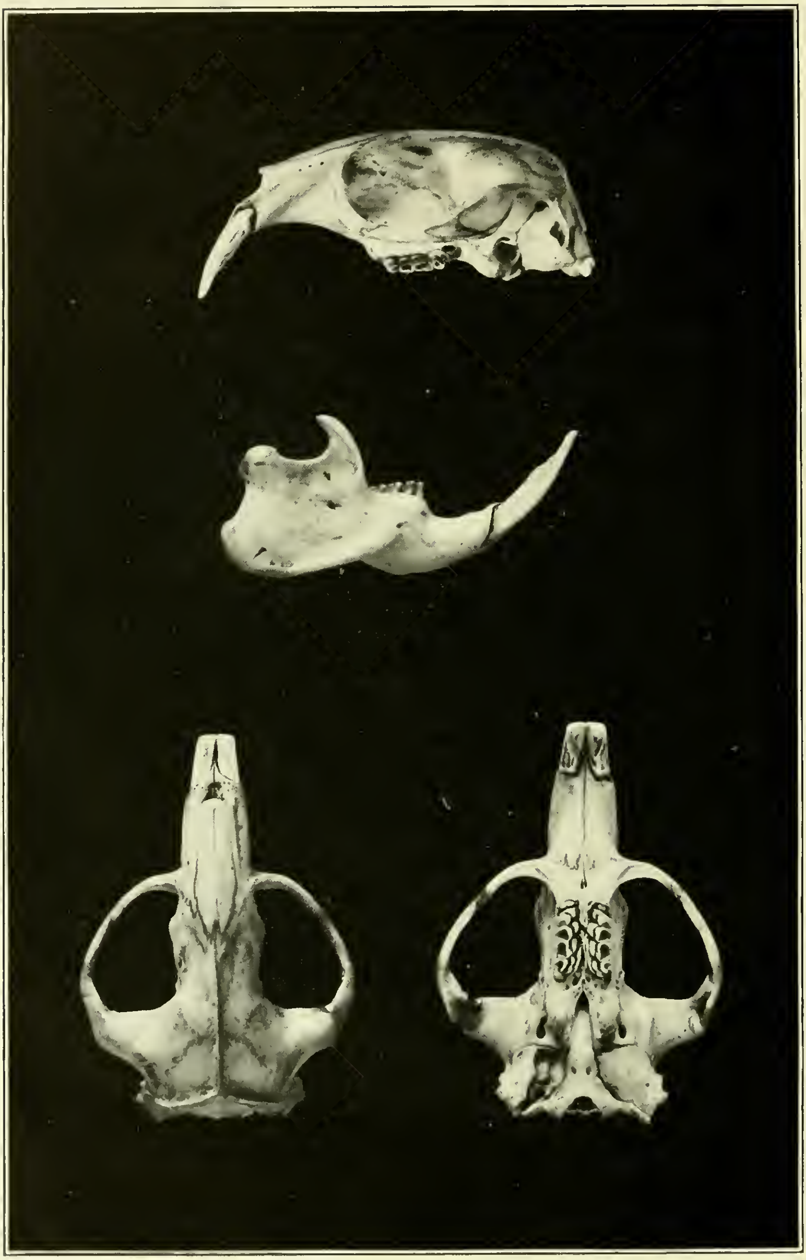


GEORYCHUS KAPITI, NEW SPECIES

Natural size

A NEW RODENT OF THE GENUS GEORYCHUS

By EDMUND HELLER

Field Naturalist, Smithsonian African Expedition

With One Plate

It has seemed desirable that the more conspicuous new mammals discovered by the Smithsonian African Expedition should be described at once, without waiting for the general account of the collections. This paper contains the first of these descriptions.

GEORYCHUS KAPITI, new species

Types from Potha, Kapiti Plains, British East Africa; adult female, No. 161708, U. S. Nat. Museum; collected by J. A. Loring, May 3, 1909; original No. 6027.

General characters.—Size small, about that of *G. nimrodi,* but skull relatively much larger, the nasals extending posteriorly considerably beyond the premaxillaries; coloration uniform drab-gray with a strong cinnamon-brown wash and without any white occipital patch.

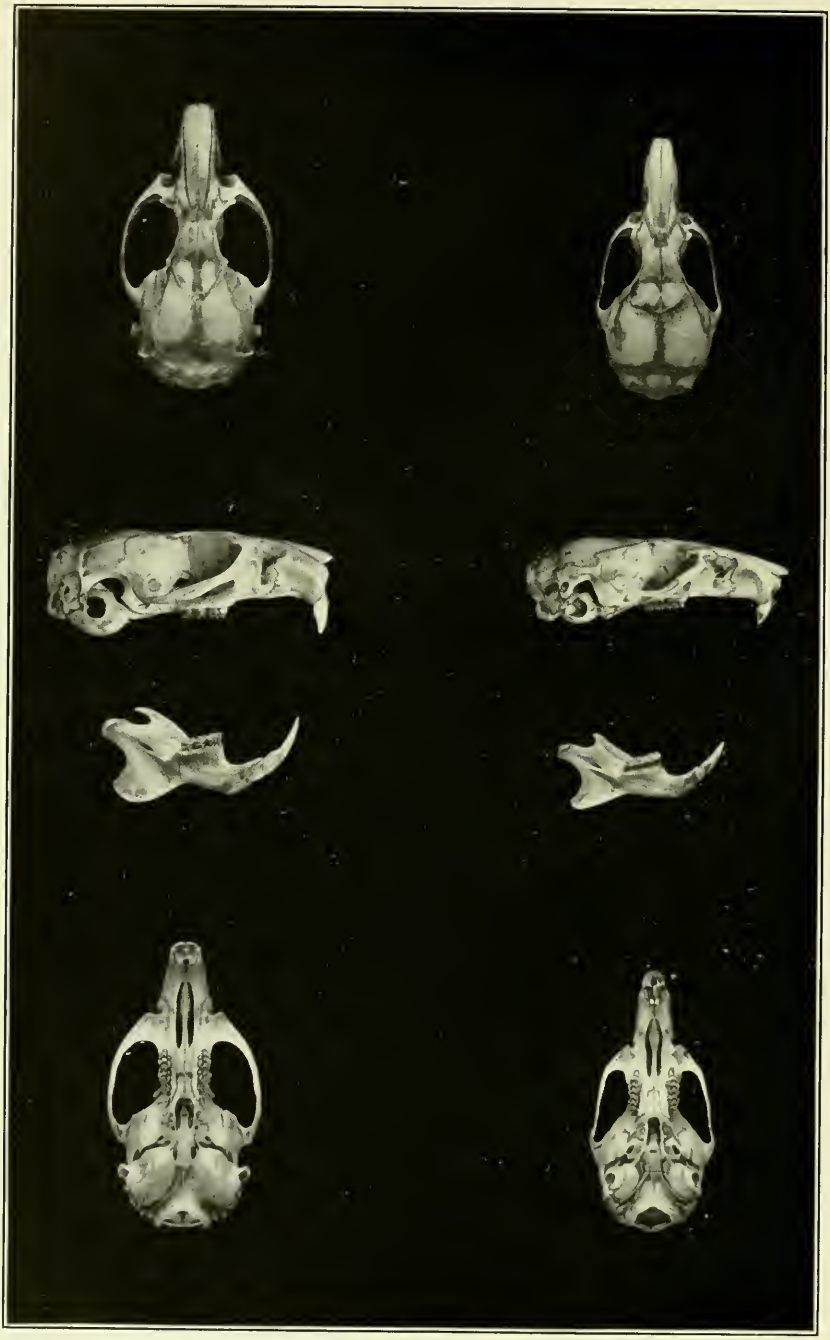
Coloration.—Uniform drab-gray everywhere, the back with a strong cinnamon-brown wash; ears, a spot on each side of snout at base of whiskers, and the long hairs covering the tail, whitish, but not forming any noticeable contrast with adjacent parts; hair everywhere plumbeous gray (about Ridgway's No. 6) at base.

Skull.—Relatively large and wide zygomatically. Nasals extending well beyond premaxillaries. Functional cheekteeth four, the crowns, when worn, subcircular in outline except the last, which has a large posterior prism; fourth cheektooth (m^1) largest, the first functional tooth (pm^2) considerably smaller than the last (m^3). Incisors long and slender, uniformly chalky-white in coloration.

Measurements.—Type: Head and body, 165; tail, 19; hind foot, 33 (29.6); skull, condylobasal length, 42.8; zygomatic breadth, 32.8; interorbital constriction, 8.8; postorbital constriction, 9.0; mastoid breadth, 20.2; nasal, 16.8; diastema, 14.6; depth at middle palate, 15.6; mandible, 33.6; maxillary toothrow (functional teeth, alveoli), 8.0; mandibular toothrow (functional teeth, alveoli), 7.0.

This species is apparently most closely related to *nimrodi* of Matabele Land, with which form it agrees in size, in the absence of a white occipital patch, and in the comparative length of the nasal bones. It differs from this form in the relatively larger skull and hind foot, larger molars, and in the presence of a cinnamon wash on back. It is at once distinguishable from *argenteo-cinereus* of German East Africa and Mozambique by its much smaller size and absence of the white occipital patch.

The series of eight specimens from the Kapiti Plains is remarkably uniform, showing practically no variation in coloration and only such variations in size as are due to age.



a
THAMNOMYS LORINGI Heller
Type. Natural size

b
MUS PEROMYSCUS Heller
Type. Natural size

TWO NEW RODENTS FROM BRITISH EAST AFRICA

By EDMUND HELLER

Field Naturalist, Smithsonian African Expedition

With One Plate

Two Murine rodents collected by members of the Smithsonian African Expedition in British East Africa during June and July, 1909, appear to be new to science. This paper, in which they are described, is the second dealing with the results of the expedition.

THAMNOMYS LORINGI, sp. nov.

(Plate LVI, *a*, skull, natural size)

Type No. 161904, U. S. Nat. Mus., adult female (skin and skull), Lake Naivasha, British East Africa, July 17, 1909; collected by J. Alden Loring; original No. 6684.

General characters.—A large *Thamnomys* agreeing with *T. dryas* Thomas in dental characters and number of mammæ (p 0 — 0, i 2 — 2 = 4); coloration distinctive, the face marked on each side with a broad black band from tip of snout through eye to base of ear.

Color.—Upperparts wood-brown, washed with black medially, tinged with light tawny on rump and lumbar region; sides paler and grayer, but brown color continuing well down to the creamy white of the underparts, the line of demarcation sharply defined; sides of head marked by a broad band of black from the snout through the eye to base of the ear; interorbital region and crown dusky, with a slight grizzle; ears scantily covered by ferruginous hairs; whole underparts, including cheeks and the fore and hind feet, creamy white, the hair basally slate-gray; tail black, clothed scantily with short black hairs which become more numerous posteriorly and form a slight pencil at the tip.

Measurements.—Head and body, 160; tail, 174; hind foot, 30; ear, 21 (dry). Skull: condylobasal length, 36.0; zygomatic breadth, 20.2; interorbital constriction, 4.8; mastoid breadth, 15.6; depth of braincase at middle, 19.6; nasal, 14.0; diastema, 10.8; mandible, 22.4; maxillary toothrow (alveoli), 5.8; mandibular toothrow (alveoli), 5.6.

MUS PEROMYSCUS, sp. nov.

(Plate LVI, *b,* skull, natural size)

Type No. 161905, U. S. Nat. Mus., adult male (skin and skull); Njoro O Nyiro, Sotik, British East Africa; June 9, 1909; collected by E. Heller; original No. 1011.

General characters.—Skull long and narrow with slender appressed zygomatic arches and produced rostrum; molar series short and narrow with the internal cusps illy defined; ears large, rounded, scantily clothed by minute hairs; tail essentially naked.

Color.—Upperparts sepia changing gradually to walnut-brown posteriorly; sides mixed grayish and fulvous, the transition to the gray of the underparts rather abrupt; sides of head and base of ears lighter brown, similar to the coloration of the rump; underparts and feet light grayish, with faint median fulvous wash; tail dusky.

Measurements.—Head and body, 135; tail, 146; hind foot, 26; ear, 22. Skull: condylobasal length, 30.4; zygomatic breadth, 16.0; interorbital constriction, 5.0; mastoid breadth, 12.8; depth of braincase at middle, 9.0; nasal, 12.8; diastema, 8.6; mandible, 19.0; maxillary toothrow (crowns), 5.0; mandibular toothrow (alveoli), 5.0.

Fig. 1

Fig. 2

THE THOMSON, GEORGIA, METEORITE. NATURAL SIZE

A HERETOFORE UNDESCRIBED STONY METEORITE FROM THOMSON, McDUFFIE COUNTY, GEORGIA

By GEORGE P. MERRILL

Head Curator, Department of Geology, U. S. National Museum

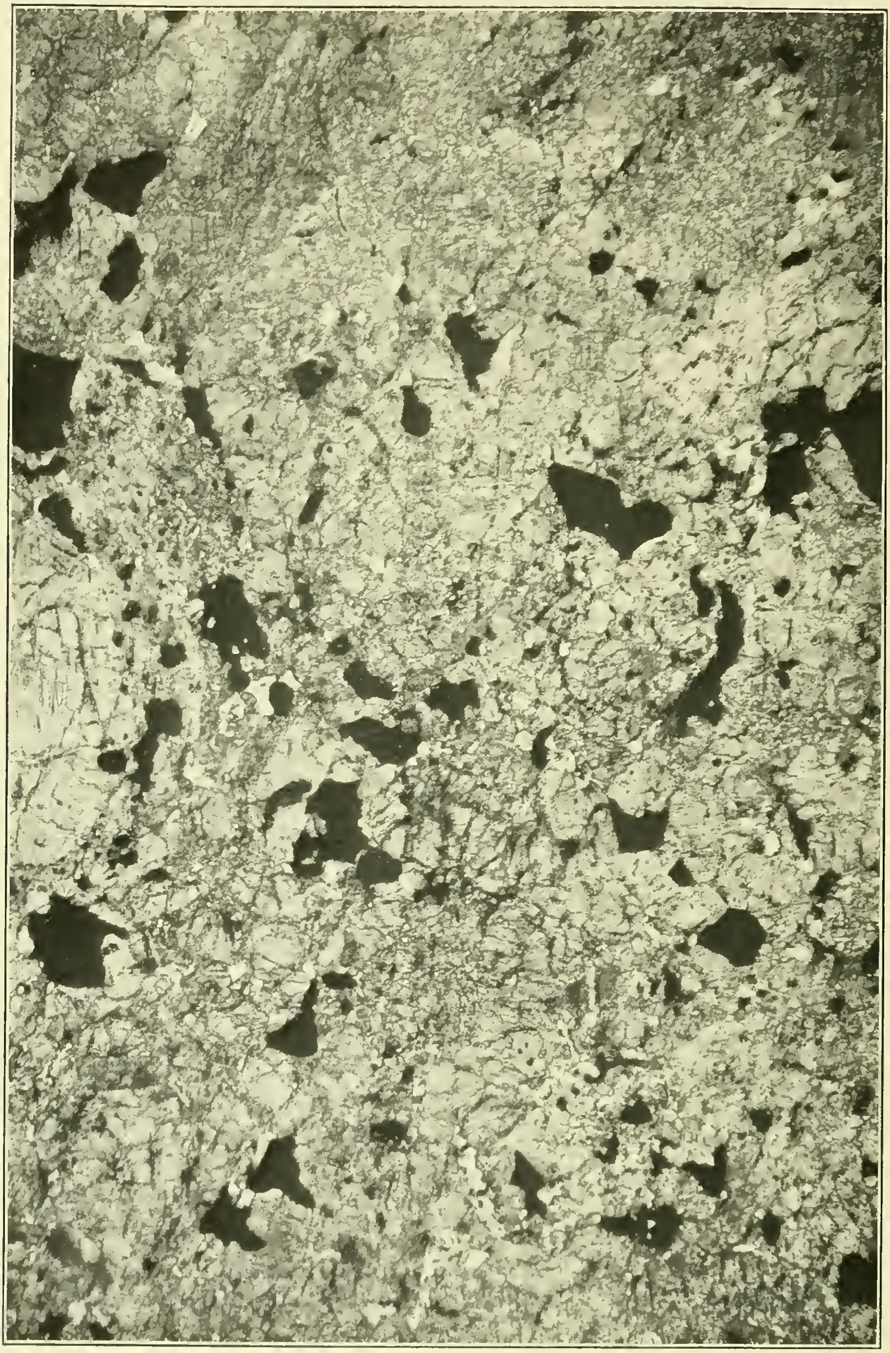
With Two Plates

Through the courtesy of Mr. George H. Plant, of Macon, Georgia, the National Museum has recently come into possession of a heretofore undescribed and, except locally, evidently unknown stony meteorite. The history of the stone, owing to the length of time it has laid in private collections, is unfortunately somewhat obscure. In a letter from B. F. Wilson to Mr. I. C. Plant, dated November 26, 1888, it is stated, "The stone sent you was picked up by the undersigned on October 15th. It was on the place of Mrs. M. A. Wilson, in McDuffie county, four miles south of Thomson. It fell within thirty yards of where the writer was at work." Nothing is said in the letter regarding the time of day, and only the natural inference can be made that it was some time between sunrise and sunset. As Mr. Wilson is now dead, letters were written to the office of the local newspaper and to the postmaster at Thomson. Only the latter replied, stating that Mr. Wilson was picking cotton at the time, and his first impression was that some one had "thrown a huge stone at his head." He then noticed "where the meteorite fell, some thirty steps away. It was buried some six or eight inches in the earth and he dug it up with a spade. Only one stone fell."

The meteorite as it reached the Museum was in a good state of preservation when all is considered. The two views, natural size, on plate LVII, show its appearance better than can any detailed description. The black crust had been knocked off some of the more exposed edges, but the fractured surface shown at the bottom, in figure 2, was very thinly and indistinctly coated with a black glass, showing that the breaking took place not long before the stone reached the ground. The crust over the main portion is thin, slightly rough, dull and lustreless, indicating at once a nearly feldspar-free stone of the olivine-pyroxene type, and such it proves to be. Nowhere on its surface are there flutings and pittings such as to indicate its orientation during flight, but the crust is apparently a trifle thicker near the center on the upper half as shown in figure 2, suggesting that this was the rear, on which the molten material would naturally gather to a greater extent than on the nose or *brustseite*. The total weight of the stone as received was 234 grams. Allowing for all abraded portions, even that from the rough surface now thinly glazed, it could not have weighed more than 250 grams. As now preserved, after cutting slices for thin sections and chemical tests, and as shown in the plate, it weighs 218 grams; specific gravity determinations made on the entire mass gave 3.51; Museum catalogue number 395.

The polished surface of the stone (fig. 2) shows a light gray ground which the pocket lens resolves into a compact mass of gray chondrules closely compressed, sometimes spherical or oval and sometimes angular, abundantly interspersed with small particles of metallic iron and iron sulphide. The surface is traversed by one short and wide black vein and one bifurcating and threadlike, both evidently emanating from the same point. The wider black vein, it will be noted, breaks up at its extremities into several threadlike forms. It would perhaps be more accurate to state that at this point on the surface several parallel-lying, threadlike veins have coalesced for a short distance, then again separated. The filling material of these veins (with the exception of the dark coloring matter which, being unacted upon by acids, is assumed to be carbon) is essentially of the same mineral nature as the body of the stone. Iron and iron sulphide are, however, relatively more abundant, especially in the smaller veins where the sulphide forms in places a spongelike and, at times, a solid filling of the fissure, or may again occur in thin plates lying near the walls, with numerous small particles scattered promiscuously throughout the interior. It naturally follows that this constituent is of more recent origin than the fissures themselves. Occasional evidences of a like secondary nature of the metallic iron are met with, but these are not satisfactorily conclusive. Where the metal fills the vein cavity for a short distance only, it is possible that it antedates the crack which merely passes around it. In other cases, however, there are what appear as mere elongated films of the metal lying parallel with the walls and in shape radically different from that in the body of the stone. Such, it is felt, must also be secondary as compared with that of the ground and, together with the sulphide, offer some interesting suggestions relative to life history.

The veins in general appearance are similar to those in the Fayette



THE THOMSON, GEORGIA, METEORITE. SHOWING MICROSTRUCTURE

County (Bluff), Texas stone, as described by the writer,[1] but differ in that the latter show no proportional increase in metallic constituents. They seem more nearly comparable with those of the Mocs stone as figured and described by Tschermak.[2]

Concerning the origin of the vein-filling matter of meteorites in general, the writer agrees with Tschermak[3] and Farrington,[4] in that it cannot have been derived from inward flowing fused material from the surface, nor can it be due to a fusion of pre-existing particles scattered throughout the mass of the stone. Even were there reason for supposing that the interior of any stony meteorite becomes highly heated during its passage through the atmosphere, the presence of the sulphide filling is indisputable evidence that such did not in this instance occur; otherwise the sulphide would itself have been consumed. The metallic portion cannot be accounted for on the supposition that pre-existing particles were drawn out into filaments through the dragging action of the walls, since it is plain that there has been no such differential movement, nor are there elsewhere in the section any corresponding filamentous forms. The suggestion of Farrington regarding the filling matter of the veins in the Farmington, Kansas, stone seems therefore inapplicable here, and one is apparently forced to the conclusion that the sulphide filling at least (ignoring for the time the doubtful metallic constituent) owes its origin to some reducing constituent acting at fairly low temperature at a period since the fracturing took place.

In respect to structure and texture, the stone is also comparable with that of Mocs, but differs in that the chondrules are compressed and firmly imbedded and break with the groundmass. In the thin section under the microscope the chondritic structure becomes very obscure, indeed, almost unrecognizable, so constant and gradual is the transition into the ground of granular silicates (pl. LVIII). Porphyritic and polysomatic forms are not abundant, the prevailing types being radiating columnar or finely granular. Of the two chief constituents, enstatite prevails over olivine in both chondritic and granular forms. Occasional chondrules are composed wholly of small, fairly well developed but closely compacted monoclinic forms, with small angle of extinction, and evidently referable to Dr. W.

[1] Am. Jour. Sci., vol. 36, 1888, p. 113.

[2] Sitz. d. k. Akad. d. Wiss. Math. Naturw. Classe, vol. 85, 1882, p. 195.

[3] Beitr. zur Classification der Meteoriten, Sitz. k. Akad. der Wiss., vol. 88, 1883, p, 15.

[4] On the Nature of the Metallic Veins in the Farmington Meteorite, Am. Jour. Sci., XI, 1901, p. 60.

Wahl's klino-enstatite.[5] Other monoclinic forms show the polysynthetic twinning so characteristic of the Renazzo stone. In addition to the above-named silicates are numerous small and irregular interstitial areas of a completely colorless, transparent, isotropic, or sometimes weakly doubly refracting mineral without cleavage lines or twin striæ, which would ordinarily pass for a glass. These, as in previous cases,[6] I have considered, for lack of evidence to the contrary, to be maskelynite, basing my determination on Tschermak's figures and descriptions in plates 16 and 17 of his Die Mikroskopische Beschaffenheit der Meteoriten.

The stone will be known, in accordance with the usual custom of naming, as the Thomson meteorite.

EXPLANATION OF PLATES

The Thomson, Georgia, Meteorite

Pl. LVII, Figs. 1 and 2. Two views. Natural size. Fig. 2 shows a polished surface, on which, at the right and near the end, is a broad, illy defined black vein. A small threadlike vein evidently starting from the same source extends upward and to the left, with frequent branching, to the highest point on the polished surface. In photographing this view the specimen was tilted a trifle more than in Fig. 1 in order that the light might so fall as to bring out the fractured surface on the lower margin.

The Thomson, Georgia, Meteorite

Pl. LVIII, showing microstructure. The black areas are of metallic iron and iron sulphide; the small, white interstitial areas the supposed maskelynite. The large chondrule at the middle of the left margin is enstatite. Elsewhere in the plate the silicates are not well differentiated.

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[5] Die Enstatitaugite, etc., Helsingfors, 1906.

[6] See description of Stony Meteorite from Coon Butte, Ariz., Am. Jour. Sci., May, 1906, p. 351, and On the Meteorite of Rich Mountain, N. C., Proc. U. S. N. M., vol. 32, 1907, p 243.

ON A REMARKABLE CUBE OF PYRITE, CARRYING CRYSTALLIZED GOLD AND GALENA OF UNUSUAL HABIT

By JOSEPH E. POGUE

Assistant Curator, Division of Mineralogy, U. S. National Museum

With One Plate

The intergrowth or interpenetration of two or more minerals, especially if these be well crystallized, often shows a certain mutual crystallographic control in the arrangement of the individuals, suggestive of interacting molecular forces. Occasionally a crystal upon nearly completing its growth exerts what may be termed "surface affinity," in that it seems to attract molecules of composition different from its own and causes these to crystallize in positions bearing definite crystallographic relations to the host crystal, as evidenced, for example, by the regular arrangement of marcasite on calcite, chalcopyrite on galena, quartz on fluorite, and so on. Of special interest, not only because exhibiting the features mentioned above, but also on account of the unusual development of the individuals and the great beauty of the specimen, is a large cube of pyrite, studded with crystals of native gold and partly covered by plates of galena, acquired some years ago by the U. S. National Museum.

This cube measures about 2 inches (51 mm.) along its edge, and is prominently striated, as is often the case with pyrite. It contains something more than 130 crystals of gold attached to its surface, has about one-fourth of its area covered with galena, and upon one face shows an imperfect crystal of chalcopyrite. The specimen came into the possession of the National Museum in 1906 and was obtained from the Snettisham District, near Juneau, Southeast Alaska. It is now on exhibition in the Mineral Department under number 86045. Three similar specimens were exhibited at the Seattle Exposition during 1909, one of which is stated by the owner, Mr. L. V. Winter, of Juneau, Alaska, to be 4 inches square and to show 170 crystals of gold upon its surface. So far as can be learned the four specimens are the sole representatives of a very unique association.

Crystallography of the pyrite.—The pyrite has four of its faces well developed; each of the two remaining ones is marred by an irregular pit, about one-half inch deep and the same in diameter, and the edge joining these two faces is imperfect. The crystal is striated parallel to the pyritohedron *e* (210), due to oscillatory combination of this form and the cube *a* (100), which gives rise to overlapping strips or laminæ parallel to (100) and bounded by (210), each lower strip being usually a bit broader than the one above. The ordinary arrangement across the laminations is: A smooth surface parallel to the cube face, 1 to 2 mm. in width; a series of steps down across alternations of cube and pyritohedron for about 1 mm.;

FIG. 81.—Pyrite cube with crystallized gold and galena. Natural size.

a flat-bottom valley 1 to 2 mm. wide; a course of steps up for 1 mm. to a second plane surface, and so on. Frequently a narrow strip extends only partly across the cube face when, cut off by two octahedral planes, it ends in a dull point, and the strip beneath continues until it perhaps is terminated by similar bounding planes. Scharff[1]

[1] Scharff, F. Ueber die Bau-weise der Würfel-förmigen Krystalle. Neues Jahr. f. Min., etc., 1860, pp. 385–425. See especially p. 412 and Figs. 41, 43, 47, Plate VI.

has figured and described natural etchings on pyrite from Traversella, Italy, which are somewhat similar to the ones here depicted. At times the gold crystals or small rounded knobs of galena are situated upon small six-sided pedestals composed of laminæ of pyrite bounded by two pyritohedron and four octahedral planes. The above features may be seen by referring to plate LIX, figure 1.

Crystallography of the gold.—The gold crystals are most abundant on the face shown in plate LIX, figure 1, though some are present on each of the other faces. They are usually from one-third to one-half buried in the pyrite, never more, and seem to have no definite orientation in regard to their host. Most of them show crystal outline and many are rather symmetrically developed; their average diameter is about 1 mm. The faces are slightly convex, without bright luster, and the edges are not sharp. No measurements were attempted on the goniometer, as the crystals were not fitted for giving reflection, nor, indeed, could they be easily plucked from their settings. The following forms, however, by aid of a hand lens, were

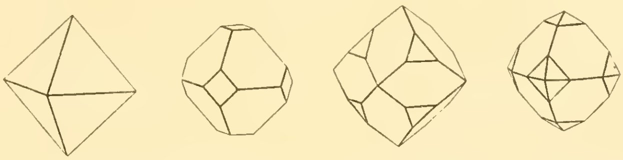

FIG. 82.—The most common shapes of the gold crystals. Enlarged octahedron; combination of cube and octahedron; combination of octahedron and dodecahedron; combination of octahedron and trapezohedron.

positively determined: cube, *a* (100); octahedron, *o* (111); dodecahedron, *d* (110), and trapezohedron, *n* (211) or *m* (311). To these should be added a hexoctahedron as probably present, this form possibly corresponding to *x* (18.10.1) described by Dana[2] on gold from California. The most common combinations, as shown in figure 82, are: Octahedron, cube and octahedron, dodecahedron and octahedron, and trapezohedron and octahedron.

Crystallography of the galena.—The galena possesses three distinct habits, two of which have two or more appearances, due to peculiarities of orientation:

(1) Normal galena. A very small part of the galena has the ordinary step-like appearance characteristic of this mineral and requires no special description. This phase is arranged with one cubic cleavage parallel to the cube faces of the pyrite, with the striations on the latter intersecting diagonally its other cleavages.

[2] Dana, E. S. On the crystallization of gold. Am. Jour. Sci., vol. 32, 1886, pp. 132–138.

(2) Galena laminated parallel to the octahedron (111). About one-fourth of the mineral is developed in this way and is arranged with its octahedral surface usually parallel, though at times slightly inclined, to the cube faces of the pyrite. Natural etching has given a triangular and hexagonal outline to the plates, as is shown in the lower right-hand corner of figure 2, plate LIX. This contour is explained by the fact that an octahedral plane alone is an equilateral triangle, and, when truncated by cube faces, forms a surface of six-sided outline. The strongly laminated nature of the galena may be due to polysynthetic twinning parallel to (111).

(3) Galena laminated parallel to the cube (100). This habit, which comprises about two-thirds of the galena, shows a varied orientation in respect to the pyrite. (*a*) The most common appearance is shown in the central portion of figure 2, plate LIX, where the laminæ are parallel to the surface of the pyrite. This is explained

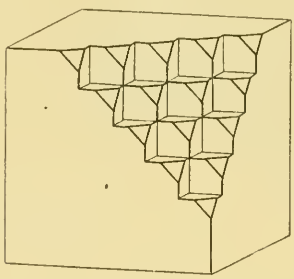

FIG. 83.—Greatly enlarged cleavage fragment of galena, showing eminent cubic cleavage modified by octahedral cleavage.

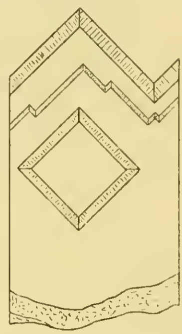

FIG. 84.—Fragment of galena, made up of laminæ, parallel to a cube face, bounded by octahedral slopes.

by the accompanying drawing (figure 84), which figures a fragment made up of plates parallel to the cube *a* (100), bounded by octahedral (111) slopes, this combination giving a square outline to the plates. (*b*) Occasionally there occur long, narrow strips, likewise made up of laminæ parallel to *a* (100) and bounded by elongated *o* (111) faces. These may have their *a* (100) faces parallel to *a* (100) of pyrite; or less often the long *o* (111) faces may have this relation. Crystals of like distortion, but without such platy structure or appearance, from Yellowstone, Wisconsin, have been described by Hobbs.[3] (*c*) Finally, the laminæ and the two cube

[3] Hobbs, W. H. Die krystallisirten Mineralien aus dem "Galena Limestone" des südlichen Wisconsin und des nördlichen Illinois. Zeitsch. für Kryst., vol. 25, 1895–'96, pp. 257–275. Especially plate 4, figure 10, and p. 263.

faces at right angles to these may all be equally inclined to the surface of the pyrite. The mineral with this arrangement has a rhombohedral appearance (imperfectly shown in the upper central portion of figure 2, plate LIX), but its true nature is revealed by exposing the cleavages, which are parallel to the external planes. At times, as is shown in plate LIX, figure 1, irregular branching forms, suggestive of fantastic figures, result from this orientation.

The preceding conclusions were arrived at by a study of dozens of cleavage fragments under the microscope and an examination with hand lens of the galena in place, the prominent cubic cleavage in all cases serving as a means of orientation. Measurements of the cleavage by the microscope gave 90½°, 89½°, 90°, 89°. Several fragments showed secondary octahedral cleavage, which is rare for galena. One example is pictured in figure 83, in which a corner of

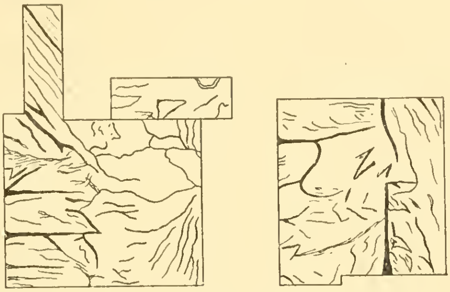

FIG. 85.—Greatly enlarged cleavage surfaces of galena, showing groovings visible by incident sunlight under the microscope.

a cleavage cube is broken across by a series of smaller cubes, with their corners, in turn, truncated by minute triangular octahedral faces.

An examination of cleavage surfaces under a high magnifying power, illuminated by incident sunlight, reveals a complicated series of striations and groovings. The striations are exceedingly minute, visible as fine hair-lines only under the most favorable conditions of reflection. There are two sets at right angles to each other and parallel to the edges of the square cleavage fragments, which may represent incipient cleavages; a third set, less distinct, is sometimes present, cutting the cubic cleavage and striations diagonally. The last holds positions identical with the trace of octahedral planes. More prominent than the striations, and much broader comparatively, are the members of a complicated series of sinuous grooves. Figure 85 is a free-hand sketch of the pattern made by these. It is seen that the groovings are predominantly parallel and diagonal to the cleavage, though many of the lines have apparently no definite orientation.

Qualitative chemical tests of the galena disclose, in addition to the lead and sulphur, the presence of silver and antimony. A careful examination for bismuth gave negative results. This becomes of interest in view of the fact that in much of the galena from other localities, known to possess octahedral cleavage, amounts of Bi_2S_3, ranging around 1 per cent, have been found, and it has been suggested that the peculiarity of cleavage might be due to the presence of this impurity.[4]

So far as the writer has been able to learn from a survey of the most important literature on the subject, the peculiar development of galena herein described has not been previously met with. Scharff,[5] Sadebeck,[6] vom Rath,[7] Hobbs,[8] Franke,[9] Miers,[10] Rogers,[11] Mügge,[12] Wada,[13] and others have described galena bearing some analogies to that here depicted, but in no case is the resemblance more than partial.

The chalcopyrite.—This mineral occurs in an irregular mass 7 mm. in diameter, shown in plate LIX, figure 1, and in two or three other smaller aggregates. It presents no peculiarities, either of crystal form or orientation.

Genesis.—The following features may have some bearing on the manner in which the specimen was formed: a few gold crystals are imbedded in the galena and one is partly enclosed by chalcopyrite; one small mass of the chalcopyrite is set in the galena; part of the

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[4] Dana's System of Mineralogy, 6th ed., p. 49.

[5] Previously cited.

[6] Sadebeck, A. Ueber die Krystallisation des Bleiglanzes. Zeitsch. für. Deutsch. geol. Gesel., vol. 26, 1874, pp. 617–670.

[7] vom Rath, A. Mineralogische Notizen. See Zeitsch. für. Kryst., vol. 4, 1880. p. 425.

[8] Previously cited.

[9] Franke, H. Galenite und Dolomite von Oradna in Siebenbürgen. Abhand. d. naturw. Ges. Isis., 1896, p. 25. Abstract: Zeitsch. für Kryst., vol. 30, 1898, p. 663.

[10] Miers, H. A. Mineralogische Notizen. Zeitsch. für Kryst., vol. 31, 1899, p. 584.

[11] Rogers, A. F. Minerals from the Joplin Zinc and Lead District. Kan. Univ. Quart., vol. 9, 1900, pp. 161–165.

[12] Mügge, O. Ueber regelmassige verwachsungen von Bleiglanz mit Eisenkies und Kupferkies mit Kobaltglanz. Tschermak's min. u. petrog. Mitth., vol. 20, 1901, pp. 349–354.

[13] Wada, T. Mineralien Japans, 1904. Abstract, Zeitsch. für. Kryst., vol. 43, 1907, p. 109.

gold and galena is surrounded by low ramparts of pyrite; the gold is never more than half buried; so far as the interior of the crystal can be examined by means of the two pits, none of the three associated minerals can be discovered within the pyrite. The most probable paragenesis is therefore regarded as this: The pyrite, when its present size was nearly attained, sustained a deposition of crystallized gold upon its surface followed by the precipitation of a small amount of chalcopyrite which, in turn, was succeeded by the formation of the galena. A further slight accretion of pyrite completed the development of the specimen.

EXPLANATION OF PLATE LIX

FIG. 1. Cube face of pyrite, showing crystals of gold, fantastic branching forms of galena, and aggregate of chalcopyrite. The striations on the pyrite, with their octahedral terminations, may also be seen. Magnified about one and one-half times.

FIG. 2. Cube face of pyrite, showing galena of various appearances. Magnified about one and one-half times.

1

2

CUBE FACE OF PYRITE

See explanation, page 484

A NEW CARNIVORE FROM BRITISH EAST AFRICA

By GERRIT S. MILLER, Jr.

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With Three Plates

A series of seven specimens of *Otocyon* collected by Dr. Edgar A. Mearns and Mr. J. Alden Loring, of the Smithsonian African Expedition, at Naivasha Station, British East Africa, represents a species readily distinguishable from *O. megalotis* of the Cape region. It may be named and described as follows:[1]

OTOCYON VIRGATUS, sp. nov.

Type: Cat. No. 162125, U. S. N. M. Adult male (skin and skull), collected at Naivasha Station, British East Africa, August 8, 1909, by J. Alden Loring. Original number 6962.

Diagnosis: Size and general appearance as in *Otocyon megalotis*, but underparts rich buff instead of whitish, and tail with conspicuous black dorsal stripe. Skull differing from that of *O. megalotis* in the flatter less inflated audital bullæ and absence of notch between angular and subangular processes of mandible. Fourth lower molar normally with two small but evident posterior cusps, its elements as in the preceding tooth.

Color: Entire dorsal surface from between ears to base of tail a nearly uniform coarse grizzle of black and light cream-buff, the cream-buff in excess everywhere except along median line, where the two colors are about evenly balanced; long hairs blackish throughout except for a cream-buff annulation about 5 mm. wide situated 5 to 10 mm. below tips; hairs of underfur drab-gray through basal half, then a rather light ochraceous-buff to tips, this color nearly overlaid by the grizzle of the longer hairs, but appearing irregularly at surface where hairs are disarranged; sides of body like back, but becoming suffused with ochraceous-buff below; underparts ochraceous-buff, brighter and more nearly a clear buff on throat, duller and

[1] This paper is the third dealing with the results of the expedition. The other papers are Nos. 1879 and 1880 in the same series as the present publication.

more brownish between fore legs; axillary region pale cream-buff in rather noticeable contrast; crown from between ears to between eyes a light indefinite grizzled gray, contrasting slightly with region behind it and conspicuously with the dark hair-brown of muzzle, forehead, upper eyelid (about 3 mm.) and upper half of cheek; lower half of cheek nearly like crown, but with a slight buffy tinge; chin dark hair-brown at extreme front, then blackish to a little behind angle of mouth; outer surface of ear between ochraceous-buff and wood-brown at base, darkening abruptly to a dark sepia on terminal third, the extreme tip blackish; margin of ear (except at blackish tip) pale cream-buff, a sprinkling of hairs of the same color on inner surface; fore legs ochraceous-buff, heavily clouded with sepia on outer surface, and darkening to blackish on feet; hind legs ochraceous-buff on inner surface, grizzled like sides externally, but more clouded with black, especially along anterior region of juncture between grizzled and ochraceous-buff areas; hind feet blackish, the soles tinged with ochraceous-buff; tail ochraceous-buff, grizzled like back at extreme base above, elsewhere essentially clear except for the black tip (about 80 mm.) and the sharply defined black dorsal stripe about 25 mm. wide extending from black terminal area to about base of middle third of tail, where it abruptly ends.

Skull: As compared with that of *Otocyon megalotis* as figured by Huxley[2] the skull of *O. virgatus* (plates LX–LXII) shows no special peculiarities in general form. The audital bulla is, however, less globular in outline, and its lower border does not descend so far below level of paroccipital process and glenoid surface. The mandible on the other hand differs strikingly from that of *O. megalotis* in the complete absence of a re-entrant notch between angular and subangular processes, the subangular region thus much resembling that of *Urocyon* except for its greater development backward so that its posterior edge lies below articular surface instead of below middle of coronoid process. Angular process apparently less curved upward than in *O. megalotis.* Coronoid process broad and relatively low, its posterior border sloping distinctly forward instead of nearly perpendicular.

Teeth: Though in general agreeing with those of the southern animal the teeth of *Otocyon virgatus* show certain peculiarities; pm_3 without trace of the "sharp cusp at the anterior end of its base" mentioned by Huxley (p. 260); m_4 much less reduced than that of *O. megalotis,* its elements exactly as in m_3. It is also worthy of

[2] Proc. Zool. Soc. London, 1880, pp. 257–258 and 263.

note that a fourth upper molar is not present in any of the eight skulls seen.

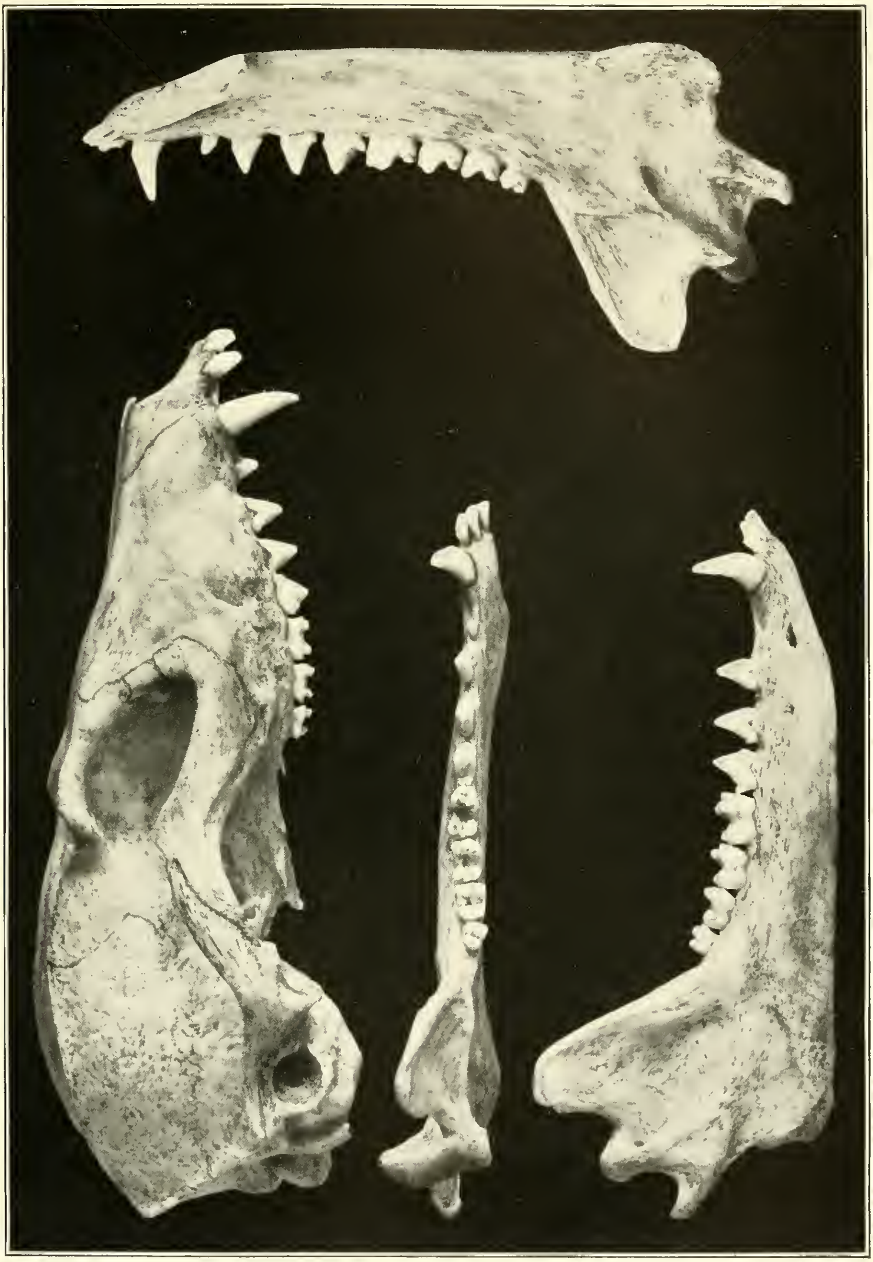
Measurements: Type: head and body, 550; tail, 281; hind foot, 137; ear from crown (dry), 105. Skull: condylobasal length, 113.6; basilar length, 106.8; zygomatic breadth, 64.8; mastoid breadth, 47.6; breadth of braincase, 43.4; postorbital constriction, 29.0; interorbital constriction, 23.0; breadth of rostrum over canines, 18.6; depth of braincase (median), 30.8; mandible, 86.2; maxillary toothrow exclusive of incisors, 44.4; mandibular toothrow exclusive of incisors, 51.6.

Specimens examined: Eight, the seven already referred to, and an adult taken at Taveta, British East Africa, in 1889, by Dr. W. L. Abbott.

Remarks: The specimens do not vary noticeably among themselves. In color the back is sometimes more buffy than in the type, owing to a more free appearance at surface of the ochraceous-buff underfur. Equally slight differences in the exact shade of buff of underparts are also to be found. The pattern of marking of the tail is strictly uniform in all the skins. In cranial and dental characters there are no variations worthy of note.

OTOCYON VIRGATUS, TYPE. NATURAL SIZE

OTOCYON VIRGATUS, TYPE. NATURAL SIZE



OTOCYON VIRGATUS, TYPE. NATURAL SIZE

DESCRIPTIONS OF FOSSIL PLANTS FROM THE MESOZOIC AND CENOZOIC OF NORTH AMERICA. I.

By F. H. KNOWLTON

With Two Plates

1. Two New Fossil Chain-ferns (Woodwardia) from Oregon and Wyoming

WOODWARDIA MAXONI, sp. nov.

Plate LXIII, Figure 3; Plate LXIV, Figures 1, 2

Outline of whole frond unknown; pinnæ lanceolate, broadest at base, narrowly acuminate at apex, cut ¾ or more of distance to the rachis into numerous, approximate, oblong, obtuse, often slightly falcate lobes which are finely serrate-toothed at apex, the basal lobes with small oblong or triangular auricles on the lower side; rachis very strong; midvein relatively strong, with a single series of elongate, or elliptic—oblong, slightly oblique, areoles on each side, the veins thence free to the margin; sori, as in the living species, linear or oblong, one to each areole, becoming confluent with age; indusium attached by its outer margin to the fruit-bearing veinlet.

Type: U. S. N. M., 33992 [pl. LXIV, fig. 1]; co-types 33993 [pl. LXIV, fig. 2]; 33994 [pl. LXIII, fig. 3].

Locality: Southeast of Rock Springs, Wyoming.

Geological horizon: Fort Union (Eocene).

This splendid species is represented by a large number of well-preserved specimens, but as all are in the form of detached pinnæ we are still in ignorance of the outline of the whole frond, though it must have been of imposing size and appearance. The pinnæ, as stated in the diagnosis, are lanceolate in shape, and, so far as observed, are always broadest at the base and narrowly acuminate at the apex. The largest, evidently nearly perfect, pinna observed is 10.5 cm. in length and its width 2.75 cm. Other pinnæ, especially the fruiting ones, are slightly smaller, though the difference is not great. In only one specimen is the extreme base of a pinna preserved, namely, that shown in figure 2. In this the basal lobes are provided on the lower side with small oblong or triangular auricles, and the pinna was apparently closely sessile.

The living species to which this fossil form appears to be most closely related is *Woodwardia virginica* (L.) Smith, the common chain-fern so widely distributed over eastern North America, from Nova Scotia to Ontario and Michigan, and south to Florida, Louisiana, and Arkansas. There are, however, a number of slight, though apparently constant, differences. In nervation and in the size and disposition of the sori, both young and mature, the two forms are practically identical. The differences are as follows: In *Woodwardia virginica* the pinnæ are almost always broadest in the middle and narrowed at base, usually very markedly so; in *Woodwardia Maxoni* they are always broadest at the base. In the living species the segments of the pinnæ are rather open or spreading and have the margins entire, while in the fossil species the segments are very close and have the ends finely serrate. In no case have auricles been observed on the basal segments of the pinnæ in the living species; as above stated, they are present in the fossil species.

Among the several fossil species previously described from this country, the one under discussion appears to approach closest to *Woodwardia latiloba* Lesquereux[1] of the Denver beds of Colorado, but from this it differs essentially in size, shape, and nervation. The other American fossil species, as set forth in the discussion under the succeeding species, all belong to other sections of the genus as gauged by the living species.

The material upon which *Woodwardia Maxoni* is based was obtained from two localities, though practically at the same horizon. The first locality is on the Brown's Park stage road about 35 miles southeast of Rock Springs, Wyoming (4 miles east of Mud Springs), in section 35, township 15 N., range 102 W. Collectors, C. A. Fisher and T. W. Stanton, July 25, 1908. This material is mostly sterile, there being only a single fragment in fruit. (See figure 3, plate LXIII.) The other locality is also on the Brown's Park stage road on the head of Vermilion Creek, about 47 miles southeast of Rock Springs, Wyoming, in section 31, township 15 N., range 101 W. Collectors, A. C. Veatch and A. R. Schultz, July 27, 1908. Nearly all these specimens are in fruit. (See figure 1, plate LXIV.) Both localities are very near the base of the Fort Union formation, here resting unconformably on the Lewis shale.

I take pleasure in naming this species in honor of Mr. William R. Maxon, of the U. S. National Museum, who has rendered valued assistance in the study of this and other fossil ferns.

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[1] Rept. U. S. Geol. Surv. Terr., vol. 7 (Tert. Fl.), 1878, p. 54, pl. iii, figs. 1, 1*a*.

WOODWARDIA COLUMBIANA, sp. nov.

PLATE LXIII, FIGURES 1, 2

Outline of whole frond unknown, though presumably the frond was pinnate; pinnæ lanceolate, apparently broadest at base, cut nearly to the rachis into numerous, linear or lanceolate, acute-pointed segments which are entire or rarely undulate-margined, and separated by deep rounded sinuses; rachis strong; midvein or midrib of segments relatively slender; veinlets forming a single row of large, oblong, sorus-bearing areolæ on either side of, and parallel to the midrib, outside of which is a single series of smaller areolæ oblique to the midrib, the veinlets thence free to the margin; sori linear or oblong, in a chain-like row on either side of the midrib and attached to the outer margin of the fruit-bearing areolæ.

Type: U. S. N. M. 7529 [pl. LXIII, fig. 1]; co-type, 7528 [pl. LXIII, fig. 2].

Locality: Cascades of Columbia River, Oregon.

Geological horizon: Pleistocene.

This species is represented by a large number of specimens, two of the best of which are here figured. Unfortunately all are in the form of detached pinnæ, so we are left in ignorance of the form of the whole frond, though, following its analogy to what are obviously its nearest relations among the living species, it was without much doubt pinnate, and must have presented an imposing appearance when living. The most perfect pinna observed in the collection is 14 cm. in length, but as this lacks both base and apex, considerable being apparently missing at both points, it seems probable that the length when perfect could hardly have been less than 18 or 20 cm. The width of the pinnæ is from 5 to 8 cm. As may be seen from the figures, especially figure 1, the pinnæ are cut nearly to the rachis into numerous linear or lanceolate, rather remote segments which are separated by deep, broad, rounded sinuses. The margin of the segments are entire or exceptionally undulate. The nervation, which is fully described above and well shown in the figures, is characteristically that of the section *Euwoodwardia* of the living species, which, to quote from Underwood,[2] has the "fronds uniform, the veins forming at least one series of areolæ between the sori and margins." The sori, as beautifully shown in figure 1, are oblong or linear, and in a chain-like row on either side of the midrib, the

[2] Our Native Ferns and their Allies, 6th Ed., 1900, p. 102.

indusia being attached to the outer margin of the fruit-bearing veinlets.

The only living North American species belonging to the section *Euwoodwardia* is *Woodwardia spinulosa* Martens and Galeotti, described originally from Mexico, which is found also in Guatemala, Arizona, California, and Washington. This species was formerly included under the Old World *W. radicans* (L.) Smith, but recently pteridologists have quite generally separated it, principally on the ground that the segments are shorter and less pointed, the row of sterile areoles outside the fruiting row is usually confined to the basal portion instead of being distinctly double throughout, and finally that the segments are separated by rather broad and round, instead of by deep, sharp sinuses; the margins of the segments in both species are usually spinulose.

The fossil species under consideration appears to combine to some extent the characters of both of the above mentioned living species. Thus it has a complete row of areolæ outside of the large fruiting row, as in *W. radicans,* but it agrees with *W. spinulosa* in having relatively short segments separated by rounded sinuses; it differs from both in having the margins of the segments entire, or at most slightly undulate.

The material upon which this species is based was collected by Mr. G. K. Gilbert, of the U. S. Geological Survey, at the Cascades of the Columbia River, Oregon.

2. A New Name for Davallia tenuifolia Swartz, as Identified by Dawson, and Asplenium tenerum Lesquereux

DENNSTÆDTIA AMERICANA, nom. nov.

Plate LXIII, Figure 4; Plate LXIV, Figures 3–5

Davallia (*Stenoloma*) *tenuifolia* Swartz. Dawson, Brit. N. A. Boundary Commission (Rept. Geol. and Resourc. Vicinity 49th Parallel) 1875, Appen. A, p. 329, pl. xvi, figs. 1, 1*a,* 2, 2*a;* Roy. Soc. Canada, Trans., vol. 4, 1886 [1787], p. 21, pl. i, figs. 1, 1*a,* 1*b;* Penhallow, Rept. Tert. Pl. Brit. Columbia, 1908, p. 52.

Asplenium tenerum Lesquereux. Rept. U. S. Geol. Surv. Terr., vol. 8 (Cret. and Tert. Fl.), 1883, p. 221, pl. xlviA, figs. 1, 2. [Not *Asplenium tenerum* Forster, Florulæ Insularum australicum Prodromus, 1786, p. 80.]

Frond apparently lanceolate in outline, bipinnate, the rachis relatively strong, grooved; pinnæ alternate, oblique, lanceolate or sometimes linear, pointed; pinnules deltoid or oblong, oblique, unequal-sided, closely sessile or slightly decurrent, cut more or less deeply into oblong, obtuse lobes—usually five on each side—which are entire or occasionally with a few low teeth; nervation delicate, consisting of a slender, slightly flexuose pinnately dichotomous midvein, with lateral nerves at an acute angle of divergence and once or twice forked; sori small, globular, on the apex of a free vein, and marginal on the tips of the lobes of the pinnules, mostly on the upper side.

This species is represented by a large number of specimens from a number of widely separated localities, though so far as known all are from the same geological horizon. They are mostly in the form of portions of detached pinnæ, of greater or less size, although occasionally a pinna is found nearly perfect, and in a few instances a considerable portion of the whole frond has been found, such, for instance, as that shown in plate LXIV, figure 5. From this it appears that it was a delicate fern of rather strict habit and apparently lanceolate in general outline. It is impossible to give the exact size, but it was at least 15 or 20 cm. in length and 8 cm. or more in width. It is not rare to find pinnæ that are 8-10 cm. in length, though the majority are apparently somewhat less than this. They are alternately and very obliquely placed on the rachis, and have a relatively rather strong secondary rachis. The pinnules are also obliquely attached, and are either sessile or sometimes slightly decurrent. In shape they are deltoid or oblong, largest on the upper side, and cut often rather deeply into oblong, obtuse usually entire lobes, on the apices of which, usually on the upper side, the sori are borne. The largest pinnules observed are about 18 mm. in length and 10 mm. in width, but the average size is much less.

This fern is referred without hesitation to the genus Dennstædtia, since it is closely congeneric in habit, nervation, and fructification with the numerous species now segregated under this designation. It is not particularly close to *Dennstædtia punctilobula,* the only living North American species, but appears to find its closest relationship in *D. scabra* (Wall.) Moore, a species widely spread over China and tropical Asia. From this it differs in being bipinnate instead of tripinnate, as well as in its narrower fronds, more slender pinnæ, and much smaller pinnules; its general appearance, however, is much the same.

The fern here renamed *Dennstædtia americana* has had a rather complicated nomenclatorial history. It appears to have been first found in 1875 near Porcupine Creek, Saskatchewan, by the British North American Boundary Commission, and was referred by Dawson to *Davallia* (*Stenoloma*) *tenuifolia* Swartz (now called *Odontosoria chinensis* (L.) J. Smith), a living species widely spread over Japan, China, tropical Asia, Polynesia, and Madagascar. A careful comparison of the sori, which are often in an admirable state of preservation, shows, however, that it is not congeneric with the forms now placed in Odontosoria, but is distinctly so with the species of Dennstædtia.

In 1883 Lesquereux[3] described and figured sterile portions of this fern from Fort Union beds at Gilmore Station, supposed to be in North Dakota,[4] under the name of *Asplenium tenerum*, apparently not connecting it with the fragments previously referred by Dawson, as set forth above, to *Davallia tenuifolia* Swartz. In transferring this material to the genus Dennstædtia, which the fruit characters now enable us to do, Lesquereux's specific name if valid should be the one available for the species, but unfortunately it has never had nomenclatorial standing, being antedated nearly a hundred years by *Asplenium tenerum* Forster,[5] a living species, and moreover this combination has been twice employed for different living forms between its use by Forster and Lesquereux, namely, Raddi, 1819, and Gaudichaud-Beaupré, 1827. It becomes necessary, therefore, to rename it, and I have called it *Dennstædtia americana*.

Although Lesquereux did not possess fruiting material of this fern, he evidently had a pretty clear idea as to its relationship, for he says: "Its nearest affinity is with living species of *Asplenium* of the section of the *Dicksoniæ*, like *Dicksonia tenera*, etc." Modern study of the ferns has resulted in drawing sharper generic lines, and not only has Asplenium, but what was long accepted as Dicksonia, been segregated into a number of smaller genera, such as Dennstædtia, Odontosoria, etc.

So far as I know there are no fossil ferns described in this country that are likely to be confused with the one under consideration, though, as both Dawson and Lesquereux pointed out, it is probable

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[3] Rept. U. S. Geol. Surv. Terr., vol. 8 (Cret. & Tert. Fl.), 1883, p. 221, pl. xlviA, figs. 1, 2.

[4] The full locality is given as "Bad Lands near Gilmore Station of the U. P. R. R. Collected by Professor Wm. Denton." I have not been able to identify exactly this locality, but it is reasonably certain that "U. P. R. R." is an error for N. P. R. R., since Professor Denton is known to have collected in the Bad Lands of North Dakota, and possibly adjacent Montana, through which runs the Northern Pacific railroad. Moreover, this species has since been collected at a number of places in North Dakota.

[5] Flor. Ins. austral. Prod., 1786, p. 80.

that *Sphenopteris Blomstrandi* Heer,[c] from the Miocene or upper Eocene of Greenland, is at least con-generic with it.

Dennstædtia americana is characteristic of the Fort Union formation, never having been, so far as I know, found outside of it. Following is a list of localities and collectors:

Porcupine Creek, Saskatchewan; British North American Boundary Commission, 1875.

Gilmore Station, North Dakota (?); Wm. Denton, about 1882.

Black Butte, 45–50 miles south of Medora, North Dakota; Earl Douglass, 1905.

Custer Trail Ranch, 5 miles south of Medora, North Dakota; F. H. Knowlton, 1907.

Sentinel Butte, North Dakota; F. H. Knowlton and A. C. Peale, 1907.

Thirty-five miles southeast of Rock Springs, Wyoming, about 100 feet above base of formation; C. A. Fisher, T. W. Stanton, and F. H. Knowlton, July, 1908.

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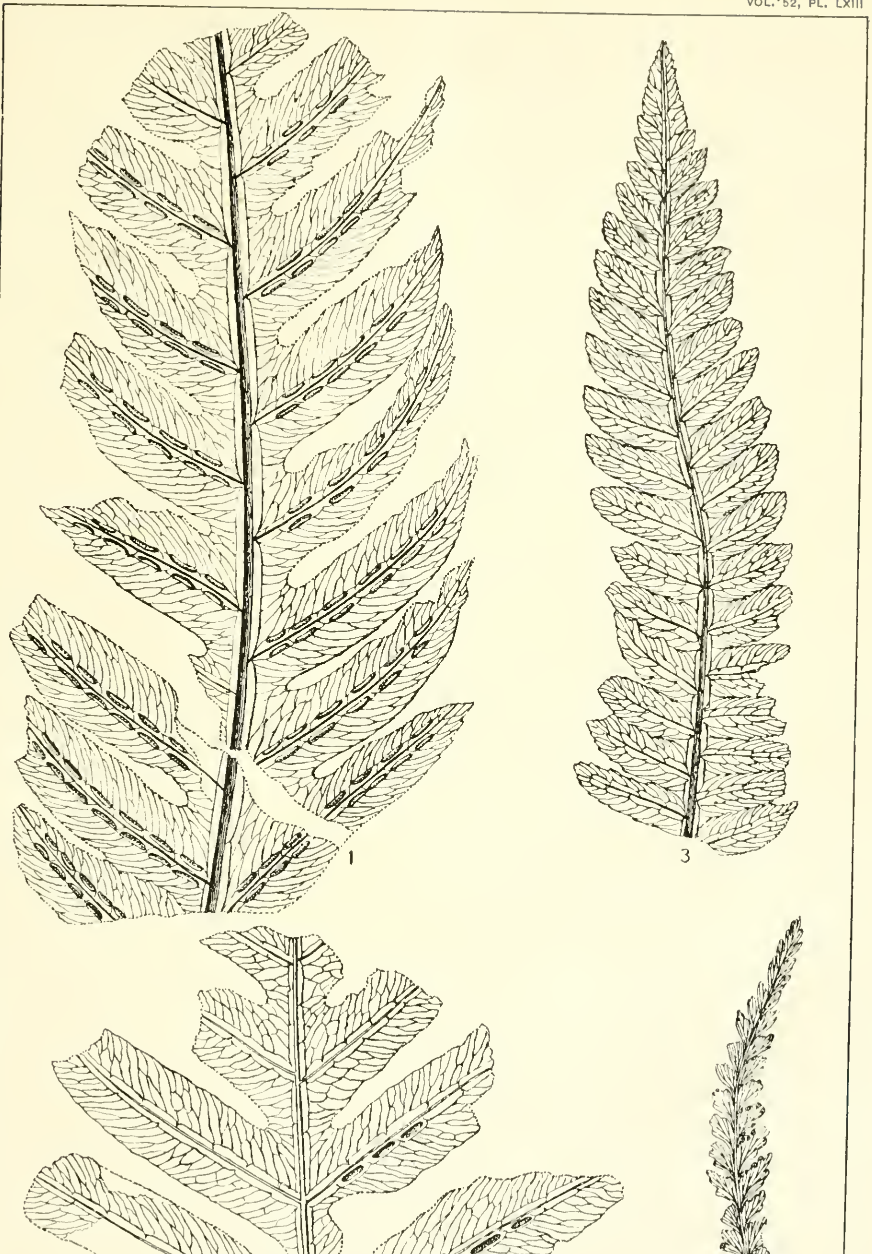
[c] Fl. Foss. Arct., vol. I, 1868, p. 155, pl. xxix, figs. 1, 5, 9

EXPLANATION OF PLATES

PLATE LXIII

PLATE LXIV



WOODWARDIA AND DENNSTÆDTIA

See explanation, page 496

TWO NEW GENERA OF MURINE RODENTS

By GERRIT S. MILLER, Jr.

Curator, Division of Mammals, U. S. National Museum

The murine rodents known as *Lemmus schisticolor* and *Cricetulus bedfordiæ* differ so markedly from the types of their respective groups as to require generic separation. In each instance the principal distinguishing characteristics are to be found in the feet.

MYOPUS, gen. nov. (Microtinæ)

Type: Myodes schisticolor Lilljeborg.

Characters: Skull and teeth as in *Lemmus;* general form vole-like, with distinct though short neck, the head not appearing to rest

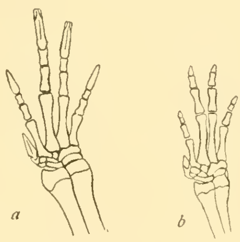


Fig. 86.—Skeleton of forefoot of *Lemmus* (*a*) and *Myopus* (*b*). ×2.

between the shoulders; ear well developed though small, with distinct meatal valve; feet slender, normal, the palm and sole with fully developed functional tubercles and no unusual growth of hair; metacarpals of third and fourth fingers slightly longer than phalanges; ungual phalanges of manus normal, much shorter than first and second combined, the claws not enlarged (see fig. 86).

Remarks: The genus *Myopus* is characterized by the combination of the skull and teeth of *Lemmus* with the general body form and non-specialized foot structure of the true voles. It therefore represents in the Old World a stage of development equivalent to that of the American *Synaptomys*. Only the type species is known.

PHODOPUS, gen. nov. (Cricetinæ)

Type: Cricetulus bedfordiæ Thomas.

Characters: Externally like *Cricetulus,* but feet unusually short and broad, densely hairy throughout, the tubercles of both palm and sole confluent into a single blister-like mass (fig. 87); skeleton of feet shortened, but proportionate lengths of bones not specially modified; skull essentially as in *Cricetulus,* but brain-case less murine in form, unusually broad and deep in front, narrow and low behind; outer wall of infraorbital canal very short, invisible when skull is viewed from above, its form much as in *Mesocricetus;* pattern of enamel folding more simple than in any of the other Old World *Cricetinæ,* the salient angles opposite, the reentrant angles of outer side of maxillary teeth not curving backward, those of inner side of mandibular teeth not curving forward.

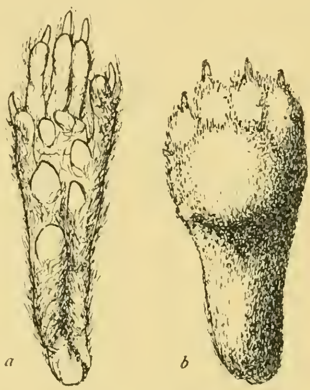


FIG. 87.—Sole of hind foot of *Cricetulus* (*a*) and *Phodopus* (*b*). × 3.

Remarks: In its highly modified foot and simple teeth *Phodopus* shows a peculiar combination of primitiveness and specialization. While the type species is the only one that I have examined, it is not improbable that *Cricetulus roborowskii* Satunin should be referred to the same group.

A SHELTER FOR OBSERVERS ON MOUNT WHITNEY

By C. G. ABBOT

Director of Smithsonian Astrophysical Observatory

With Two Plates

There have been few American scientific expeditions which have excited more interest here and abroad than Mr. Langley's expedition to Mount Whitney in 1881. It was undertaken to determine the relative transparency of the air at high and low altitudes, and thereby to fix the value of the "solar constant of radiation." If we measure the intensity of sun rays at the earth's surface by wholly absorbing them during a noted time interval over a measured area and expressing the results in heat units, we do not get a true measure of the intensity of the sun's output of radiation, owing to the losses in the air; neither can these losses be allowed for by merely measuring the total radiation at different hours of the day, when different thicknesses of air are traversed, for the losses affect the intensity of rays of different colors differently, and some rays are almost wholly cut off in the upper air, so that they cannot be estimated in any easy manner. Langley recognized the necessity of measuring the intensities of rays of all wave-lengths separately, and acted upon his discovery by employing the bolometer (a highly sensitive electrical thermometer) to measure in all parts of the solar spectrum. Observations at Allegheny, Pennsylvania, were disappointing, owing to the dusty state of the lower air; hence he formed the plan of going to a high altitude in the then little known West with the complete complex outfit which he called the spectro-bolometer. His plans called for observations at a low station and, as nearly as possible simultaneously, at a very high station near by. On the advice of those who knew the region, he chose Mount Whitney, in the Sierra Nevada range, since shown to be the highest peak in the United States (proper), for his high station, and Lone Pine, in the Owens Valley, only about 15 miles distant, as the lower one. Mount Whitney has an elevation of 14,502 feet; Lone Pine, only 3,850 feet.

Mr. Langley's expedition was not lacking in features of interest and picturesqueness, apart from its highly valuable scientific aims. It was financed by the late William Thaw, of Pittsburg, a man who supported Langley's work on many occasions, but always stipulated that his name should not appear in the published acknowledgments. The expedition was carried on and its results published under the auspices of the Signal Service of the United States Army, and a detail of Signal Service officers assisted in the observations. The Pennsylvania Railroad provided a private car, which was furnished free transportation to San Francisco by the Pennsylvania, Union Pacific, and Central Pacific railroads. A military escort was provided from San Francisco to Mount Whitney. The expedition traversed the Mojave desert in August on the way to Lone Pine, certainly a novel experience for Easterners. It is unquestionable that the success achieved was due in no small measure to the presence of the late Mr. Keeler, afterwards the discoverer of the nature of the rings of Saturn, and always distinguished for his wonderful skill and resourcefulness in observation, as well as for his charming personality. The traditions of the expedition, including the story of the Dutch oven, the swim in the icy lake, the attendance at the dance, were ever interesting when heard from Keeler's lips.

Langley found it impracticable to carry his spectro-bolometer to the summit of Mount Whitney, and contented himself with observing at "Mountain Camp," now known as "Langley's Camp," on the west side of Mount Whitney, at an elevation of 11,700 feet. The results obtained on the expedition were of great value, but, unfortunately, for 25 years they retarded rather than aided the progress of science, because Langley erred in his theoretical construction of them, and set the value of the solar constant at 3.0 calories per square centimeter per minute rather than 2.1, which his observations give when rightly reduced. On his return to the East he recommended that Mount Whitney be reserved by the Government as a favorable site for a high-altitude observatory, and his recommendations were favorably acted upon. Mount Whitney is now included in the Sequoia National Forest.

We now pass to the steps which led to the actual occupation of the summit of Mount Whitney for observing purposes. The expedition of Langley ascended by a circuitous route from Lone Pine, which occupied several days' time and led by a discouraging series of ups and downs to Mountain Camp. Farther advance by that route with animals was then impossible and is so still. In 1904 the citizens of Lone Pine and vicinity, under the leadership of Mr. G. F. Marsh, built a trail to the summit of Mount Whitney, directly up Lone Pine Cañon, over a pass at 13,400 feet, and thence as high as possible on the west side of the range, over a waste of granite rocks of all sizes, to the very summit of the mountain. Funds were scanty, and it was only by the greatest economy, pluck, and perseverance that Mr. Marsh succeeded in getting his trail to the top. To an Easterner it is hardly a trail even now, and even Mr. Marsh said to the writer on our last descent that he hardly saw how the mules could go over it, unless they had hooks on their hind feet to hang on by till they found a place for their fore feet. There are places where, with almost precipitous descent staring them in the face, the mules must step down as far as from a high desk to the floor, landing on jagged rocks, not on dirt or sand. However, they do go over the trail, and in the transportation this year of upwards of 20,000 pounds of material and apparatus for the Smithsonian Institution not a mule was lost or seriously hurt and no material was even injured, thanks to the skill of the packers, especially Mr. Horace Elder. The west slope of the ridge leading to Mount Whitney is extremely rough and broken throughout. Pinnacles of naked rock rise often nearly vertically, and are crossed both vertically and horizontally by seams and cracks in such a manner as to give the impression of being a very crazy, crumbling, insecure structure, likely to be shaken down if a great earthquake should come. Indeed the whole slope is covered, clear to "Langley's Meadow," with rocks of all sizes which have broken off and rolled down. It was through this difficult country that the Lone Pine citizens built their trail. In some places, where they could only proceed by blasting, the rock was too crumbling to be drilled, so that the powder charge had to be tamped into a crack between rocks, and when exploded would bring down a slide from above sufficient to fill all the space cleared by the blast, and all would have to be done over again and again. It reflects very high credit on Mr. Marsh and his supporters that the trail was ever completed.

To Director W. W. Campbell, of the Lick Observatory, is due the credit of initiating plans for a shelter on Mount Whitney. The following account is from a recent note by him "On the spectrum of Mars" in Publications of the Astronomical Society of the Pacific (vol. XXI, No. 128, October, 1909, pages 201-2).

"When the spectrum of Mars was under observation extensively at Mount Hamilton in 1894, for the purpose of detecting the presence of water vapor in that planet's atmosphere, I realized that the water vapor in the earth's atmosphere was and is the great obstacle in the way of success, and I then resolved to observe the spectrum of Mars from the summit of Mount Whitney, the highest point of land in the United States, when the planet should again come into a position favorable for the purpose. This would occur in August-

September, 1909, when Mars would be near the earth and high above the horizon, at the time of year when Mount Whitney could be ascended with instruments.

"Late in August, 1908, I ascended Mount Whitney, in order to determine the limiting sizes of instruments which could be transported over the rocky trail on the backs of pack animals, and to plan the living arrangements for the proposed expedition of 1909. I was accompanied by Director C. G. Abbot, of the Smithsonian Institution Observatory, who was interested in the summit of Mount Whitney in connection with high-altitude studies of solar radiation, as Professor Langley's pioneer expedition had been interested in 1881. We remained on the summit through the night of August 24, 1908. The readings of the dry- and wet-bulb thermometers obtained by Director Abbot indicated that the conditions were extremely favorable for the solution of the proposed problem. Before leaving the summit I decided definitely that observations in 1909, requiring a residence of a week or more, should not be undertaken unless a building of some kind could be erected as a shelter in case of storm, and the question of ways and means was discussed. Director Abbot suggested that the purposes of such a building might perhaps come within the scope of the Hodgkins Fund of the Smithsonian Institution. A few weeks later, after receiving my description of a building which would meet the needs of the proposed expedition, he was pleased to present the subject to Dr. C. D. Walcott, Secretary of the Smithsonian Institution, for consideration. Through the Secretary's lively interest an appropriation to provide the building for the shelter of the 1909 and any worthy future expeditions was made."

The sketch and specifications proposed by Director Campbell contemplated a three-room hut with stone walls and steel roof and doors, to be used not primarily as an observatory, although it might be convenient to use a part of it occasionally as a dark-room for photography, but rather as a shelter and living quarters for observers in any branch of science who might apply to the Smithsonian Institution for permission to use the building during the progress of observations. Not only astronomers, but meteorologists, physicists, chemists, geologists, and perhaps botanists, zoologists, and medical men, might desire to make experiments on the top of Mount Whitney. The writer transmitted Director Campbell's plans with a letter of explanation and recommendation to Secretary Walcott, who, on October 30, 1908, approved a grant from the Hodgkins Fund for erecting the proposed shelter on Mount Whitney.

PERSPECTIVE ELEVATION OF MOUNT WHITNEY SHELTER

Messrs. Speiden and Speiden, architects, under the writer's instruction, worked up the plans for the structure nearly as contemplated by Director Campbell. Figure 88 and plate LXV give the ground plan and perspective elevation as constructed. Two of the rooms communicate, and are kept locked by the Institution except when in use by authorized observing parties. The third room is accessible to the general public, and will doubtless be very welcome to persons who may be caught by storms or cold blasts on the top of Mount Whitney.

In carrying out the construction Director Campbell offered to act as the Institution's agent in San Francisco to award contracts for steel and cement, and to supervise the construction and actual trial erection in San Francisco of all steel parts. He performed this work

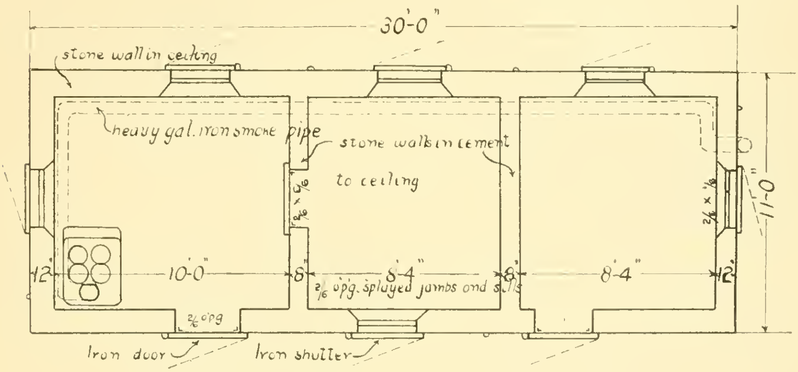
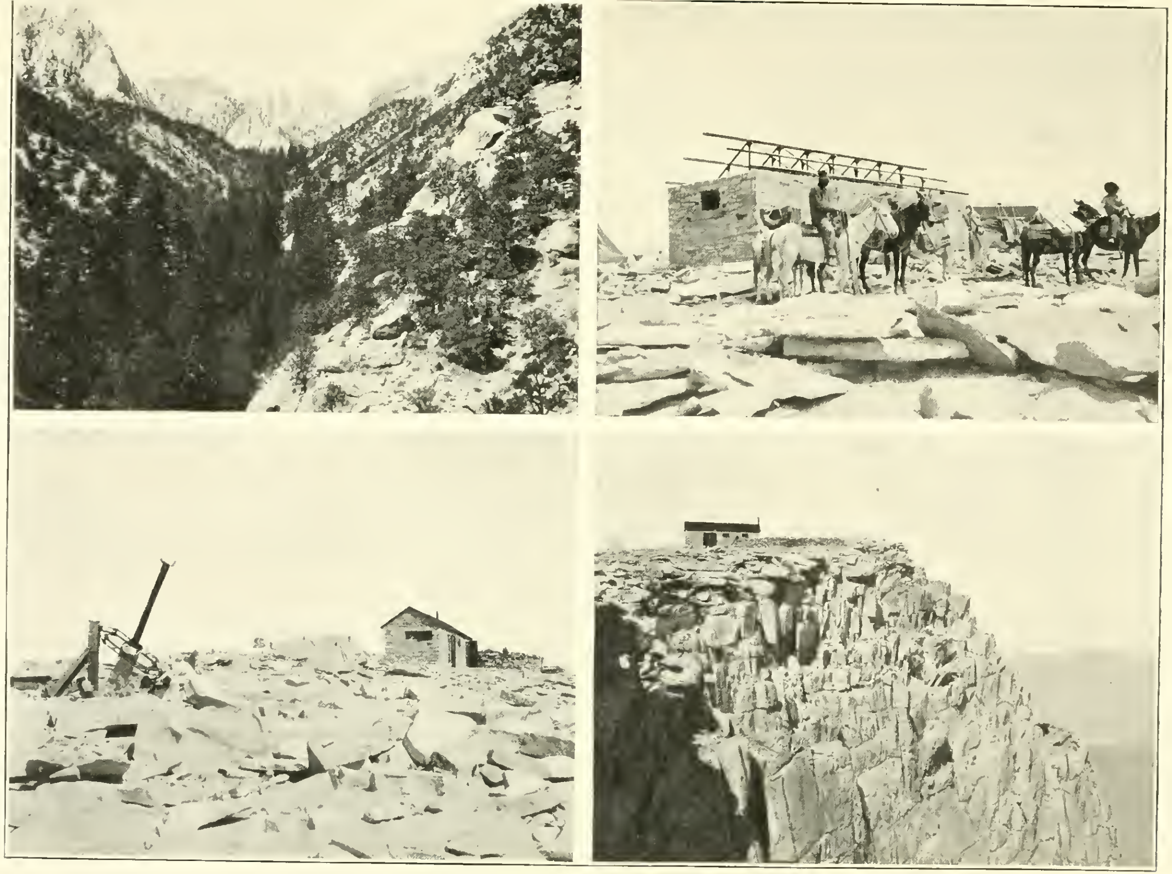


FIG. 88.—Ground plan of Mount Whitney shelter.

with the most conscientious and painstaking care. The charge of the transportation from Mount Whitney Station to the summit and of the construction of the building were intrusted to Mr. G. F. Marsh, of Lone Pine. It was an article of agreement with Mr. Marsh that the Institution should be at no expense for the repair of the trail, and so as early as April Mr. Marsh and his friends held a ball at Lone Pine which proved to be a highly enjoyable and successful affair and netted a considerable fund. As soon as work could begin he started repairs on the trail, but was hindered by the deep snows until later than had been expected. The first mule train reached the top July 28, 1909, and Mr. Marsh completed the house just a month later. Some of the difficulties he overcame are mentioned in a report the writer made of his trip to Mount Whitney in August, 1909, from which quotations follow. During a part of this stay of 2½ weeks Director Campbell's party was there for the study of the spectrum of Mars, and the writer is under obligations to them for their kindness and good fellowship.

"MOUNT WILSON, CAL., *Sept.* 14, 1909.

"DEAR SIR: I left Pasadena about 9.30 p. m., August 19, and took the 11.30 p. m. train at Los Angeles for Mojave. I slept occasionally but with great fear lest I should be carried by Mojave, and at length reached there, a little late, at 4.30 a. m. The train for Little Lake, mostly a freight train, left at 7 a. m., and, after stopping all along the way to shift and unload freight cars, reached Little Lake, 3½ hours late, at 6 p. m. I got supper there and started by auto-stage at 6.15. Having 3 boxes of delicate apparatus, one of which I felt it necessary to carry in my arms, the ride of 50 miles from Mojave to Little Lake was not altogether pleasant. Two automobiles started together, but the one I was in stopped near Olancha and nearly two hours of work failed to start it, so that all the passengers crowded into the other. We reached Lone Pine at 11.30 p. m. At 8.30 a. m., August 21, with Mr. Wm. Skinner, of Lone Pine, as guide, and with a driver and animals to carry my baggage, I started for Mount Whitney. We camped about 4 p. m. with Mr. Robinson and his packers at Big Meadow; elevation about 10,500 feet. I found that nearly all the material for the house had gone up to the top, and my boxes were at Robinson's camp. Mr. Skinner and I left camp at 6 a. m. and arrived on the summit of Mount Whitney about 11 a. m., August 22. We found Mr. Marsh with four workmen. The walls of the building were done except gables and partitions, and the frame of the roof was up. The masons were laying the walls of the little stone hut for my work, and they finished it, including the roof, that day. Several 6 x 6 tents had been loaned by Professor Campbell, and in these we cooked, ate, and slept. Ham, bacon, Mulligan stew, and flap-jacks were the staple foods. I rather ran down during the week before Mr. Campbell came, and got into bed by Friday afternoon. Fortunately Mr. Campbell brought a doctor, who cured me in a couple of days. I found that a few days before my coming there had been a thunder-storm on the mountain one night. One of the men had gone out of the tent and had been nearly killed by lightning or fright. There is a monument close by where a man was killed by lightning in 1904. All the mountain was glowing with St. Elmo's fire, and they all had been pretty uneasy. On the following night all the workmen left Mr. Marsh and ran down the trail when another storm began. However, they returned to him in a couple of days, thanks to his grit in staying on top all alone. I found also that a number of people in Lone Pine had been working against the project, and that Mr. Marsh had had great difficulty to repair the trail. There was much snow and ice, and he and others were completely snow-blinded for a day or so. The packers had been slow in beginning, and had deserted the job once or twice, so that he had to leave the top once and go down to Lone Pine and stir up Mr. Robinson. Mr. Marsh told me that once he



SHELTER FOR OBSERVERS ON MOUNT WHITNEY

was so discouraged that he sat down on the trail and cried, but got up and went at it again. In the face of the opposition and the natural difficulties, I think very few men could have carried the job to completion. Marsh worked at all kinds of jobs himself—cooking, breaking stone, carrying stone, carrying snow for water, riveting and cementing, as well as general bossing. He will never get paid in this world for the work he did on that house. I hope the Secretary will write him an appreciative letter of thanks.

"I had set my apparatus up mainly by Thursday night, August 26. Friday it snowed a little, but the house was finished Friday afternoon, August 27. Two of the workmen went down that day, and the masons on Saturday morning. On Friday about noon, three of us being seated about the stove, one of the workmen tried to show us how convenient a Smith & Wesson hammerless revolver is for shooting from the pocket. He forgot it was loaded, and it went off bang! and struck the stove pipe in the corner of the room. Fortunately nobody was hurt and the stove pipe was too thick to penetrate, so that the bullet fell at his feet. This celebrated the completion of the house.

"Mr. Campbell, with Messrs. Albrecht, McAdie, Dr. Miller, Hoover, and Skinner, came about noon on Saturday, August 28. They arrived in a thunder-storm of sleet. Lightning struck near by just as they reached the door. It became partially clear on the following Wednesday, and Campbell secured good observations on Wednesday and Thursday nights. My own preparations were set back by the storm, so that I only got ready Thursday afternoon, September 2. Friday morning was beautiful, and I think my observations of that forenoon were satisfactory. I took two bolographs also about 2 and 5 p. m. of Friday afternoon between clouds. On Saturday it snowed 4 inches. Mr. Campbell and party went down. They almost lost one mule among the rocks (had to leave the mule behind after two hours' work, but it went down the trail the following Wednesday), and three others slid off of the ice on the east side of the range and rolled a hundred feet or so. The Smithsonian has been so fortunate as not to have had any of the animals in its employ injured during the whole operations. This no doubt is largely due to the skill of the head packer, Horace Elder, of Lone Pine. He is said to be perhaps the most skilled packer in California, and his good nature and eagerness to do his best for us in the work were very refreshing. After waiting several days without much improvement in the weather, Mr. Marsh and I left on Wednesday, September 8. I hope it will be possible for me to complete my work up there next July or early August, when the weather will probably be better. We were very unfortunate this year in being up there while storms prevailed in Mexico and all over the Rocky Mountain States.

"A little later I hope to send pictures taken on Mount Whitney. One of the pictures which I did not get would have represented me on the back seat of the auto riding the 50 miles to Little Lake, holding my pyrheliometer box in my arms in a desperate effort to keep it from jolts, while I leaned over the back *seasick,* and all at 3.30 a. m., September 9.

"Yours truly, C. G. ABBOT.

"Mr. C. D. WALCOTT,
"Secretary Smithsonian Institution."

The observations of Director Campbell on the spectrum of Mars were entirely conclusive in showing that water-vapor, if present at all in the atmosphere of Mars, is in less quantity than is contained in the extremely rare and dry part of the earth's atmosphere which is above Mount Whitney. In fact, no evidence at all of water-vapor on Mars was detected by Campbell.

The writer's experiments involved the use of a complete spectro-bolometric outfit in the determination of the solar constant of radiation, and it was the first occasion in which this complex apparatus had ever been used at so great an elevation. Fortunately it worked well, the observations were highly satisfactory, and they yielded results which confirm almost exactly the accuracy of the work done by Smithsonian observers at Mounts Wilson and Washington in recent years. Unfortunately both Director Campbell and myself were on Mount Whitney during unusually unfavorable weather, for the whole Southwest, including northern Mexico, was just at that time visited by floods of rain and cloudy weather. Such a condition would not probably be met with at that season one year in ten.

It is the hope of the Smithsonian Institution that many observing expeditions in many branches of science will apply in the years to come for the use of its shelter on Mount Whitney. There are few mountain peaks in the world of like elevation which are so readily accessible, or which present more nearly the conditions of dryness and marvelous transparency of air which would be expected in high flights with balloons. Persons who desire to work upon Mount Whitney should apply to the Secretary of the Smithsonian Institution for information or permission to use the house there.

PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

Continued from List in Quarterly Issue, Vol. V, Part 3

No.	*Title.*	*Series.*	*Price.*
1869	Abbe, Cleveland. Mechanics of the Earth's Atmosphere. A collection of translations. Third Collection. Hodgkins Fund Publication. (In press)	M.C. 51	
1870	Greene, Edward Lee. Landmarks of Botanical History. Part I.—Prior to 1562 A. D. 1909	M.C. 54	
1871	Becker, George F., and Van Orstrand, C. E. Smithsonian Mathematical Tables—Hyperbolic Functions. 1909	Sp.	4.00
1872	Smithsonian Miscellaneous Collections (*Quarterly Issue*), Vol. V, Part 4 (containing Nos. 1873–1887). 1910. (The *Quarterly Issue* ends with this volume)	M.C. 52	.50
1873	Fewkes, J. Walter. Prehistoric Ruins of the Gila Valley. (*Quarterly Issue*). 1909	M.C. 52	
1874	Stejneger, Leonhard. Description of a New Frog from the Philippine Islands. (*Quarterly Issue*). 1909	M.C. 52	
1875	True, Frederick W. A New Genus of Fossil Cetaceans from Santa Cruz Territory, Patagonia; and description of a Mandible and Vertebræ of Prosqualodon. (*Quarterly Issue*). 1909	M.C. 52	
1876	Bean, Barton A. and Weed, Alfred C. Notes on Certain features of the Life History of the Alaskan Freshwater Sculpin. (*Quarterly Issue*). 1909	M.C. 52	
1877	Vaughan, T. Wayland. The Geologic Work of Mangroves in Southern Florida. (*Quarterly Issue*). 1909	M.C. 52	
1878	Pogue, J. E. Crystallographic Notes on Calcite. (*Quarterly Issue*). 1909	M.C. 52	
1879	Heller, Edmund. A New Rodent of the Genus Georychus. (*Quarterly Issue*). 1909	M.C. 52	
1880	Heller, Edmund. Two New Rodents from British East Africa. (*Quarterly Issue*). 1909	M.C. 52	
1881	Merrill, George P. A Heretofore Undescribed Stony Meteorite from Thomson, McDuffie County, Georgia. (*Quarterly Issue*). 1909	M.C. 52	
1882	Pogue, Joseph E. On a Remarkable Cube of Pyrite Carrying Crystallized Gold and Galena of Unusual Habit. (*Quarterly Issue*). 1909	M.C. 52	
1883	Miller, Gerrit S., Jr. A New Carnivore from British East Africa. (*Quarterly Issue*). 1909	M.C. 52	
1884	Knowlton, F. H. Descriptions of Fossil Plants from the Mesozoic and Cenozoic of North America. I. (*Quarterly Issue*). 1910	M.C. 52	
1885	Miller, Gerrit S., Jr., Two New Genera of Murine Rodents. (*Quarterly Issue*). 1910	M.C. 52	

No.	*Title.*	*Series.*	*Price.*
1886	ABBOT, C. G. Shelter for Observers on Mount Whitney. (*Quarterly Issue*). 1910	M.C. 52	
1887	List of Publications. (*Quarterly Issue*)	M.C. 52	
1888	SQUIER, MAJ. GEORGE O., U. S. Army. The Present Status of Military Aeronautics	R. 1908	
1889	JOURDAIN, PIERRE-ROGER. Aviation in France in 1908	R. 1908	
1890	FESSENDEN, R. A. Wireless Telephony	R. 1908	
1891	ARMAGNAT, HENRI. Phototelegraphy	R. 1908	
1892	REDDIE, LOVELL N. The Gramophone and the Mechanical Recording and Reproduction of Musical Sounds	R. 1908	
1893	THOMSON, J. J. On the Light Thrown by Recent Investigation on Electricity on the Relation between Matter and Ether	R. 1908	
1894	NERNST, W. Development of General and Physical Chemistry During the Last Forty Years	R. 1908	
1895	WITT, O. N. Development of Technological Chemistry During the Last Forty Years	R. 1908	
1896	GUTTMANN, OSCAR. Twenty Years' Progress in Explosives.	R. 1908	
1897	KAPTEYN, J. C. Recent Research in the Structure of the Universe	R. 1908	
1898	ABBOT, C. G. Solar Vortices and Magnetism in Sun Spots.	R. 1908	
1899	GREGORY, J. W. Climatic Variations, Their Extent and Causes	R. 1908	
1900	JOLY, JOHN. Uranium and Geology	R. 1908	
1901	ADAMS, GEORGE I. An Outline Review of the Geology of Peru	R. 1908	
1902	WIECHERT, E. Our Present Knowledge of the Earth	R. 1908	
1903	MACHAT, J. The Antarctic Question	R. 1908	
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1905	MACDOUGAL, DANIEL TREMBLY. Heredity and the Origin of Species	R. 1908	
1906	SAFFORD, WILLIAM EDWIN. Cactaceæ of Northeastern and Central Mexico, together with a Synopsis of the Principal Mexican Genera	R. 1908	
1907	GILL, THEODORE. Angler Fishes, their Kinds and Ways	R. 1908	
1908	DEWAR, DOUGLAS. The Birds of India	R. 1908	
1909	LULL, RICHARD S. The Evolution of the Elephant	R. 1908	
1910	WINCKLER, HUGO, and PUCHSTEIN, O. Excavations at Boghaz-Keui in the Summer of 1907	R. 1908	
1911	ROSS, RONALD. Malaria in Greece	R. 1908	
1912	NATHORST, A. G. Carl von Linné as a Geologist	R. 1908	
1913	THOMPSON, SYLVANUS P. Life and Work of Lord Kelvin.	R. 1908	
1914	BROCA, ANDRÉ. The Work of Henri Becquerel	R. 1908	
1915	Report of the Secretary of the Smithsonian Institution for the year ending June 30, 1909	R. 1909	
1916	Report of the Executive Committee and Proceedings of the Board of Regents for the year ending June 30, 1909	R. 1909	

No.	Title.	Series.	Price.
1917	Annual Report of the Smithsonian Institution for the year ending June 30, 1908 (containing Nos. 1855, 1856, and 1888–1914). 1909	R. 1908	
1918	Annual Report of the Smithsonian Institution for year ending June 30, 1908, Part 2, National Museum. 1909.	M.R. 1908	
1919	Annual Report of the Smithsonian Institution for year ending June 30, 1909, Part 2, National Museum. 1909.	M.R. 1909	
1920	Brockett, Paul. Bibliography of Aeronautics. Hodgkins Fund Publication. (In press)	M.C. 55	
1921	Smithsonian Miscellaneous Collections (*Quarterly Issue, Vol. V*), Vol. LII. 1910	M.C. 52	

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